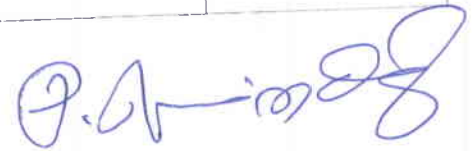# CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

INDEX

3.4.3 Details of research papers per teacher in CARE Journals notified on UGC website during the Academic Year 2022-23

Energy efficient routing with secure and adaptive trust threshold approach in mobile ad hoc networks

M. Venkata Krishna Reddy[1,2] · P. V. S. Srinivas[3] · M. Chandra Mohan[1]

Abstract

A Mobile ad hoc network (MANET) is a wireless, self-configuring network, dynamic in nature and works without any topology. Due to its widespread usage in many heterogeneous networks like Internet of Things (IoT) and the requirement for communication with heterogeneous devices, MANET is receiving more attention. Important data is gathered using smart devices or IoT sensors. These sensors communicate with one another independently within the range. Their energy levels and computing resources are restricted and they migrate frequently as topology is quiet active. Due to the energy constraints, nodes in the network behave selfishly and drop the packets during communication. Identification of the trustworthy and energy efficient nodes is essential for ensuring secure data transmission. The proposed method Energy Trust-Based Approach (ETA) combines trust, energy and reliable routing. Based on trust and energy values, nodes are involved in routing. This method identifies trusted nodes based on direct, indirect, past experiences and estimates their energy levels such that routing is performed only with the trusted nodes whose residual energy exceeds the determined threshold. Efficiency of the routing can be enhanced by calculating the energy levels of the trust adopted nodes in the network. The proposed ETA method ensures efficient routing between source and destination with the involvement of trustworthy and energy efficient intermediate nodes. The proposed work is simulated using Network Simulator (NS-2) and compared with other approaches, Trusted Energy Secured Ad hoc On Demand Vector scheme (TES-AODV), Secure Trust along with Adaptive Trust Threshold Method (STAT) and Ad hoc on demand vector routing (AODV). The simulation results have shown efficiency over the performance metrics like Packet delivery ratio PDLR with an increase of 5.34%, 4% decrease in Packet drop ratio PDR, 8% improvement in Throughput, 9% improvement in Residual energy, 8% reduction in Latency, 1.4% reduction in Overhead, 1,4 h increment in Network lifetime and 9% decrease in Delay. Thus ETA ensures stable, secured and trusted data transmission compared to simple AODV, STAT and TES-AODV.

Extended author information available on the last page of the article

An enhanced opportunistic rank-based parent node selection for sustainable & smart IoT networks

Premkumar Chithaluru [a g], Aman Singh [b h], Mahmoud Shuker Mahmoud [c], Sunil Kumar [d g], Juan Luis Vidal Mazón [b g i], Ahmed Alkhayyat [e], Divya Anand [f b]

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Abstract

The Internet of Things (IoT) is a network of interconnected devices that includes low-end devices (sensors) and high-end devices (servers). The routing protocol used the Low-Power and Lossy Networks (RPL) protocol, which was designed to collect data in Low-Power and Lossy Networks (LLN) efficiently and reliably. The RPL rank property specifies how sensor nodes are placed in Destination Oriented Directed Acyclic Graphs (DODAG) based on an Objective Function (OF). The OF includes information such as the Expected Transmission Count (ETX) and packet delivery rate. The rank property aids in routing path optimization, reducing control overhead, and maintaining a loop-free topology by using rank-based data path validation. However, it causes many issues, such as optimal parent selection, next-hop node selection, and network instability. We proposed an Enhanced Opportunistic Rank-based Parent Node Selection for Sustainable and Smart IoT Networks to address these issues. The optimal parent node is determined by forecasting the expected energy of each node using Received Signal Strength (RSS) and an enhanced reinforcement learning algorithm. The proposed method addresses the issue of selecting the next-hop neighbor node and improves routing stability. Furthermore, when a large number of new nodes try to join the sustainable IoT-based smart cities, the proposed technique provides optimal load balance.

Introduction

An IoT is a collection of network devices that are used to communicate and collect information from monitoring areas throughout the wireless node's links[1]. The data packets can be transmitted via multiple sensor nodes with a single gateway node, and it is linked to other networks such as wireless Ethernet (WLAN)[2]. It contains many sensor nodes and base stations to communicate with the monitored area. The environmental or Physical conditions are monitored by using the IoT[3], the conditions may be in the form of sound, temperature, pressure, wind speed, and direction, pollution levels, humidity, etc and this monitored information will be passed via the network to a central location[4].

The IoT network has been constructed first then its applications can be used in several domains such as military, sports, transportation, healthcare, and other industrial fields[5]. In general, an IoT is composed of a significant number of sensor nodes ranging from hundreds to thousands[6]. In IoT, some sensor node types of equipment are exploited, like a microcontroller and radio transceiver, along with an antenna, an energy source, an interfacing electronic circuit, and a battery[7]. The sensor node's size will range from the shoe box's size to as small as the grain of dust's size[8]. The prices of IoT devices have also ranged from a few pennies to hundreds of dollars, depending on the functionality parameters of the sensors, such as computational speed rate, energy consumption, memory, and bandwidth[9].

RPL is an LLN that can be utilized as a routing protocol in IoT with low power consumption[10], but it is vulnerable to packet loss during packet transmission[11]. Depending on the distance vectors, it will act as a proactive protocol and can work on IEEE 802.15.4[12]. It is the best solution for many-to-one communication and assists with one-to-one messages[13]. Routing must frequently change in most cases, while the sensor node only covers a limited range. Every wireless link has been influenced by its environment. Wherever it operates, such fixtures provide combination and reflection, and links are generated either permanently or temporarily undependable[14].

RPL protocol is connected to a Directed Acyclic Graph (DAG)[15], which determines the topology. In a wireless network, each sensor has a rank that increases as the nodes move away from the sink, called Destination Oriented Directed Acyclic Graph (DODAG)[16]. In the said case, the route selection requirement process follows, and by using the lowest range values, nodes can re-transmit the packets[17].

The RSS can be estimated by using the transmission power, the radio capabilities, and the distance between receiver & transmitter[18]. The RSS will be estimated for each received packet. The Received Signal Strength Indicator (RSSI)[19] is calculated using estimated RSS energy. To some extent, the RSSI

2

Underground Water Level Prediction in Remote Sensing Images Using Improved Hydro Index Value with Ensemble Classifier

Andrzej Stateczny [1],*[ID]**, Sujatha Canavoy Narahari** [2][ID]**, Padmavathi Vurubindi** [3][ID]**, Nirmala S. Guptha** [4][ID]
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Abstract: The economic sustainability of aquifers across the world relies on accurate and rapid estimates of groundwater storage changes, but this becomes difficult due to the absence of in-situ groundwater surveys in most areas. By closing the water balance, hydrologic remote sensing measures offer a possible method for quantifying changes in groundwater storage. However, it is uncertain to what extent remote sensing data can provide an accurate assessment of these changes. Therefore, a new framework is implemented in this work for predicting the underground water level using remote sensing images. Generally, the water level is defined into five levels: Critical, Overexploited, Safe, Saline, and Semi-critical, based on water quantity. In this manuscript, the remote sensing images were acquired from remote sensing images. At first, Wiener filtering was employed for preprocessing. Secondly, the Vegetation Indexes (VI) (Normalized Difference Vegetation Index (NDVI), Normalized Difference Snow Index (NDSI), Infrared index (IRI), Radar Vegetation Index (RVI)), and statistical features (entropy, Root Mean Square (RMS), Skewness, and Kurtosis) were extracted from the preprocessed remote sensing images. Then, the extracted features were combined as a novel hydro index, which was fed to the Ensemble Classifier (EC): Neural Networks (NN), Support Vector Machine (SVM), and improved Deep Convolutional Neural Network (DCNN) models for underground water level prediction in the remote sensing images. The obtained results prove the efficacy of the proposed framework by using different performance measures. The results shows that the False Positive Rate (FPR) of the proposed EC model is 0.0083, which is better than that of existing methods. On the other hand, the proposed EC model has a high accuracy of 0.90, which is superior to the existing traditional models: Long Short-Term Memory (LSTM) network, Naïve Bayes (NB), Random Forest (RF), Recurrent Neural Network (RNN), and Bidirectional Gated Recurrent Unit (Bi-GRU).

Keywords: improved Deep Convolutional Neural Network; improved hydro index; remote sensing; Support Vector Machine; underground water level prediction; Wiener filter

1. Introduction

The groundwater is the world's greatest supply of fresh water, and it is crucial for human consumption and general development of an area [1–3]. The water food energy nexus is mostly dependent on groundwater, which accounts for close to 30% of the world's freshwater reserves [4–6]. Globally, groundwater supplies provide nearly half of the world's drinking water. In addition, groundwater is widely utilized in agricultural processes, and

A proficient video recommendation framework using hybrid fuzzy C means clustering and Kullback-Leibler divergence algorithms

H. Anwar Basha[1] · S. K. B Sangeetha[2] · S. Sasikumar[3] · J. Arunnehru[2] ·
M. Subramaniam[4]

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Abstract

A video recommendation framework for e-commerce clients is proposed using the collaborative filtering (CF) process. One of the most important features of the CF algorithm is its scalability. To avoid the issue, a hybrid model-based collaborative filtering approach is proposed. KL Divergence was developed to address the CF technique's scalability problem. The clustering with enhanced sqrt-cosine similarity Recommender scheme is proposed. For successful clustering, Kullback–Leibler Divergence-based Fuzzy C-Means clustering is suggested, with the aim of focusing on greater accuracy during movie recommendation.The proposed scheme is viewed as a trustworthy contribution that significantly improves the ability of movie recommendation by virtue of the KL divergence-based Fuzzy C-Means clustering mechanism and enhanced sqrt-

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ORIGINAL ARTICLE

Optimizing CNN-LSTM hybrid classifier using HCA for biomedical image classification

Ashwini Kumar Pradhan ✉, Kaberi Das, Debahuti Mishra, Premkumar Chithaluru

Abstract

In medical science, imaging is the most effective diagnostic and therapeutic tool. Almost all modalities have transitioned to direct digital capture devices, which have emerged as a major future healthcare option. Three diseases such as Alzheimer's (AD), Haemorrhage (HD), and COVID-19 have been used in this manuscript for binary classification purposes. Three datasets (AD, HD, and COVID-19) were used in this research out of which the first two, that is, AD and HD belong to brain Magnetic Resonance Imaging (MRI) and the last one, that is, COVID-19 belongs to Chest X-Ray (CXR) All of the diseases listed above cannot be eliminated, but they can be slowed down with early detection and effective medical treatment. This paper proposes an intelligent method for classifying brain (MRI) and CXR images into normal and abnormal classes for the early detection of AD, HD, and COVID-19 based on an ensemble deep neural network (DNN). In the proposed method, the convolutional neural network (CNN) is used for automatic feature extraction from images and long-short term memory (LSTM) is used for final classification. Moreover, the Hill-Climbing Algorithm (HCA) is implemented for finding the best possible value for hyper parameters of CNN and LSTM, such as the filter size of CNN and the number of units of LSTM while fixing the other parameters. The data-set is pre-processed (resized, cropped, and noise removed) before feeding the train images to the proposed models for accurate and fast learning. Forty-five MR images of AD, Sixty MR images of HD, and 600 CXR images of COVID-19 were used for testing the proposed model 'CNN-LSTM-HCA'. The performance of the proposed model is evaluated using six types of statistical assessment metrics such as; Accuracy, Sensitivity, Specificity, F-measure, ROC, and AUC. The proposed model compared with the other three types of hybrid models such as CNN-LSTM-PSO, CNN-LSTM-Jaya, and CNN-LSTM-GWO and also with state-of-art techniques. The overall accuracy of the proposed model received was 98.87%, 85.75%, and 99.1% for COVID-19, Haemorrhage, and Alzheimer's data sets, respectively.

CONFLICT OF INTEREST

The authors state that they have no known competing financial interests or personal ties that could have influenced the research presented in this study.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Kaggle at **https://www.kaggle.com/search?q=covid+19+dataset** .

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Computational-Intelligence-Inspired Adaptive Opportunistic Clustering Approach for Industrial IoT Networks

Premkumar Chithaluru[ID], Fadi Al-Turjman[ID], Manoj Kumar[ID], *Member, IEEE*, and Thompson Stephan[ID], *Member, IEEE*

Abstract—The major issues and challenges of the Industrial Internet of Things (IIoT) include network resource management, self-organization; routing, mobility, scalability, security, and data aggregation. Resource management in IIoT is a challenging issue, starting from the deployment and design of sensor nodes, networking at cross-layer, networking software development, application types, environmental conditions, monitoring user decisions, querying process, etc. In this article, computational intelligence (CI) and its computing, such as neural networks and fuzzy logic, are used to tackle the challenges of resource management in the IIoT. The incorporation of the neuro-fuzzy technique into the IIoT contributes to the self-managing intelligence systems' self-organizing and self-sustaining capabilities, offering real-time computations and services in a pervasive networking environment. Most of the problems in IIoT are real-time based; they require fast computation, real-time optimal solutions, and the need to be adaptive to the situation of the events and data traffic to achieve the desired goals. Hence, neural networks and fuzzy sets would form appropriate candidates for implementing most of the computations involved in the issues of resource management in IIoT networks. A real-time testbed network is simulated and implemented on the Crossbow mote (sensor node) using TinyOS.

Index Terms—Computational intelligence (CI), industrial IoT, mobile node, neuro-fuzzy technique, resource management, self-managing, self-organizing, self-sustaining.

I. Introduction

THE INDUSTRIAL Internet of Things (IIoT) is dynamic in nature. The input traffic and other environmental data are fraught with uncertainty [1]. They are prone to unanticipated overloads and outages. Fuzzy logic looks to be a potential solution for addressing such critical features of IIoT [2], [3]. It

provides a strong mathematical foundation for dealing with real-world imprecision and nonstatistical uncertainty. A thorough search and study of the literature demonstrates that current research on fuzzy logic in communication networks ranges from queuing, buffer management, and load management to routing, bandwidth allocation, network administration, and quantitative network performance evaluation [4].

IIoT is becoming more prevalent in the above-mentioned real-time operations and emerging applications. As a result, there is a need to investigate and comprehend system behavior in a variety of environments based on potential application requirements and issues, such as resource management, self-organization, routing, mobility, and scalability. Along with these issues and challenges in IIoT, the techniques should tackle the requirements of applications like real-time event detection, location-based monitoring, operating environment decisions, etc. [6], [7].

1) *Resource Management:* IIoT is subjected to a unique set of resource constraints. Some of them include limited hardware, networking, and support for software development. IIoT mobile nodes are unreliable, which causes network failures and faults more often. Similarly, there are no universally accepted standard routing protocols or network services. In such a resource-constrained environment, resource allocation in a distributed environment, their activation, data storage, computation, and preprocessing allocation are to be monitored [8]. The resource reservation for future applications and different events of occurrence based on the environmental parameters are to be reserved and allocated. Application priority, real-time requirements, and data-intensive task-based applications are to be synchronously and asynchronously monitored. Link bandwidth utilization, throughput, and bit error rate are the essential link parameters in the IIoT that are to be allocated, reserved, and monitored for better network resource management using computational intelligence (CI) methods.

2) *Scalability, Mobility, and Dynamic Network Topology:* The number of sensor nodes (n_i) placed to examine an IIoT environment for many envisioned applications could be in the hundreds or thousands. Depending on the application, the number might be in the millions. Scalability in a network environment occurs when an application grows; the network should be flexible
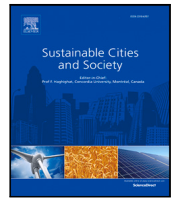
Energy-balanced neuro-fuzzy dynamic clustering scheme for green & sustainable IoT based smart cities

Premkumar Chithaluru [a], Fadi Al-Turjman [b,c], Manoj Kumar [d], Thompson Stephan [e,*]

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ARTICLE INFO

ABSTRACT

The Internet of Things (IoT) is a pervasive computing technology that provides solutions to critical sustainable smart city applications. Each sustainable application has its own set of requirements, including energy efficiency, Quality of Service (QoS), hardware, and software resources. Even though green IoT devices operate in a resource-constrained environment. Monitoring, recognizing, and responding to activities that entail continuous access to timely information in a partially or fully distributed ecosystem is a difficult task. To overcome the challenges of resource management in the IoT, we proposed an energy-efficient Dynamic Clustering Routing (DCR) protocol using a neuro-fuzzy technique for restricting the resources of IoT devices. The proposed protocol uses a dynamic self-organizing neural network to create dynamic clusters in a network. The test-bed analysis is for computing the real-time event detection and clustering sensor nodes using TinyOS. The simulation result shows that the proposed protocol achieved a significant gain over peer-competing well-known green communication routing protocols like Low-energy Adaptive Clustering Hierarchy (LEACH) and Low-energy Adaptive Clustering Hierarchy-Centralized (LEACH-C). The proposed model results show that using neuro-fuzzy logic is effective for sustainable IoT devices and green smart city applications in terms of resource management and dynamic clustering. The result analysis shows that the proposed protocol shows an average 35% significant gain on the First Node Dies (FND), Last Node Dies (LND), the number of packets sent to CH & BS, network convergence time, network overhead, and average packet delay to compare with the LEACH and LEACH-C.

1. Introduction

Recent advancements in wireless communication technology and advanced techniques, as well as the decrease in electrical and sensor equipment, have sparked great interest in green IoT research (Abbasi & Shahid Khan, 2018; Javed et al., 2022). A Sustainable IoT network is made up of several sensor nodes that may communicate wirelessly and is widely placed inside a designated region of green smart cities (Chithaluru, Tiwari, & Kumar, 2021f; Mukherjee, Goswami, Yang, Yan, & Daneshmand, 2020). They use wireless channels to send and receive data from other nodes. The sensor nodes must be equipped with the ability to recognize nearby neighbors and contribute to the development of wireless networks using green communication protocols (Chithaluru, Khan, Kumar, & Stephan, 2021c; Saleem, Afzal, Ateeq, Kim, & Zikria, 2020).

Sustainable IoTs are application-specific, varying as per smart city applications. Small node size, low node cost, power efficiency, durability, extensible, self-configure, a place that enables, high availability, flexibility, safety, manufacturing costs, an environment in which it operates, sensor topology, hardware restrictions, and communication channels of all IoT networks (Jain et al., 2022; Zikria, Kim, Hahm, Afzal, & Aalsalem, 2019). These elements are significant because they serve as a framework for developing a protocol or algorithm for sensor networks. IoT efficiency may be increased by the unified network (Chithaluru, Al-Turjman, Kumar, & Stephan, 2020a), targeted, and resource strategies (Zikria, Yu, Afzal, Rehmani, & Hahm, 2018). In this case, the sensor nodes have natural capabilities for detecting nearby neighbors and assisting in the development of a wireless

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Hybridizing Artificial Intelligence Algorithms for Forecasting of Sediment Load with Multi-Objective Optimization

Arvind Yadav [1], Marwan Ali Albahar [2], Premkumar Chithaluru [3,4,*], Aman Singh [5,6], Abdullah Alammari [7], Gogulamudi Vijay Kumar [8] and Yini Miro [4,9]

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Abstract: Forecasting of sediment load (SL) is essential for reservoir operations, design of water resource structures, risk management, water resource planning and for preventing natural disasters in the river basin systems. Direct measurement of SL is difficult, labour intensive, and expensive. The development of an accurate and reliable model for forecasting the SL is required. Sediment transport is highly non-linear and is influenced by a variety of factors. Forecasting of the SL using various conventional methods is not highly accurate because of the association of various complex phenomena. In this study, major key factors such as rock type (RT), relief (R), rainfall (RF), water discharge (WD), temperature (T), catchment area (CA), and SL are recognized in developing the one-step-ahead SL forecasting model in the Mahanadi River (MR), which is among India's largest rivers. Artificial neural networks (ANN) in conjunction with multi-objective genetic algorithm (ANN-MOGA)-based forecasting models were developed for forecasting the SL in the MR. The ANN-MOGA model was employed to optimize the two competing objective functions (bias and error variance) with simultaneous optimization of all associated ANN parameters. The performances of the proposed novel model were finally compared to other existing methods to verify the forecasting capability of the model. The ANN-MOGA model improved the performance by 12.81% and 10.19% compared to traditional AR and MAR regression models, respectively. The results suggested that hybrid ANN-MOGA models outperform traditional autoregressive and multivariate autoregressive forecasting models. Overall, hybrid ANN-MOGA intelligent techniques are recommended for the forecasting of SL in rivers because of their relatively better performance as compared to other existing models and simplicity of application.

Keywords: multi-objective-based genetic algorithm; water discharge; artificial neural network; sediment load; Mahanadi River

1. Introduction

Hydrology deals with the efficient utilization of water resources and their management through the use of hydrological forecasting. Forecasting sediment load (SL) is an important concern in water resource management, and it is essential to know information about reservoir operations, water resource planning, flooding, water pollution control, reservoir design in rivers, and risk management as well as for preventing natural disasters [1,2].
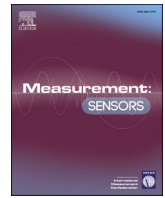
Reliable cluster based data aggregation scheme for IoT network using hybrid deep learning techniques

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ABSTRACT

Background: Several IoT nodes are deployed in the monitoring environment to ensure reliability. In both sensor and sink nodes, the same data is sensed and forwarded. While redundant data maintains reliability, sink nodes waste energy processing the redundant data.
Objective: In order to upholdthe compromiseamong energy ingesting and reliability, necessary to eliminate the redundancies in sensed data up to an appropriate level. Data aggregation algorithms currently assign time slots based on data sensing period and program rate, disregarding packet loss and latency.
Methodology: In this paper, we suggest a cluster based reliable data aggregation (CRDA) scheme for IoTnetwork which ensures data collection and aggregation in energy efficient manner and transfer to another end very effectively. We first introduce a monarch and sine-cosine (MSC) algorithm to form clusters by grouping the IoT sensors which ensures the effective data transferring. In data aggregation phase, we utilize the multiple design metrics to compute the trust degree of each IoT sensors and design an improved sunflower optimization (ISFO) algorithm to optimize the design constraints. The highest trust degree owned swelling is act as cluster head (CH) of the cluster which ensures data aggregation. A reformative optimal–learning-based deep neural network (ROL-DNN) is then used to compute routes between IoT sensors which ensures reliabledata aggregation and transferring.
Results: and analysis: Finally, we validate our proposed routing with the different simulation scenario and their results are compared with the existing routing protocols to prove the effectiveness.

1. Introduction

Internetof Things (IoT) permits brilliant articles and savvy frameworks to collect and share information worldwide to allow shrewd climate [1]. There is a developing interest in the utilization of remote detecting advancements in different IoT situations.Given the enormous development of objects and their applications, gathering and examining their item information is becoming one of the significant difficulties. As sensor hubs are controlled by batteries, energy productive activities are critical. For this reason, it is attractive for the sensor hub to de-copy the information got from the adjoining hubs prior to communicating the last information to the focal station. Information accumulation [2,3] is one of the powerful strategies to wipe out information overt repetitiveness and further develop energy productivity; expanding the lifetime of remote sensor organizations (WSNs). A difficult issue for data management is effectively deliver data to relevant users. It uses economical

techniques such as efficient flow distribution systems for IoT [4]. The system collects integrated data streams generated from different collectors and transmits relevant data to relevant users based on user queries entered into the system [5]. Create two new data structures to meet the requirements of high efficiency data flow propagation in two conditions, such as point-to-point systems and flow propagation in wireless transmission systems. Assessment of approaches using real-world datasets shows that they can transmit connected data streams more efficiently than current technology [6].

In IoT advances, multiple data configurations are recommended for efficient data processing and minimal data recovery. This includes storing centralized data, such as the cloud system, on nearby distribution systems. Smart cities are the practical implementation of IoT, which aims to provide people with efficient, reliable and secure applications such as water, electricity and transportation through rational management [7]. The database-based IoT platform is required to implement

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Fog Computing: Applications, Challenges, and Opportunities

Rajanikanth Aluvalu, Lakshmi Muddana, V Uma Maheswari, Krishna Keerthi Channam, Swapna Mudrakola, MD Sirajuddin, CVR Syavasya

Abstract

Cloud computing, is a widely accepted utility computing model. All the application processing takes place in the cloud data center managed by the cloud service provider. This includes network latency and delays in processing. Each time the application is executed, data has to be transported from node to the cloud. This will increase network traffic and is practically not feasible to transport data from node to remote cloud server and back. Fog computing, a new paradigm of cloud computing will help in overcoming this challenge. In fog computing technology, the data processing tasks are executed at the node level either completely or partially, which highly increases the speed of responses. Also, it reduces latency, processing costs, and bandwidth problems, and improves the efficiency of customer driver services with better response time. Fog is highly useful in locations where network connectivity is an issue because fog has a separate protocol suite that will support weak network connections. In this article, the various parameters of the fog computing paradigm such as challenges, application, and opportunities are

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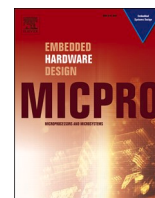
Prof. Michel Cotsaftis
Director of Undergraduate Scientific Research Program/ECE Paris Graduate School of Engineering, Paris, France

Prof. Ali Kashif Bashir
Department of Computing and Mathematics, Manchester Metropolitan University, United Kingdom

Submission

The novel emergency hospital services for patients using digital twins

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ARTICLE INFO

ABSTRACT

The Digital twins will duplicate the actual objects, create the virtual world and execute using IoT devices and Sensors. The Emergency Room Service (ERS) is a critical phase for patients in health condition evaluation, Digital Health records will help us in understanding the cause of illness, medical history will help us to start the treatment. The most challenging for ERS is anonymous person or unknown follow ups about patients. The proposed model (Emergency Service Room with Digital Twins), helps to treat a patient with fast-track service and reduce the length of Stay in ER. The risk factor of a patient's life by reviewing the medical history of the patients through digital health records. This novel method will help doctors in treating patients by Computing Image Processing in face recognition of patients. The biometric used for authentication to access the cloud for digital health records. The communication system used to acknowledge the family, Insurance Company and expert adviser. The empirical results successfully proved the novel proposed idea with above 80% of success rate. We can build an intelligent expert system to collaborate the Digital Health Record, E-H-S, Expert Adviser, and an expert system in the future. In treating Anonym patients in the Emergency department.

1. Introduction

The role of digital twins (DT) to Autonomous business medical applications through digital devices. The function of DT includes - Monitoring Digital Twins, Imaginary Digital Twins, Predictive Digital Twins, Prescriptive Digital Twins and Recollection Digital Twins are controlled by the life cycle of the control module in the framework. Smart farming is an advanced and most required approach in farming. Digital Twins help to study the environment virtually. Dynamic actions are taken based on the intelligent decision taken by the Digital Twin framework designed using IoT devices, twining the devices in data acquisition, and data analysis on the system. The applications of smart farming like Livestock Farming, Planthouse, Dairy houses, Chemical-Free Farming and Agriculture Farming. The Digital Twin collaborates with different modules in the farming life cycle through the virtual world. In this European IoF2020 project, six digital twins exist to analyze the current state, predict future actions, and monitor and some of application area are shown in Fig. 1 [1] and a list of medical applications using digital

twins is discussed in Table 1.

Identifying the Challenges in Digital Twins will help exploit the research world's solutions. The first Challenge is that AI algorithms are used in digital twins and the block chain. Most of the AI methods are black-box in nature. The AI decision-making methods suffer from apprehensible logic clearness in the reasoning. The explained Artificial Intelligence is expected for trustworthiness [2]. It isn't easy to collect data about physics and chemical info about food raw materials in the digital twins' Challenge in the food safety industry. Adopting new technology in the existing system is also difficult. Much statistical calculation needs to be done to predict the values [3]. The Digital Twins challenge in Constructions is a comprehensive design model expected from design to execution in planning, model construction, monitoring, operation executions, and quality check management [4].

Recent Trends in Digital Twins: Digital twins are used in eliminating mistakes and defects (Poka Yoke) products in the manufacturing industry. The robot manufacturing products work in collaboration with digital twins and predict the failure of the equipment, failed execution,

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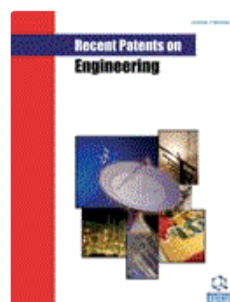
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Research Article

A Secure Network with Minimization of Energy for E-healthcare Application in IoMT

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Abstract

Aims: Protect patient healthcare records.

12

A proficient video recommendation framework using hybrid fuzzy C means clustering and Kullback-Leibler divergence algorithms

H. Anwar Basha[1] · S. K. B Sangeetha[2] · S. Sasikumar[3] · J. Arunnehru[2] · M. Subramaniam[4]

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Abstract

A video recommendation framework for e-commerce clients is proposed using the collaborative filtering (CF) process. One of the most important features of the CF algorithm is its scalability. To avoid the issue, a hybrid model-based collaborative filtering approach is proposed. KL Divergence was developed to address the CF technique's scalability problem. The clustering with enhanced sqrt-cosine similarity Recommender scheme is proposed. For successful clustering, Kullback–Leibler Divergence-based Fuzzy C-Means clustering is suggested, with the aim of focusing on greater accuracy during movie recommendation. The proposed scheme is viewed as a trustworthy contribution that significantly improves the ability of movie recommendation by virtue of the KL divergence-based Fuzzy C-Means clustering mechanism and enhanced sqrt-

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Competing Interests: None

Intelligent Particle Swarm Optimization Based Resource Provisioning Technique in Cloud Computing

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Abstract

Objectives: To find the optimal allocation of resources and minimize the overall cost while meeting the performance requirements of the applications. **Methods:** The proposed Intelligent PSO-based resource optimization in cloud computing evaluates the quality of the solutions based on their resource allocation parameters. Cloud Sim software is used as a simulation tool for testing and evaluating new solutions and strategies in the cloud. The Closest Data Center Service Broker Policy is implemented in Cloud Simulation. **Findings:** The proposed technique assigns workloads effectively on available resources with an improvement of 10.46% in electricity consumption. **Novelty:** The algorithm can further be employed for identifying the unused VM's in the Data Center to reduce the cost.

Keywords: Cloud computing; Resource Scheduling; Load balancing; Particle Swarm Optimization; Quality of Service

1 Introduction

In the field of computer science, cloud computing technology is showing phenomenal growth due to the advancement of the internet[1]. Cloud computing provides infrastructure, platform, and software as services. Cloud resources are providing customers with a pay-as-you-use model. To provide quality services to customers, there is a Service Level Agreement (SLA) between the customers and the cloud service providers as shown in Figure 1. Cloud service providers need to verify if a sufficient number of resources are available to customers to ensure that QoS requirements like execution time, deadline, and budget restrictions are met. However, running too many applications on a single resource can result in a drastic performance loss, which deters cloud consumers. It is challenging to match workloads to the right resources for cloud execution. The existing approaches of Resource optimization in cloud computing involves managing multiple resources and balancing different performance metrics, which can be complex and challenging. Developing an effective optimization algorithm requires significant expertise and resources. For effective resource use, three primary QoS limitations must be taken into account[2].
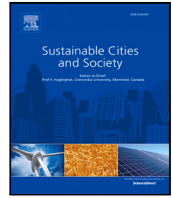
An Optimized Bio-inspired Localization Routing Technique for Sustainable IIoT Networks & Green Cities

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ARTICLE INFO

ABSTRACT

The industrial Internet of Things (IIoTs) network life is shortened due to sensor node (SN) energy limitations and computational capability. As a result, optimum node location estimation and efficient energy usage are two critical IIoT requirements. This work reduces energy consumption by performing node localization and cluster-based routing using an improved evolutionary algorithm called Cat Swarm Optimization (CSO). First, the CSO method is used to optimize the bio-inspired node's location. Second, to conserve SN energy in the IIoT network, a cluster-based routing technique is used. The objective function is defined as minimizing the average distance between the cluster and its SNs while selecting the most energy-efficient Cluster Head (CH). In terms of fitness value, the Improved CSO (ICSO) algorithm outperforms the Particle Swarm Optimization (PSO) algorithm. In this paper, real-time test-bed analysis was used to investigate the performance of both node localization and energy-efficient clustering. When it comes to achieving sustainable IIoT and green cities, the findings show that ICSO outperforms in terms of convergence rate and network lifetime.

1. Introduction

The development of smart devices is facilitated by the creation of a user-friendly environment. These devices should be self-aware and communicative. The Internet of Things (IoT) connects intelligent devices to perform a task by utilizing smart networking protocols (Wu et al., 2023). The rapid advancement of wireless communication technologies has piqued the interest of both industry and academia in real-world solution research and development. Furthermore, IoT is a powerful infrastructure-less networking unit comprised of low-power SNs organized in an ad-hoc system (Tanwar, Balamurugan, Saini, Bharti, & Chithaluru, 2022). These SNs can collect and process data from their intended environment to communicate with one another. Enemy battlefield monitoring, ecological parameter monitoring, off-shore energy sector monitoring, biological detection, industrial diagnostics, and other sensors are randomly deployed in a physical environment that serves as the sensing layer for IIoT applications (Shit, Sharma, Puthal, & Zomaya, 2018).

The IIoT is a network of independent SNs distributed in a nested application that can sense, determine, and update data in the Base Station (BS) (Chithaluru, Al-Turjman, Kumar, & Stephan, 2021). Fig. 1 depicts a typical IIoT application in various emerging technologies. Each SN in the IIoT is made up of a sensing unit for sensing environmental parameters, an antenna for transmission and reception, and a processor and memory device (Lashkari, Rezazadeh, Farahbakhsh, & Sandrasegaran, 2018). Nonetheless, the IIoT components are designed with more constraints, particularly in terms of energy and processing capabilities. The main limitation of IIoT is the sensor unit's power supply. When deployed in a hostile environment, the batteries that power the SNs are not easily replaceable. As a result, energy consumption is a difficult subject that necessitates extensive research to extend the IIoT's lifespan (Chithaluru, Kumar, Singh, Benslimane, & Jang, 2021).

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Research Article

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Dharmana Jayaram, and Pulipati Venkateswara Rao

Aspect-based sentiment analysis on multi-domain reviews through word embedding

Abstract: The finest resource for consumers to evaluate products is online product reviews, and finding such reviews that are accurate and helpful can be difficult. These reviews may sometimes be corrupted, biased, contradictory, or lacking in detail. This opens the door for customer-focused review analysis methods. A method called "Multi-Domain Keyword Extraction using Word Vectors" aims to streamline the customer experience by giving them reviews from several websites together with in-depth assessments of the evaluations. Using the specific model number of the product, inputs are continuously grabbed from different e-commerce websites. Aspects and key phrases in the reviews are properly identified using machine learning, and the average sentiment for each keyword is calculated using context-based sentiment analysis. To precisely discover the keywords in massive texts, word embedding data will be analyzed by machine learning techniques. A unique methodology developed to locate trustworthy reviews considers several criteria that determine what makes a review credible. The experiments on real-time data sets showed better results compared to the existing traditional models.

keywords: aspect-based sentiment analysis, product reviews, cold start, sentiment analysis, word embedding

1 Introduction

It could require a lot of time to conduct online research for product reviews [1]. A consumer must read multiple reviews on various websites to get a feel of a product's benefits and drawbacks. Customers are looking for a more accurate breakdown of all reviews when they read many testimonials on social media. Making the user's decision-making process easier would be to provide dependable reviews based on specific criteria. Finding a method for effectively condensing review data would not only assist customers in making wiser judgments but also increase market awareness of quality [2].

In addition, an efficient review analyzer would provide quick input that could be applied to improving services. As a result, the market needs quality keyword extraction and polarity quantifying techniques that would help in the optimal mapping of customers and companies. The use of sentiment analysis is advantageous in a wide range of different industries to sort out business challenges [3]. The main applications

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Article

A Novel Approach to Integrating Uncertainty into a Push Re-Label Network Flow Algorithm for Pit Optimization

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Abstract: The standard optimization of open-pit mine design and production scheduling, which is impacted by a variety of factors, is an essential part of mining activities. The metal uncertainty, which is connected to supply uncertainty, is a crucial component in optimization. To address uncertainties regarding the economic value of mining blocks and the general problem of mine design optimization, a minimum-cut network flow algorithm is employed to give the optimal ultimate pit limits and pushback designs under uncertainty. A structure that is computationally effective and can manage the joint presentation and treatment of the economic values of mining blocks under various circumstances is created by the push re-label minimum-cut technique. In this study, the algorithm is put to the test using a copper deposit and shows similarities to other stochastic optimizers for mine planning that have already been created. Higher possibilities of reaching predicted production targets are created by the algorithm's earlier selection of more certain blocks with blocks of high value. Results show that, in comparison to a conventional approach using the same algorithm, the cumulative metal output is larger when the uncertainty in the metal content is taken into consideration. There is also an additional 10% gain in net present value.

Keywords: open-pit mine; ultimate pit limit; uncertainty modeling; minimum cut; network flow

MSC: 68W40; 68W50

1. Introduction

A challenging issue in mine planning and design is open-pit mine production scheduling. To maximize the total discounted profit, an open-pit optimization problem is used to remove mining blocks from the pit while satisfying all of its constraints. Reserve constraints: the restriction that a block can only be mined once during its lifetime. Slope constraints: a block cannot be mined before its predecessors. A group of overlying blocks must be removed to reach a given block. Mining constraints: to ensure the effective use of mining equipment, the total weights of blocks mined during each period should be at least equal to a minimum mining limit. On the other hand, it should not be greater than the capacity of the mining equipment that was in use at the time. Both the upper bound and the lower bound must be satisfied under mining constraints. Processing constraints: this primarily depends on the processing capacity of the plants. The total number of ore blocks mined during each period should at least be equal to the minimum number needed for processing, but it should not exceed the processing plant's capacity because the excess ore must then

ANN-ABC META-HEURISTIC HYPER PARAMETER TUNING FOR MAMMOGRAM CLASSIFICATION

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ABSTRACT

In recent past, artificial neural networks (ANN) have reaped improvements in the domain of medical image processing by addressing many unmanageable problems. The initialized hyperparameters control ANN performance and selecting sensible hyperparameters by hand is time-consuming and tiresome. This study suggests a metaheuristic optimization of the fine-tuning hyperparameters approach to remedy this flaw. The method is then evaluated on mammography images to assess whether the mammogram contains cancer. In the proposed ANN model, a modified Artificial bee colony (ABC) optimization method is used to fine tune the hyperparameters, and it categorizes the tumors in the breast as benign or malignant in two-class case and normal, benign, and malignant in three-class case with an accuracy of 97.52% and 96.58% respectively. Hyperparameters to the neural network framework were assigned instantly with the help of ABC method with wrapped ANN as objective function. Manual search, Grid Search, Random Grid search, Bayes search are all cutting edge ANN hyperparameters methods. In addition to the mentioned, nature-inspired optimization methods such as PSO and GA have adopted for fine tuning parameters. Additionally, the suggested model's performance in classifying breast pictures was compared to that of the published hyperparameter technique using sizable datasets on breast cancer that were made accessible to the public.

Keywords: *Artificial Neural Networks, Hyperparameters, Artificial bee colony, Mammogram images, Grid Search.*

1. INTRODUCTION

Out of two women newly breast cancer diagnosed one woman dies in India. Breast cancer ratio is 14% of all women cancers in India and in it is the topmost cancer in case of new cases registered in 2020 with 178361(26.3%) cases in women in India [25]. Overall, out of twenty-nine women one woman likely to detect with Breast cancer in her lifetime. Furthermore, it the second most common cancer in the world next to lung cancer, irrespective of gender [1]. Studies are proved that early breast cancer detection could cut the rate of death drastically, reduces the radiologist effort to treatment and disease morbidity [2]. For the Radiologist, early state breast cancer detection is a tiresome job as they must deal with huge number of digital mammogram images, which inclined to develop an automated and simplified early-stage cancer detection method. Medical diagnosis system could have been inculcated with the

intelligent based systems like neural networks models [24]. Traditional decision-making methods are outperformed by the artificial intelligence-based ANN models. In this regard, many swarm based nature-inspired optimization algorithms (NIOA) like ABC, PSO (particle swarm optimization) and GA (Genetics Algorithm), etc. are adopted in finding the optimized solutions to real-time medical diagnosis problems [3]. This research proposed an automated hyperparameter fine tuning ANN model by adopting ABC as its tuning method instead of traditional methods like Grid Search.

1.1 Artificial Neural Networks

Biological neurons in human brain and their relationships inspire the development of basic ANN model. ANN metrics like performance accuracy and efficiency builds upon its structural parameters like number of neurons in input and

Energy Efficient Data Aggregation Scheme using Improved LEACH Algorithm for IoT Networks

Guguloth Ravi[1], M. Swamy Das[2], Karthik Karmakonda[3]

Abstract: The Internet of Things makes it possible to have connected buildings, businesses, and intelligent homes by merging embedded technology, wireless sensor networks, control and automation technologies, and wearable gadgets. It is critical to regularly monitor the energy usage of the Internet of Things network since sensor nodes have limited power. In wireless sensor networks, the most significant obstacle is the exhaustion of available energy, and extending the network's lifetime can be accomplished by lowering the amount of energy that is spent. Energy aware routing protocol is highly important in IoT-based networks, although routing protocol that simply considers energy parameter has not performed successfully in managing excessive energy consumption. Energy aware routing protocol is very important in IoT-based network. The emergence of congestion in network nodes results in an increase in the amount of energy consumed and the loss of packets. Routing algorithms should strive for energy efficiency and load balancing across diverse nodes in order to lengthen the lifetime of a network. This will allow for more nodes to participate in the network. Clustering is one of the optimal techniques for efficient data aggregation among the sensor nodes. In a clustered setup, the Internet of Things (IoT) network is partitioned into a predetermined number of smaller networks. One of the most common and widely used clustering methods is LEACH, which stands for low-energy adaptive clustering hierarchy. It is unfortunate that it has some restrictions. In this study, we suggest the use of CAW-LEACH (CONGESTION AWARE - LEACH) as a means of enhancing energy efficiency, CH stability, and the capacity to aggregate data without experiencing congestion. The enhanced protocol that has been proposed takes into account both the depletion energy ratio (DE) and the expected remaining energy (PRE) of the nodes while selecting CH and generating random numbers. Its purpose is to ensure that the CH node that was just recently elected will not be given a second chance in this round. This technique establishes a correlation between the threshold that is utilised in conventional LEACH and each node's energy consumption ratio. The proposed congestion aware data aggregation scheme aggregates the data through traffic free paths by estimating the congestion indicator (CIN) & link error rate (LER), Residual Energy (RE) of the all-available routing paths. By comparing the suggested method to other energy-efficient data aggregation schemes, according to the findings of the experiments, the proposed technique increases the network's durability.

Keywords: *WSN, energy consumption, data aggregation, LEACH, link error rate, congestion indicator, clustering, CAW-LEACH.*

1. Introduction

Many IoT applications also provide access to highly developed software and communication services, in addition to Internet connectivity. The Internet of Things (IoT) is a network of devices, appliances, and other items that were not previously connected to one another. There are many examples of where IoT has been put to use, including in projects that aim to boost computer and network efficiency [1]. Self-configuring wireless networks connect everything that can be connected in a wireless network. There is something in this network that

serves as a communication link. In their present form, these open lines provide a wide range of possible methods of contact. Radio-frequency identification chips are the backbone of the Internet of Things (RFID). A Wi-Fi layer, which can be found at the internet's very core, is being used to build out the worldwide infrastructure for RFID tags. The network allows for the exchange of information between the various devices and computers that are linked to one another. These components are a part of a larger, more intricate system. Data is gathered from a variety of sensors to aid in taking temperature readings and other measurements in the immediate vicinity of the sensor. Data is transmitted to nearby sensors so it can be analysed and interpreted in accordance with the requirements of the currently active applications [2].

Many different routing techniques are implemented in order to cut down on the amount of data transfer and, as a result, the required amount of power [3]. When using a WSN, data are transmitted from the sensor node to the

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A Review on Malware Analysis for IoT and Android System

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Abstract

Today all humankind is willing to avail more facilities and hopes everything should be available with a click of the button. In order to offer different services, the developers have come with inbuilt modules of several systems. This make easy system develoment and services may be offered intantly. These services are connected to the internet and accessible via Android phones and IoT devices. But this inbuilt module suffers from a lot of vulnerabilities, bugs, and default settings which may be difficult to change, as happened at the time of changing the password of home-based Wi-Fi router, which require external applications and OTP verifications, etc. Due to these issues and new hacking tools and techniques, security is a major challenge today. The basic framework to provide adequate

RESEARCH ARTICLE

Efficient Throttled load balancing algorithm to improve the response time and processing time in data center

Ramana Reddy B , Indiramma M

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Summary

In today's world, cloud computing is an emerging service, and it has proved to be a profit-oriented business model. A drastic growth was observed in cloud computing during the last decade because of its easy access to services. As the number of users are increasing dynamically, load balancing is required to handle the user's load. Load balancing algorithms minimize the data center processing time and increase the throughput. Therefore cloud service providers need the best dynamic strategies. In this work, the proposed Efficient Throttled load balancing algorithm improves the performance in the data center environment. Our experimental results indicate that the Efficient Throttled load balancing algorithm improves the average overall response time by 6.47% and average data center processing time by 20.74%, compared to the Throttled load balancing algorithm.

Research Article

A Hybrid Intelligent Clustering Model for Tackling Incomplete Mixed Data Using Heuristic Algorithm with Artificial Intelligence

Hima Vijayan ✉, Subramaniam M. & Sathiyasekar K.
Published online: 11 Nov 2022

📄 Full Article   🖼 **Figures & data**   📎 **References**   66 **Citations**   📊 **Metrics**   🖨 **Reprints & Permissions**   **Read this article**

Abstract

Recently, in various information areas including image processing and social networks, data clustering has been vastly utilized. Thus, the clustering task is taken as successful while imputing the quality of uncertain values, whereas the traditional methods observe only poor performance. To enhance the performance, the hybrid intelligent-based clustering model is proposed by the adaptive concept. Initially, the data is collected from benchmark datasets that are composed of incomplete mixed data. The first level of clustering is processed by optimized K-Means Clustering (KMC) to acquire the optimal centroid, in which the centroid is optimized by the Adaptive Probability-assisted Water Strider Algorithm (AP-WSA). Similarly, the second clustering is done through K-Correlation-based Clustering (KCC) to obtain the clustered output. Thus, the final clustering process is named as Hybrid K-Means K-Correlation (HKMKC) clustering algorithm. Finally, the experimental results are validated with the performance measures and estimated with the traditional methods. Through the result analysis, the Average Silhouette Coefficient (AS) of the designed AP-WSA-HKMKC is 50%, 28%, 16%, and 5.45% progressed than KMC, FCM, KCC, and K-median clustering methods for dataset 2 at 15% miss rate. Thus, the designed hybrid clustering ensures the efficiency of handling incomplete data regarding accurate clustered outputs.

🔍 **Keywords:** Adaptive Probability-assisted Water Strider Algorithm   artificial intelligence   hybrid intelligent clustering model   Hybrid K-Means K-Correlation   K-Correlation based clustering   K-Means clustering   processing incomplete mixed data

Data Availability Statement

The data underlying this article are available in the iris dataset, at "https://www.kaggle.com/datasets/uciml/iris?select=database.sqlite: Access Date: 2022-06-27."

The data underlying this article are available in the red wine quality dataset, at "https://www.kaggle.com/datasets/uciml/red-wine-quality-cortez-et-al-2009: Access Date: 2022-06-27."

The data underlying this article are available in the glass classification dataset, at "https://www.kaggle.com/datasets/uciml/glass: Access Date: 2022-06-27."

The data underlying this article are available in the Bank Note Authentication UCI dataset, at "https://www.kaggle.com/datasets/ritesaluja/bank-note-authentication-uci-data: Access Date: 2022-06-27."

The data underlying this article are available in the contraceptive method choice dataset, at "https://www.kaggle.com/datasets/faizunnabi/contraceptive-method-choice: Access Date: 2022-06-27."

Figure 13. Efficiency estimation of designed intelligent hybrid incomplete mixed data clustering model over clustering approaches regarding (a) Accuracy, (b) DBI, and (c) AS for dataset 5.

A STUDY: MAMMOGRAM IMAGE SEGMENTATION AND CLASSIFICATION BASED ON ABC ALGORITHM AND ARTIFICIAL NEURAL NETWORKS

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Abstract: Adopting Nature inspired optimization algorithms for image processing is on the double growth in the last decade. Artificial Bee Colony (ABC) approach is highly potential nature inspired optimization method mimics the bee's foraging behaviour. Moreover, the popularity of classification and artificial intelligence in different fields leads to the employment of ABC algorithm in upsurge. Notably, Early detection of breast cancer through digital mammogram images is essential as it is the one the most common cause of humankind cancer deaths. the aim of this comprehensive survey was to methodically analyse the effectiveness of using ABC algorithm in medical image enhancement, segmentation, and classification. This study firstly gives introduction of ABC algorithm and its basic mathematical and biological principles and operations respectively. Furthermore, this academic study summarizes the ABC applications on image segmentation techniques like Otsu and image classification approaches like Artificial Neural Networks (ANN). Finally, this far-reaching study come up with the challenges while exercising ABC algorithm in medical image processing, especially in mammogram images.

Keywords: Mammogram images, Artificial Bee Colony, Artificial Neural Networks.

1. Introduction

Breast cancer is the commonest caner among Indian women. one woman out of two newly breast cancer diagnosed dies in India, mortality rate is 50percent that is 87,090 breast cancer patients out of 1,62,468 newly diagnosed were reportedly died in 2018 [1]. Despite of gender, breast cancer is the second leading cancer next to lung cancer [2]. Early detection of malicious tumour in breast cancer decreased the prevalence, morbidity of disease and reduces the human effort to cure the any kind of cancer disease. Practicing medical image processing techniques is the first step in detection of breast cancer by identifying the breast tissue abnormality [3]. In the process of detection, Radiologists come across with large amount of digital mammogram images, diagnosis accuracy is direct propositional to the radiologists' fatigue and workload. Therefore, it is fascinating to have a highly adequate automated mechanism to improve the efficiency, non-erroneous and accuracy in detection of abnormal tissue in breast and ensure the patient safety. Consequently, preventing needless treatment and decreasing the mortality rate of breast cancer patient by identifying benign tumour accurately.

Nowadays, Medical image shows a crucial role in disease diagnosis, gauging treatment and pinpointing of abnormalities in different human body parts such as the breast, lungs, brain, stomach, and the eye. Scrutinizing the human body to diagnose, track or treat a disorder using specific methods

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A Novel Trust Adaptability Approach for Secure Data Transmissions using Enhanced Collaborative Nodes Trustworthiness in Mobile Ad-hoc Networks

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Abstract

Objectives: To find an efficient security routing model based on trust adaptability by considering various transmission parameters that influence the node's behavior. **Methods:** Enhanced Collaborative Trust Based Approach (ECTBA) was applied to isolate the malicious nodes from routing by computing their enhanced collaborative trust value based on the node's behavior using transmission parameters. Parameters that influence the node's behavior like the number of data packets and control packets forwarded, dropped, or misrouted by the node are quantified to compute direct trust value and neighbor reputation. Node's Enhanced Collaborative trust value was generated by the combination of direct and neighbor observations. **Findings:** The proposed strategy is compared with several cases like the Direct Trust Based Approach (DTBA), where routing involves trustworthy nodes categorized based on only direct trust, existing methods like Belief-dependent trust evolution method(BETM), Novel extended trust-dependent method (NETM) where routing is done with nodes that are categorized as trustworthy depending on direct and indirect observations and simple AODV routing performed with all the possible random nodes without any trust detection. The performance parameters of the proposed ECTBA exhibit a success rate of 10.2% in false positives detection (FPD),network throughput of 438.12 Kbps,and packet delivery ratio (PDR) of 92.3%.This method proves to be a better method when compared with the traditional trust-based security methods(BETM and NETM) in terms of efficiency. **Novelty:** This research suggested a novel and fine-tuned method for quantifying a node's trustworthiness and for secure routing that coupled the direct and indirect observations into enhanced collaborative trust

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Enhancing the Routing Security through Node Trustworthiness using Secure Trust Based Approach in Mobile Ad Hoc Networks

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Abstract—Mobile Ad Hoc Networks, also known as MANET's are the part of many heterogeneous networks which utilizes the technologies like Internet of Things. Internet is filled with known as well as unknown sources which are still considered as a challenge. Secure routing is always a major concern in MANET's. Among all the existing and proposed cryptographic approaches to provide security to these networks seemed lengthy, complex and inefficient in eliminating malicious nodes. Many trust based approaches are proposed to replace these traditional cryptographic security methods for secure routing in MANET's. But all those trust based approaches concentrate on either direct observations or hybrid observations to determine the node's trustworthiness without taking into count network parameters. Considering the security challenges that arise due to the topology, infrastructure and bandwidth of MANET's, a novel secure trust based approach (STBA) is proposed in this article to strengthen the evolution of trust component for effective isolation of malicious nodes and secure routing. This work focuses on the computation of the node's trust factor based on network parameters and node's behavior to simulate the challenge of providing the secure transmission. The proposed method, STBA computes secure trust of a node depending on three tier observations. The performance of the proposed secure trust mechanism STBA is evaluated by comparing it with routing without any trust calculation, with existing Belief based Trust Evaluation Mechanism (BTEM) and Novel extended trust based mechanism (NETM) where routing is performed involving only with direct and indirect trust computation for node's distribution in both cases. Results show the proposed method is performing well.

Keywords—Mobile Ad Hoc networks, secure routing, node trustworthiness, direct trust, indirect trust, secure trust

1   Introduction

MANET are portable adhoc networks, which in general forms a dynamic routing virtual network. They are collection of remote self-organized nodes fueled by battery

Computer Integrated Manufacturing Systems

Scalable data exchange using robust data exchange availability tactic on MQTT protocol

V. Tirupathi, K Sagar

Abstract

The Internet of Things (IoT) is a network of interconnected, internet-connected objects that may gather and transmit data via a wireless network without the need for human participation. MQTT (Message Queuing Telemetry Transport) is a lightweight Internet of Things communication protocol with a publisher-subscriber messaging structure that allows for data flow across devices with complexities. Hence in this research, the technical complexities in achieving efficient data exchange in MQTT protocol is removed by using Scalable Data Exchange and Redirection of Clients in Large-scale Distributed IoT network thru MQTT protocol, in which the availability and scalability problem caused when the subscriber client could not obtain the data from the broker is removed by using Robust data exchange availability tactic which constructs a topic set table at each broker in the network. Moreover, the issue in handling the crashed MQTT broker while broadcasting the published data is eliminated by using Redirecting data flow control mechanism in which the brokers are controlled by the software-defined network (SDN) controller. Thus, the Scalable Data Exchange and Redirection of Clients in Large-scale Distributed IoT network thru MQTT protocol can be outperforming the other existing model with low delay and high throughput.

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Computer Integrated Manufacturing Systems

Scalable data exchange using redirecting data flow control mechanism on mqtt protocol

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Abstract

The Internet of Things (IoT) is a network of interconnected, internet-connected objects that may gather and transmit data via a wireless network without the need for human participation. MQTT (Message Queuing Telemetry Transport) is a lightweight Internet of Things communication protocol with a publisher-subscriber messaging structure that allows for data flow across devices with complexities. Hence in this research, the technical complexities in achieving efficient data exchange in MQTT protocol is removed by using Scalable Data Exchange and Redirection of Clients in Large-scale Distributed IoT network thru MQTT protocol, in which the availability and scalability problem caused when the subscriber client could not obtain the data from the broker is removed by using Robust data exchange availability tactic which constructs a topic set table at each broker in the network. Moreover, the issue in handling the crashed MQTT broker while broadcasting the published data is eliminated by using Redirecting data flow control mechanism in which the brokers are controlled by the software-defined network (SDN) controller. Thus, the Scalable Data Exchange and Redirection of Clients in Large-scale Distributed IoT network thru MQTT protocol can be outperforming the other existing model with low delay and high throughput.

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CREATING A BRIDGE OF BROKERS FOR MESSAGE QUEUE TELEMETRY TRANSPORT (MQTT) PROTOCOL

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Abstract. As we all know that, all soft computing devices are able to connect with each other through internet. This is calling as internet of things (IoT) [4],[8]. IoT uses different protocols to exchange information among various devices. Different protocols are available i.e., constrained application protocol (CoAP), message queue telemetry transport (MQTT), Advanced message queuing protocol (AMQP) and so on. These protocols are intended for constrained devices i.e., devices with low RAM size and processor. MQTT is a light weight protocol with publish/subscribe communication model. MQTT uses a broker to provide communication among devices which are subscribed to the broker. Various brokers are available in the market like mosquito, RabbitMQ and so on. These brokers allow to receive and send information, only the devices which have subscribed to a particular broker. The devices which have subscribed to other broker are unable establish communication. If devices would like make communication with the devices connected with other brokers is required to make a group or bridge of brokers.

Introduction

Internet of Things (IoT) [7],[8] is a way of connecting everything to the internet. All these things/devices are connected with each other through internet and exchange information. These devices are constrained in terms of resources like less RAM size and lower processing speeds. All these devices have low computational power, so they require special communication protocols to establish communication. Constrained application protocol (CoAP), Message queue telemetry transport (MQTT), Advanced message queuing protocol (AMQP) and DDS. These protocols are being used at application layer level. Among these protocols some may follow client/server communication model or publish/subscribe model. For example, CoAP follows client/server and MQTT follows publish/subscribe communication model.

Message queue telemetry transport (MQTT) [4] is a light weight communication protocol, it follows publish/subscribe communication model. MQTT protocols requires intermediary

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Energy Aware Priority Based Event Routing Protocol Using TDMA Communication for Internet of Things

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Abstract

The Internet of Things (IoT) is a well-known platform for analysing data generated by environmental sensors and instruments. Transporting data from IoT sensor nodes to the cloud is time-consuming due to congestion and energy consumption in IoT networks. As a consequence, in this paper the Priority-Based Event Routing Protocol using TDMA channel to forward the packets in different network traffic constraints. In our proposed work we categorize the normal and priority packet by two properties such as transmission rate and priority then we can uses the Time slot based mechanism TDMA protocol to forward the packet in the network based on their time intervals to avoid the congestion and increase the packet forwarding ratio. This approach will increase the network robustness and reduces the congestion. In our work we uses the Qualnet Simulator, the experiments showed that the proposed technique performs more and enhance the performance in IoT networks with saving energy consumption by 19.696%, reduces routing overhead by 77%, and reduces end-to-end delay by 50.6% with respect to existing ones.

Keywords Internet of things · Routing protocols · Energy · Congestion · Communications

1 Introduction

The most recent development in communication technology is IoT, where it is collection of RFID Tags or Sensor nodes [1]. The communication between the sensor nodes are carried through the Wifi, LTE, Wimax and Bluetooth [2-4]. The sensor nodes are having limited storage, computation and battery power and they can communicate with in shorter distances. IoT devices need to be smart in handling, communicating and transmitting about the occurred event in the environment [5, 6]. The event manager in the IoT environment handles the middleware to publish or subscribe events and it acts as the coordinator between the sensor nodes. Many routing protocols are developed to address the communication in IoT [7]. Most of them are concentrated on IEEE 802.15.4 and extended IPV6 standards and it is not preferable for small sensor networks. In the recent studies [8-10], the researchers are concentrated on developing the clustering techniques for effective routing in IoT nodes. The most common issue in the IoT network is event based routing. The events in the IoT

Extended author information available on the last page of the article

ESRRL – An Energy efficient Secure routing protocol based on Reinforcement learning for MANETs

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Abstract

The Mobile Ad Hoc Network, or MANET, is made up of a collection of wireless nodes that are able to offer users the benefits of communication despite the absence of access points or centralized control. When designing the routing protocols for a mobile ad hoc network (MANET), one of the most difficult challenges is to create a network that is both secure and energy efficient in order to achieve the highest possible levels of network performance and safety. In order to handle MANET applications, robust security development is required. Cryptography techniques are highly advantageous for security purposes. However, resource limitations in MANET, makes it difficult to apply any security scheme. Hence, to use cryptography scheme, energy-efficiency must be guaranteed in MANET. Therefore, a special energy efficient and secure routing protocol is of great importance in MANETs. In this paper, a new energy efficient secure routing protocol based on reinforcement learning (ESRRL) is proposed. In this work, for energy efficiency, the network is divided into clusters and each cluster is represented with CHs. The CHs are selected using Firefly algorithm which takes residual energy, distance, link lifetime parameters. A novel routing scheme based on reinforcement learning algorithm is introduced. Multi-objective parameters like delay cost, node distance, energy cost, node mobility, and node degree are considered for routing process. A light-weight novel hybrid key establishment scheme is proposed for optimal key management that requires less computation resources and minimum computation cost. The efficiency of the suggested routing protocol is demonstrated by comparing it to that of some other, more established routing methods. Performance research demonstrates that the suggested protocol has better energy consumption and secure key agreements for network data transmission.

Keywords: MANET, Multi-objective, Key management, Energy consumption, Secure communication.

I.   Introduction

Mobile ad hoc networks, also known as MANETs, are the wireless networks of the future that will be used as the communication mechanism for all devices. MANETs are able to function despite the lack of any complex design that is often built into wired infrastructure networks [1]. These types of networks are able to connect and communicate with one another regardless of the device or time it was added to the network. Because the nodes in a typical wired network are fixed or stationary, it is not possible to communicate data using mobile nodes in this manner because the traditional wired network does not have mobile nodes. Researchers are focusing their efforts on developing new methods of communication, specifically wireless technologies for the transmission of data [2]. The nodes in a wireless ad hoc network are free to roam anywhere on the network while still being able to communicate with one another, in contrast to the limitations of wired networks. The implementation of the wireless network in a challenging environment is easy, and the deployment of this is carried out in a wasteful amount of time. The simplicity

A Semantic Approach to Solve Scalability, Data Sparsity and Cold-Start Problems in Movie Recommendation Systems

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Abstract: Recommender systems play a vital role in providing users with personalized information and enhancing their browsing experiences. However, despite the advancements in collaborative filtering techniques, several challenges persist in movie recommendation systems, including the cold start problem, scalability limitations, and data sparsity. The cold start problem arises when there is insufficient data to establish connections between users and items, resulting in inaccurate recommendations. Data sparsity further complicates the issue by making it difficult to identify reliable similar users due to the limited ratings provided by active users. Scalability poses yet another challenge, as real-time environments with a high number of users and extensive data processing requirements struggle to deliver efficient recommendations. To address these issues, this paper proposes a semantic approach that leverages singular value decomposition (SVD), a matrix factorization technique. By applying SVD, the system reduces the dimensionality of the data, overcoming the limitations of the cold start problem, scalability, and data sparsity. Experimental results demonstrate the effectiveness of the proposed system, showcasing improved recommendation accuracy and the ability to generate reliable suggestions even in situations with limited data. Moreover, the system showcases scalability by efficiently processing large volumes of data in real-time, ensuring seamless user experiences. Overall, this semantic approach offers a comprehensive solution to tackle the challenges of scalability, data sparsity, and the cold start problem in movie recommendation systems, potentially enhancing user satisfaction and recommendation quality.

Keywords: Scalability, Data sparsity, Cold-start problem, Singular Value Decomposition.

1. Introduction

The field of movie recommendation systems has garnered substantial attention in recent years. Exponentially, the internet is expanding due to the proliferation of available data. Amidst exploring websites and navigating the vast online landscape, users demand personalized and high-quality information more than ever before. By utilizing user preferences, search histories, and other factors, recommender systems are important in fulfilling this requirement. They offer personalized recommendations. To enhance the precision and effectiveness of these suggestions, collaborative filtering techniques [1] have been broadly adopted. Nevertheless, despite multiple methods and techniques, various obstacles remain in motion picture suggestion systems. Challenges comprise obstacles such as starting difficulties in low temperatures, scalability limitations, and a paucity of data.

The cold start problem [2] creates a fundamental challenge for recommendation systems. The lack of adequate data to establish relevant connections between users and items results in this phenomenon. By introducing new users or items, there is insufficient information to produce accurate recommendations. Less personalized or relevant recommendations may be a consequence at first. The system may experience problems offering important suggestions when historical data about user preferences or item characteristics is not present. The outcome is a subpar user experience. The cold start problem is quite frequent in dynamic environments that continuously add users and items. Effectively handling this challenge demands the implementation of robust solutions. Movie recommendation systems encounter another significant issue: data sparsity. Acquiring dependable and comprehensive ratings is difficult because of the huge number of movies available and the vast user base. This includes all potential combinations of users and items. Sparse user-item matrices result from active users usually rating only a small portion of available items. Finding similar users with sufficient overlap in preferences is difficult for the system due to this sparsity. Dependable recommendations rely on this being in place. Movie recommendation systems' performance and effectiveness are undermined due to data sparsity.

Another important issue in recommendation systems is scalability. In situations where there is a high number of users and significant data processing requirements in real-time, this particularly stands out. The increasing demand for recommendations necessitates that the

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Enabling effective location-based services for road networks using spatial mining

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Abstract---A co-location pattern represents a subset of Boolean
spatial attributes whose instances are located in a close geographic
space. These patterns are important for location-based services.
There are many methods for co-location pattern mining where the
distance between the events in close geographic proximity is
calculated using a straight-line distance called Euclidean distance.
Since most of the real-time tasks are bounded to the road networks,
the results computed using Euclidean distance is not appropriate.
So to compute co-location patterns involving network we define a
model where initially a network model is defined and the
neighbourhood is obtained by using network distance. By comparing
this approach with the previous Euclidean approach, the results

Fake face image detection using feature network

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Abstract---In the recent times, the image data in social networks such as Instagram, Whatsapp, Facebook, Snapchat, twitter etc has an exponential growth in terms of volume, variety due to the velocity of the data stream. On the other hand, the advancements in the image and video processing led to increase in the fake images relatively in huge volumes. Due to the involvement in spreading fake news and leading mob incitements fake images became major concern to handle that demands an efficient a fake image detector is of at most concern to entire social networking organizations. In this paper, a deep learning framework is proposed that differentiates fabricated parts of the image from the real image using supervised learning strategies. Also a modified neural network structure called the Fake Feature Network is proposed in this work which consists of advanced convolution networks. In order to make model effective, the proposed methodology has a two major steps in learning which combines a modified neural structure that uses classifier and pairwise learning for the fake image detection. The performance of

DESIGN OF A NOVEL ENSEMBLE INTRUSION DETECTION FRAMEWORK USING THE CICIDS 2017 DATASET

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Abstract— Complexity and diversity of today's cyber assaults make it challenging to create a multi-attack categorization intrusion detection system. Intrusion Detection Systems need efficient classification to counteract hackers' advanced strategies. A single classifier can't properly detect several sorts of attacks, which is another problem. We suggested an unique ensemble architecture named Leader Class and Confidence Decision Ensemble Technique (LC&CDET) that accurately detects threats. The recommended strategy for spotting attacks involves ranking the detection capabilities of different base classifiers. The voting technique utilises a majority of the classifiers, regardless of whether the algorithm can detect the assault. It chooses the best ML model from three advanced methods (XGBoost, LightGBM, and CatBoost) for each attack category. Class leader models with confidence values are used to assess cyberattack detection. The proposed LC&CDE successfully detects intrusions using publicly accessible CICIDS2017 dataset with an accuracy and F1-score of 99.813 and 99.811%.

Keywords— Intrusion Detection System, CAN Bus, LightGBM, XGBoost, Ensemble Learning CICIDS2017;

I. INTRODUCTION

Cybercrime and other risks to computer and internet security are on the rise as the digital world develops. As a result, classic Intrusion Detection Systems (IDS) are rapidly becoming defunct. Previous IDS-based security solutions depended on signatures concepts that had already been specified [1], making them unable to spot newly generated abnormalities and attack variations [2]. The main issue was that the signature database wasn't being updated and expanded quickly enough to keep up with the rapidly changing nature of threats [2]. With the increasing complexity of modern assaults, researchers are constantly developing new methods for anomaly-based threat detection and protection [3]. In order to equip systems with robust intrusion detection tactics for the future, researchers are utilizing cutting-edge methods based on machine learning (ML) and deep learning (DL). However, not all modern-day threats can be detected using a single machine learning approach.

Numerous studies have been suggested in this area, with authors claiming that their IDS systems can accurately classify attacks even when presented with just historical data. The success of an Intrusion Detection model in the real world, however, hinges on how well it can

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Energy efficient routing with secure and adaptive trust threshold approach in mobile ad hoc networks

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Abstract

A Mobile ad hoc network (MANET) is a wireless, self-configuring network, dynamic in nature and works without any topology. Due to its widespread usage in many heterogeneous networks like Internet of Things (IoT) and the requirement for communication with heterogeneous devices, MANET is receiving more attention. Important data is gathered using smart devices or IoT sensors. These sensors communicate with one another independently within the range. Their energy levels and computing resources are restricted and they migrate frequently as topology is quiet active. Due to the energy constraints, nodes in the network behave selfishly and drop the packets during communication. Identification of the trustworthy and energy efficient nodes is essential for ensuring secure data transmission. The proposed method Energy Trust-Based Approach (ETA) combines trust, energy and reliable routing. Based on trust and energy values, nodes are involved in routing. This method identifies trusted nodes based on direct, indirect, past experiences and estimates their energy levels such that routing is performed only with the trusted nodes whose residual energy exceeds the determined threshold. Efficiency of the routing can be enhanced by calculating the energy levels of the trust adopted nodes in the network. The proposed ETA method ensures efficient routing between source and destination with the involvement of trustworthy and energy efficient intermediate nodes. The proposed work is simulated using Network Simulator (NS-2) and compared with other approaches, Trusted Energy Secured Ad hoc On Demand Vector scheme (TES-AODV), Secure Trust along with Adaptive Trust Threshold Method (STAT) and Ad hoc on demand vector routing (AODV). The simulation results have shown efficiency over the performance metrics like Packet delivery ratio PDLR with an increase of 5.34%, 4% decrease in Packet drop ratio PDR, 8% improvement in Throughput, 9% improvement in Residual energy, 8% reduction in Latency, 1.4% reduction in Overhead, 1,4 h increment in Network lifetime and 9% decrease in Delay. Thus ETA ensures stable, secured and trusted data transmission compared to simple AODV, STAT and TES-AODV.

Extended author information available on the last page of the article

1 Introduction

A Manet [1] is made up of numerous densely distributed wireless mobile nodes that self-organize in a dynamic network environment. They are employed in many heterogeneous applications like home automation, smart homes and agriculture. Communication among mobile nodes does not depend on topology. Nodes can freely move arbitrarily and they can enter or exit the network at any movement. The dynamic behaviour of MANET does not guarantee consistent and secure data transmission. Each mobile node behaves as either source or destination node in the network or as intermediate node to transfer other node's packets during communication. MANET believes that every intermediate node transfer packets fairly. Because of malicious nodes presence in the network, this MANET expectation will not be met forever which in turn makes network vulnerable and data transmission inconsistent. Traditional routing protocols designed assuming a collaborative network environment fails in case of vulnerable environment of MANET that severely degrades network performance. Nodes should dissipate their own energy for forwarding others data packets. Nodes intentionally drop the packets to save their resources and behave maliciously. Identification and isolation of malicious nodes to provide reliable routing in MANET has been become an important research area.

Trust factor can be used to recognize and isolate the malicious nodes in order to mitigate the security threats. The definition of the trust, an entity has for an interest neighbour forms the basic building block of the model [2]. Trust-based routing ensures consistent and secure data transfer between nodes depending on cooperation of trusted nodes in the network. Here, trust value plays an important part in identifying and isolating the misbehaving nodes from the routing in the network. Conventional routing methods focus on establishing the shortest routes whereas trust-based routing protocols establishes trusted paths to provide trustworthy, secure, reliable and consistent routing. It is desirable to compute trust values of nodes before involving them in routing and compare with adaptive trust threshold value which is generated for every node depending on network conditions in order to isolate malicious nodes. Trust-based routing performs better when compared with conventional routing protocols.

MANET's in general configured of sensor devices that usually operates on mobile battery for communication across the wireless medium. These nodes are battery depended. They should be energy efficient in order to extend the battery life of each node individually. One of the disadvantages of MANET is that the sensor nodes are operated on limited power supplies. A MANET's life span is determined by how long the nodes' power supplies last. Power is also a limited resource because of size restrictions [3]. To extend the lifetime of ad hoc networks, it is crucial to reduce the total transmits power consumption per communication request, thereby extending the lifetime of individual nodes. Avoid low energy nodes from the routing even though they are trustworthy [4]. Nodes even that are classified as trustworthy

may drop the packets due to lack of energy, become selfish and breaks the network. If a highly trusted node runs out of power, it is a waste to invest the overhead of computing value of trust and then preferring node for routing. Hence computing trust of nodes may not be enough for efficient and reliable routing. Energy levels of the trusted nodes should also be computed before involving them in routing. Hence it is recommended to select nodes for effective routing while taking into account their values for trust and energy.

The proposed ETA method computes trustworthiness of the intermediate nodes and also evaluates the energy levels of those nodes. Later establishes the secure routing and data transfer between source and destination using only the trustworthy and energy efficient nodes. Thus ensures secure and efficient routing. ETA aims (1) to compute trustworthiness of the node using direct, indirect and historical observations (2) Adaptive trust threshold of each node using network parameters. (3) Energy levels of the trustworthy node.

2 Related work

Shajin et al. in [5] proposed a TSGRP-Trust centric Secure Geographical Routing-based Protocol for detecting the presence of attackers, depending on the trust value for a node derived from the combination of location and the direct trust information. This work targets to compute the direct observations of every node and the trust factor is updated for reliable and efficient data transmission between sender and receiver node. In this approach only direct trust is used for node's trust computation and energy levels are not taken into account for routing. In [6], a new routing protocol based on energy efficiency is presented where the concept of Cluster Head CH panel minimizes energy requirements. This approach concentrates more on the concept of feedback about data delivery in it from the base station. Sathiyavathi et al. proposed a concept of node trust calculation in ad hoc networks by using the multi-path distance vector approach. In this approach, the model performs better only when compared with the routing in normal conditions [7]. The primary point in this work shows that the nodes selection for reliable routing is based on trust but node's energy levels are not considered during selection. Madhukar and Uttam Kolekar suggested trust-based mechanism considering the previous trust values, direct and indirect observations of the nodes [8]. Here, the nodes current trust values are predicted based on their past values. However, the author merely depended only on static trust threshold values. The reason behind this failure is due to the computations that are used for routing each node are accountable for the degree of trust it carries and it becomes less dependable as the energy of the nodes decreases progressively. Fathima et al. considered the nodes to form a cluster based on the estimated trust value, and it appears that malicious nodes in MANETs, may be isolated based on the threshold levels of the trust value [9]. From the above context, the studies carried out by Chauhan and Mahajan [8] and Fathima et al. [9] are primarily concerned with the trust calculations but in both cases, node's energy efficiency is not considered.

Mandhare and Kadam examined the routing methods in MANETs like Dynamic Source Protocol, etc. using trust-based node calculations [10]. The work adopted by Mandhare and Kadam calculates the trust values for each node using direct and indirect approach despite the fact that no adaptive method was used for determining trust threshold and energy calculation. As mentioned by Zhang et al. in [11], energy efficiency should be assessed to ensure trustworthy routing coupled with energy threshold. In a similar context, Wadhwani and Khatri's technique demonstrates a better routing scheme, which may be built when malicious nodes are recognized by using a trust-based database with a threshold for improved forwarding [12]. However, when a mix of metrics and trust is assessed, the system becomes more complicated and may be considered the biggest disadvantage while dealing with a maximum number of nodes at a time. A secure-based energy-related cluster-based routing protocol is presented in [13] which is based on two objectives namely identification of trustworthy nodes and selection of cluster head for secure routing between source and destination. This method identifies trustworthy nodes based on direct trust methodology. A better trust model [14] is proposed to ensure secure and safe routing from source to destination by isolating malicious nodes. In this model, trust-based communication feature is adopted by existing AODV routing protocol. This trust-dependent routing scheme emphasizes both node and route trust equally. However, in both cases adaptive trust threshold factor is not taken into account. Authors in [15] proposed a "PAW-AODV—power-aware based ad hoc on-demand distance vector routing scheme" for effective power-based routing. The proposed protocol uses the restricted energy resources effectively as it paths are found depending on power-dependent cost-effective function. However, the real-time performance of the above protocol was found unsatisfactory. Trust-dependent multiple way routing method is presented in [16]. In this method, routing protocol is incorporated with trust mechanism which includes only direct trust recommendations that considers packet forwarding nature of the node. This approach allows to discover congestion and packet loss. This method computes trust and evaluates trustworthy nodes based on only one parameter.

A new trust calculation model is proposed in [17] where trustworthiness of a node is evaluated based on direct and indirect observations. The trust value is calculated by including the intruder node. The level of trust factor will determine how the routing information is conveyed. By avoiding broadcasting of unwanted control information, the node not only saves power but also bandwidth which is very crucial in the case of MANET. The intruder nodes may or may not be trusted ones. The intruder node has the ability to misbehave in the network and attack the control packet. Here, a trustworthy path which can be utilized for network communication and independent of the shortest or longest path is suggested. The whole route is used to determine route trust value. In this case adaptive trust threshold is not considered. Secured trust with adaptive threshold (STAT) is proposed in [18] which computes trust values of the nodes before involving in routing. This method uses Secure trust-dependent approach (STBA) for calculating the node's trust values by considering direct observations, indirect observations and self-appraisal observations on node in collaboration with Adaptive threshold technique (APTT) where adaptive threshold computed based on network conditions is used for evaluating trust worthy nodes[19]. However,

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energy levels of the trustworthy nodes are ignored in this method which may lead to inefficient routing. The proposed TES-AODV in [20] computes trust values and also energy levels of the nodes before allowing them into the routing. Trust is evaluated based on only direct observations in this approach which may not isolate the malicious nodes efficiently from routing. A Trust-dependent scheme is proposed in [21] where trust is evaluated using nodes observations directly and indirectly. This method fails to address the energy issue of the trustworthy nodes.

As a result of the study carried, it is seen that trust calculations are examined utilizing the direct, indirect approaches. However, it was observed that transmission parameters and adaptive trust threshold are not taken into consideration for node's trust computation and isolation of misbehaving nodes. The existing and proposed routing strategies perform routing using trusted nodes without considering their energy levels. Even though nodes are trustworthy but with little energy they cannot carry out efficient and reliable routing. In terms of bandwidth, MANET routing should be stable and adaptable. However, if malicious nodes are discovered in a network, they tend to disturb the optimal features of MANETs. In this context, an attempt can be made to evaluate reliable routing by considering the trustworthy nodes and then evaluating the energy levels of these trusted nodes to ensure that the routing process can be a trusted one.

In this article, an Energy trust-based approach (ETA) is proposed which ensures secure and reliable routing between source and destination by considering node's trust and energy levels This approach computes node's trust values considering various transmission parameters, direct, indirect observations, historical trust and takes adaptive threshold into account to isolate malicious nodes and identify trustworthy nodes. Further the energy levels of the trustworthy nodes are evaluated to determine their fair participation in the routing. Simulation is carried out in order to showcase the efficiency of the proposed method in comparison with existing protocols AODV, STAT, and TES-AODV. Secure and consistent routing for data transfer in Mobile ad hoc networks is possible with trustworthy and energy efficient nodes.

3 Methodology

The dynamic behaviour of mobile ad hoc networks keeps nodes moving and unstable, makes it difficult to provide reliable and efficient routing [22]. Despite this, nodes on a network, exchange data with other nodes within their range and communicate with one another. Nodes which are not in the range, communicates each other by depending on intermediate nodes. However, certain nodes in the network continue to participate in routing but drop packets while transmitting them. This imposes significant influence on routing effectiveness. Nodes should also maintain enough energy to carry out transmission successfully.

Node's that are trustworthy and energy efficient should be involved in data transfer and efficient routing. Evolution of node's trustworthiness is always challenging. Computation of node's trust component as a combination of direct, indirect and historical observations has a greater probability of identifying and eliminating false positives from the routing. Identification and isolation of malicious nodes can be

done effectively by comparing node's trust value with adaptive trust threshold rather than static threshold value. Due to their dynamic nature, node's in MANET move in and out frequently. Node's adaptive trust threshold is evaluated taking into consideration MANET network conditions. Node evolved as trustworthy may drop packets during data transfer due to lack of energy. Hence energy levels of trustworthy nodes should be examined before involving them in routing. The proposed ETA method combines three factor trustworthiness of node with adaptive trust threshold comparison for identification and isolation of malicious nodes. Further it examines energy levels of trustworthy nodes and performs routing only with energy efficient trustworthy intermediate nodes. Thus ensures secure and reliable routing. An Energy trust-dependent ETA is presented which identifies reliable and trustworthy nodes with enough energy levels for routing. The architecture of the proposed ETA method is shown in Fig. 1.

3.1 Trust computation

Trust is determined for all the nodes involved in the network. Final Trust value is calculated from observations made from every node.

3.1.1 Resultant trust

Three level observations on the node under computation are used to produce the final trust value [18]. It consists of direct, neighbour, and historical node trust. Equation 1 is used to produce the resulting trust value.

$$\text{Final Resultant Trust Value} = \text{Direct Trust Value} + \text{Neighbour Trust Value} + \text{Historical Trust Value}$$

(1)
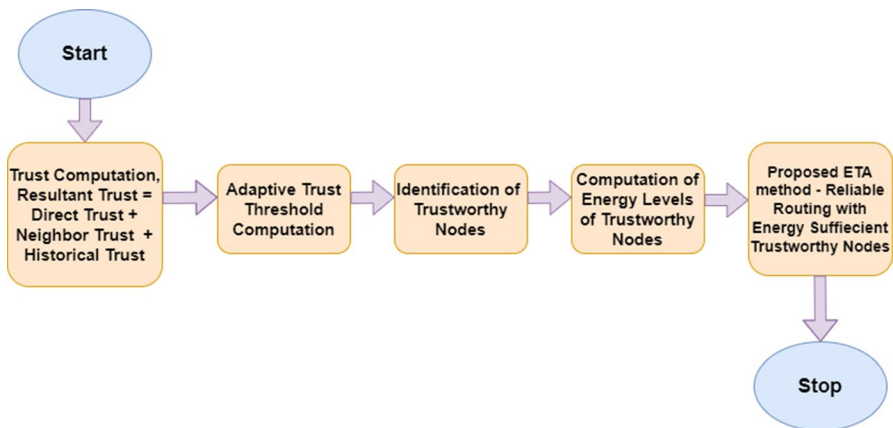
Fig. 1 Architecture of proposed ETA method

3.1.2 Direct trust

The evaluation of direct trust value is dependent on direct observations on the node whose trust is being calculated. The transmission parameters taken into account are

Data packets:

Number of packets related to data received overall at the node = D_t

Number of packets of data correctly transmitted by the node = D_{fr}

Number of data packets that the node dropped = D_{dr}

No. of data packets that the node incorrectly routed = D_m

Number of data packets erroneously injected by the node = D_{fi}

Data Packets ratio, DPR given in Equation 2.

$$\mathrm{DPR} = x_1 * \left(D_{fr}/D_t\right) + x_2 * \left(D_{dr}/D_t\right) + x_3 * \left(D_m/D_t\right) + x_4 * \left(D_{fi}/D_t\right) \quad (2)$$

where $x1$, $x2$, $x3$, $x4$ are the weights and $x_1+x_2+x_3+x_4= 1$

Control packets:

Packets of route request received overall at the node = R_{trq}

Packets of route reply received overall at the node = R_{trp}

Packets of route error received overall at the node = R_{ter}

Packets of route acknowledgment received overall at the Node = R_{tac}

Packets of route request forwarded by the Node in number = R_{rq}

Route reply packets forwarded by the Node in number = R_{rp}

Route error packets forwarded by the Node in number = R_{er}

Route acknowledgment packets forwarded by the Node in number = R_{ac}.

Control packets ratio, CPR is given in equation 3.

$$\mathrm{CPR} = x1 * \left(R_{rq}/R_{trq}\right) + x_2 * \left(R_{rp}/R_{trp}\right) + x_3 * \left(R_{er}/R_{ter}\right) + x_4 * \left(R_{ac}/R_{tac}\right)$$

$$(3)$$

where $x1$, $x2$, $x3$, $x4$ are the weights and $x_1+x_2+x_3+x_4= 1$

$$\text{Then, Direct Trust, } D_T = z_1 \times \mathrm{DPR} + z_2 \times \mathrm{CPR} \quad (4)$$

where $z_1+z_2=1$ and $z1$, $z2$ are weights allotted to DPR and CPR considering network environment.

3.1.3 Neighbour trust

It is the collective evolution of trust carried out by all neighbouring nodes within one hop of the node which is under trust evolution.

Neighbour Trust is given in equation 5

$$N_T = (x1 * \mathrm{NT1} + x2 * \mathrm{NT2} + x3 * \mathrm{NT3} + x4 * \mathrm{NT4} \dots xn\mathrm{NT}n)$$
$$/(\text{Number of Neighbour Nodes in 1 Hop distance}) \quad (5)$$

whereas, NT1, NT2, NT3, NT4… NTn are neighbouring node's trust values and $x1$, $x2$, $x3\dots x_n$ represent the weights given to the neighbour nodes.

3.1.4 Nodes historical trust

It is calculated using parameters as given below.
   Number of packets sent (Good) = $P_{fr} = a$
   Number of packets that were not forwarded but were dropped (Bad) = $P_{dp} = b$
   Number of falsely injected packets (Bad) = $P_{fi} = b$
   Then historical trust, H_T, as given in equation 6

$$H_T = a/(a + b)$$ (6)

Final resultant trust, T is evaluated using equation 7.

$$T = aD_T + bN_T + cH_T$$ (7)

where a, b, c are constants given to the trust observations based on network conditions
   Resultant trust: $0 <= T <= 1$
   Final resultant trust value is evaluated as a combination of direct, indirect and historical observations in order to avoid false positives. The three tire evaluation strengthens the trust factor and effectively isolates malicious nodes from the routing.

3.1.5 Adaptive trust threshold

Various network parameters are used to calculate the Adaptive trust threshold that includes rate of link changes, node degree variations and average neighbourhood.
   a) Node degree,

$$\sum \sigma = \sigma n/|T|$$ (8)

Where T is the overall number of nodes. σn = Node Degree of node 'n'
   b) Rate of link changes at Node 'μ',

$$\sum \eta = 1 - \eta\mu/2\mu$$ (9)

where $\eta\mu$ is Rate of Link Changes for node 'μ'. $\sigma\mu$ is Node Degree of node 'μ'
   c) Average neighbourhood trustworthiness,

$$\sum_T = 1/n \sum_{j=1}^{n} Tj$$ (10)

where T_j is neighbour nodes trust of Node μ (10)
   Adaptive trust threshold value, $\mathcal{E}_\mu$ is

$$\sum_\mu = \left(x \sum_\sigma + y \sum_\eta + z \sum_T \right)/(x + y + z)$$ (11)

where ξ_σ = Optimal Node degree threshold value of the Node. ξ_η = Optimal Rate of Link changes threshold value of the Node. ξ_T = Optimal Average Neighbourhood Trustworthiness threshold value of the Node and x,y,z are constants and $x+y+z$ is taken into account for higher throughput.

Trustworthy nodes are identified based on

Resultant trust value evaluated, T $>= \xi_\mu$, trustworthy node

$$T < \xi_\mu, \text{ malicious node},$$

Then, remove the malicious node from the process of routing.

3.1.6 Trust computation algorithm

Procedure Resultant trust with adaptive threshold for isolation of malicious nodes(T, D_T, N_T, H_T, ξ_μ, ξ_σ, ξ_η, ξ_T)

{

// T = Resultant trust value

// D_T = Direct Trust

// N_T =Neighbor Trust

// H_T =Historical Trust

// ξ_μ = Value of Adaptive Trust Threshold

//ξ_σ = Optimal Node Degree Trust Threshold value

//ξ_η = Optimal Rate of Link Changes Trust Threshold value

//ξ_T = Optimal Average Node Trustworthiness Trust Threshold

Step: 1 Calculation of Node's trust is initiated, for all nodes in the network

Step:2 Data Packets ratio, DPR = x_1*(D_{fr}/ D_t) + x_2*(D_{dr}/ D_t) + x_3*(D_m/ D_t) + x_4*(D_{fi}/ D_t)

Step:3 Control Packets Ratio, CPR = x_1 *(R_{rq} / R_{trq}) + x_2 *(R_{rp} / R_{trp}) + x_3 *(R_{er} / R_{ter}) + x_4 *(R_{ac}/ R_{tac})

Step:4 Direct Trust, D_T = z_1 * DPR + z_2 * CPR

Step:5 Neighbour Trust, N_T = (x1*NT1 + x2*NT2 + x3*NT3+ x4*NT4…. +xnNTn) /(Number of Neighbouring Nodes in 1 Hop distance)

Step:6 Historical Trust, H_T = a / (a + b)

Step:7 Resultant Trust T = aD_T + bN_T + cH_T

Step:8 Node degree, $\xi\sigma = \sigma n / |T|$

Step:9 Rate of link changes,$\xi\eta = 1 - \eta\mu /2\sigma\mu$

Step:10 Average Neighbourhood Trustworthiness, $\xi_T = 1/n \sum_{j=1}^{n} Tj$

Step:11 Resultant Adaptive Trust Threshold , $\xi_\mu = (x\xi_\sigma + y\xi_\eta + z\xi_T)/(x+y+z)$

Step:12 if (T $< \xi_\mu$) then consider as malicious node and eliminate the node from routing process.

else classify as Trustworthy node, include in the process of routing.

end if

}

end procedure

3.2 Energy calculation

Behind every successful transmission, nodes energy levels play an important role. Even though nodes are detected as trustworthy and have a good success record of transmission rate, still they fail due to lack of energy. So it is necessary for all the trustworthy nodes to maintain sufficient energy levels for efficient data transmission. Energy levels of the trustworthy nodes are evaluated and compared with threshold value calculated using the neighbourhood nodes' average energy levels. Only a reliable node whose energy level above the threshold is chosen for routing. Energy levels of trustworthy nodes are calculated based on four modes: nodes transmission, reception, idle and overhead mode. Initial and consumed energy levels of a node are taken into account while calculating a node's current energy level. Initial energy level of a node is assumed as 100 Joule during simulation. Every time a node transmits, the transmission and reception power are reduced from the node's initial energy value. RREQ and RREP packets are used for route discovery between nodes during the process of simulation. In RREP packets, energy values are embedded. Even when a node is trusted and has total support for routing, it can only perform properly if it consists of enough energy. As a result, nodes' energy needs must be taken into account while routing because nodes can run out of energy. Thus, before taking part in routing, trust and energy levels of nodes should be checked for secure, reliable and effective data transmission in MANETs.

3.2.1 Procedure for energy calculation

Energy Levels of the node are evaluated based upon four modes
   a) Transmission Mode
   In this mode, Nodes transmit packets.
   Power consumed during transmission of a packet, [20]

$$\text{Consumed Energy } = \text{Pt} * T \tag{12}$$

where, T= Transmission time and P_t = Transmitting Power
   b) Reception Mode
   Nodes receive packets in this mode.
   Power consumed during reception of a packet, [20]

$$\text{Consumed Energy} = \text{Pr} * T \tag{13}$$

where, T = Reception time and Pr = Reception Power.

c) Idle mode

Nodes neither transmit nor receive packets will reside in idle mode. Power consumed in the idle situation, [20]

$$\text{Consumed Energy} = \text{Pid} * T \tag{14}$$

where, T = Idle time and Pid = Power consumed during idle mode.

d) Overhead mode

Overhearing of the node consumes power.

Power consumed for overhead, [20]

$$\text{Consumed Energy} = \text{Po} * T \tag{15}$$

where, T = Overhear time and P_O = Power consumed in overhead mode

Finally, consumed energy of a Node = Energy consumed in all Modes.

$$\text{Residul Energy Level/Present energy level of the node,}$$
$$\text{RE=Initial Energy Level.Consumed Energy Level} \tag{16}$$

Energy Threshold is calculated by taking into account the energy consumed by all the neighbouring nodes. [20]

$$\text{Energy Threshold, } E_T = \sum_{i=1}^{n} \text{Consumed Energy of all Nodes}/n \tag{17}$$

where n = total no of nodes

The energy value evaluated for a node, if it is greater than or equals to energy threshold, then the node has sufficient energy, can be considered for routing. Otherwise, if it is less than threshold then the node has less energy, cannot be considered for routing.

$RE \geq E_T$: Trustworthy Node has sufficient energy and eligible for routing

$RE < E_T$: Trustworthy Node has insufficient energy and not eligible for routing

3.2.2 Algorithm for energy levels computation

Procedure Energy Computation (Initial Energy, Consumed-energy, Residual Energy)
{
// E_T = Energy threshold
// RE = Residual Energy Level / Current energy level of the node.
Step:1 Calculate energy levels for all trustworthy nodes that gets route request from
        a source node.
Step:2 Set Initial energy of the node as 100J, Total number of nodes as 100.
Step:3 Each node in MANET may function in any of the below modes. Calculate
        the power consumed and remaining energy from the below modes.
Step:4 Transmission mode , Consumed energy = Pt $*$ T [20]
        Where T is the transmission time, Pt is the transmitting power.
Step:5 Reception mode, Consumed energy = Pr * T [20]
        Where T is the receiving time, Pr is the reception power.
Step:6 Idle mode, Consumed energy = Pid * T [20]
        Where T is the idle time, Pid is the power consumed in idle mode.
Step:7 Overhear mode, Consumed energy = Po * T [20]

        Where T is overhear time, Po is the power consumed in overhearing.
Step:8 Computation of consumed-energy and remaining residual energy,
        Consumed Energy of a Node = Energy Consumed in all Modes
        Residual Energy Level / Present node's energy,
        RE = Initial Energy Level – Consumed Energy Level
Step:9 Source Node collects energy value calculated (consumed energy) of all
        nodes through RREP packets.
Step:10 Compute Energy threshold as
        $E_T = \sum_{i=1}^{n} Consumed\ Energy\ of\ all\ Nodes$ /n. [20]
Step:11 if (RE >= E_T) then node has sufficient energy and can be considered
                        for routing
        else node has less energy, avoid from routing process
          end if
Step:12 Repeat the procedure of computing energy levels for all trustworthy nodes
}
end procedure

4 Experimental results

The proposed ETA scheme is simulated using NS2 along with the traditional AODV and other schemes STAT, TES-AODV. This ETA Scheme uses trusted and energy efficient paths for ensuring smooth movement of data packets between source and destination. This work is simulated using 100 nodes. The simulation results obtained

for the proposed ETA method is compared with the simulation results obtained for traditional protocols like AODV, existing trust-based method STAT and trust energy-based scheme TES-AODV. The results are compared based on Packet delivery ratio, Packet drop ratio, Delay, Throughput, Latency, Overhead, Network lifetime and Residual energy. The proposed ETA exhibits efficiency in terms of performance metrics. PDLR, Throughput and Network lifetime are high, delay, latency, packet loss and overhead are minimized and consumption of energy is also less when compared with simple AODV STAT, TES-AODV. The findings indicate a PDLR rise of 5.4% on average. This increase is due to the result of nodes being chosen according to their energy and trust values. The throughput, network lifetime is increased and delay is decreased for the proposed ETA. This energy and trust-based routing ensures efficient routing and keeps misbehaving nodes out of the routing path. Only reliable and highly energetic nodes are chosen for routing, which eventually cuts down on the amount of time needed to arrive at destination. A node's ability to function in the network depends on energy and trust. Nodes with high trust values may be chosen for routing; however, low energy may cause the node to perform poorly for routing. This proposed method ETA exclusively chooses trustworthy nodes with high energy levels.

The constant packet rate is taken as 512 bytes for both 200 and 100 packets per second. Table 1. shows the simulation parameters. Figure. 2 shows a simulated network that has been established with 100 nodes in a 700×500 m area and displays malicious nodes that has been marked.

4.1 Results analysis

The results from simulations are examined. Node's trustworthiness and energy levels are determined based on the proposed method ETA. The simulation's findings and calculations for computing resultant trust, adaptive threshold and isolation of malicious nodes are presented in Table 2. Energy Levels computation of trustworthy nodes is presented in Table 3.

Direct, Indirect and Historical Trust observations are computed using above equations during simulation. Energy values of trustworthy nodes are observed during simulation.

Energy levels of trustworthy nodes identified are computed along with energy threshold. Nodes with less energy are isolated from the routing process. Computations as given in Table 3 below.

The following performance metrics are discussed to demonstrate how the proposed ETA scheme improves upon the simple AODV, STAT, and TES-AODV schemes.

4.1.1 Packet delivery ratio (PDLR)

As shown in Fig. 3, the proposed ETA has a greater PDLR than AODV, STAT, and TES-AODV. According to the data, the Packet Delivery Ratio for the ETA method

is 94.64%, compared to 89.3% for TES-AODV, 82.1% for STAT, and 53% for simple AODV at 100 packets per second. PDR for 200pkts/s is 86.8% for the ETA technique for 100,000 packets transmitted and 86864 packets received, 79.5% and 69.3% for TES-AODV and STAT, and 32% for AODV. In the case of PDLR, the proposed ETA approach performs better than TES-AODV, STAT, and AODV.

Figure. 4 depicts an examination of the proposed and current trust centric routing techniques based on Packet Delivery Ratio vs user count. The graphical depiction, plots the values of the packet delivery ratio vs. the quantity of users on the *X* and *Y* axis respectively for several trust-based approaches. The graph shows that the packet delivery ratio for the suggested ETA is higher than that for the current approaches. The packet delivery ratio is proved to be higher than TES-AODV, STAT, and AODV. For ETA PDLR is attained at 0.85, 0.87, 0.88, 0.9, 0.95, 0.96, and 0.97.

When compared to AODV, STAT and TES-AODV, ETA ensures reliable routing by removing misbehaving nodes from the routing path and offering higher packet delivery because the path is established solely with dependable, energy efficient, and trustworthy nodes. The energy efficient and trustworthy nodes transfer's data efficiently without dropping the packets between source and destination. Thus increases PDR. The proposed ETA method shows 5.34% increase in PDR.

4.1.2 Packet drop ratio (PDR)

Less packets should be discarded during communication as a desirable asset. Figure. 5 indicates that ETA performs well compared to TES-AODV, STAT and AODV related to Packet Drop Ratio. The proposed ETA finds reliable routes by lowering the packet drop during data transfer. Comparing ETA with other approaches drops less packets.

According to experimental results, for 100 packets per second, 1801 packets were lost out of 50,000 delivered packets, hence the Packet Drop Ratio for the ETA technique, TES-AODV, STAT, and AODV is 3.6, 4.1, 4.6, and 45%, respectively. Packet Drop Ratio is 17.9% in the proposed ETA approach for 200pkts/s, 100,000 packets delivered and 17908 packets lost, compared to 18.6, 19.8, and 67% for TES-AODV, STAT, and AODV, respectively. Comparing ETA with other methods, fewer packets are lost.

Table 1 Parameters used for Simulation	Tool used for simulation	NS2
	Overall number of nodes simulated	100
	Model used for propagation	Two ray ground
	Simulation time	500 s
	Malicious nodes declared	16
	Declaration time of malicious nodes	0 t
	Type of topography	700×500 (M)
	Mobility (r)	5 m/s
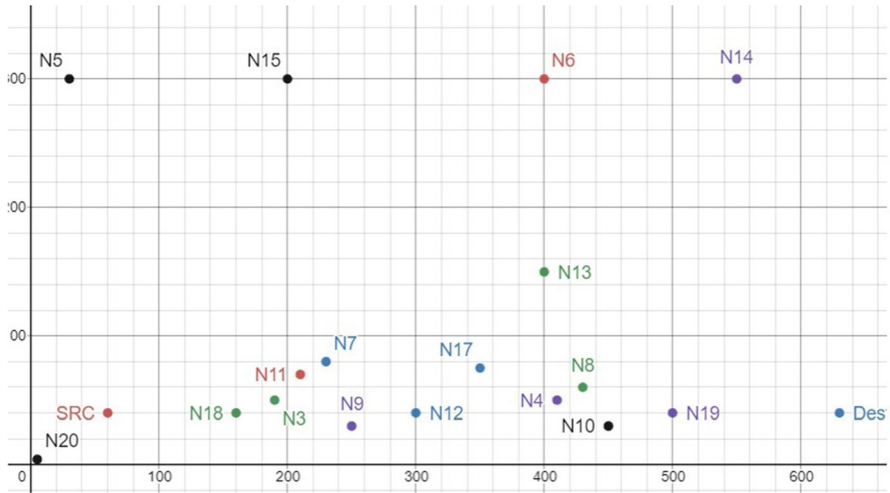
Fig. 2 Random node deployment in simulation network and malicious node detection

Table 2 Resultant Trust Value, Adaptive Trust Threshold Computation and Isolation of Malicious Nodes

Node	Direct observations-trust	Neighbour observations-trust	Historical observations-Trust	Resultant final trust value	Adaptive trust threshold value-ε_μ	Classification
ND1	0.81	0.3843	0.76	0.812	0.646	Trustworthy node
ND2	0.69	0.3971	0.893	0.724	0.676	Trustworthy node
ND3	0.26	0.5467	0.87	0.645	0.651	Malicious node
ND4	0.34	0.542	0.86	0.564	0.423	Trustworthy node
ND5	0.72	0.4913	0.63	0.428	0.321	Trustworthy node
ND6	0.42	0.4178	0.74	0.885	0.478	Trustworthy node
ND7	0.43	0.1576	0.76	0.825	0.822	Trustworthy node
ND8	0.54	0.7812	0.88	0.451	0.726	Malicious node
ND9	0.61	0.4934	0.81	0.697	0.538	Trustworthy node
ND10	0.79	0.2362	0.82	0.682	0.695	Malicious node
ND11	0.75	0.623	0.91	0.563	0.584	Malicious node
ND12	0.61	0.3384	0.97	0.617	0.762	Malicious node
ND13	0.47	0.4235	0.76	0.765	0.714	Trustworthy node
ND14	0.63	0.3942	0.83	0.792	0.721	Trustworthy node
ND15	0.34	0.342	0.74	0.629	0.384	Trustworthy node

Table 3 Energy Levels of Trustworthy Nodes, Energy Trust Threshold and Isolation Process

Node No	Node resultant trust value	Adaptive trust threshold-ξ_μ	Classification	Residual energy RE	Energy threshold E_T	Decision for routing
ND1	0.812	0.646	Trustworthy node	62.23	53.4	Sufficient
ND2	0.724	0.676	Trustworthy node	57.45	53.4	Sufficient
ND4	0.564	0.423	Trustworthy node	65.36	53.4	Sufficient
ND5	0.428	0.321	Trustworthy node	78.64	53.4	Sufficient
ND6	0.885	0.478	Trustworthy node	82.82	53.4	Sufficient
ND7	0.825	0.822	Trustworthy node	38.44	53.4	Not sufficient
ND9	0.697	0.538	Trustworthy node	32.74	53.4	Not sufficient
ND13	0.765	0.714	Trustworthy node	45.54	53.4	Not sufficient
ND14	0.792	0.721	Trustworthy node	56.21	53.4	Sufficient
ND15	0.629	0.384	Trustworthy node	41.38	53.4	Not sufficient

A comparison of the proposed ETA and existing trust centric routing techniques based on Packet Drop Ratio vs. User Count is shown in Fig. 6. Based on several trust centric routing algorithms, the graphic representation plots the values of Packet Drop Ratio versus the quantity of users on the *X*- and *Y*-axis. The proposed ETA's packet drops ratio in relation to users found was 1.3, 1, 0.9, 0.7, 0.5, 0.5, and 0.4, which is lower than other approaches like TES-AODV, STAT, and AODV. The suggested routing method is found to have a lower packet drop ratio. In ETA, routing is performed involving only trustworthy and energy efficient nodes which reduces packet losses and drops by the malicious nodes. ETA shows 4% of reduction in packet drops.
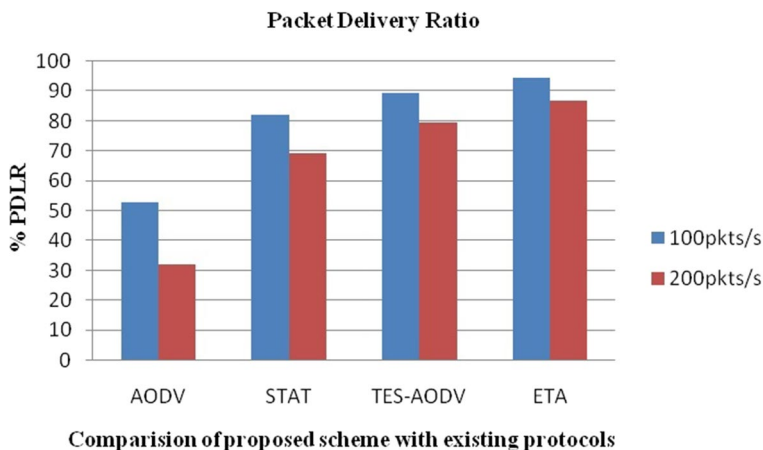
Fig. 3 PDLR for 100 and 200 packets

4.1.3 Throughput

According to Fig. 7, ETA is 15% better than TES-AODV, 18% higher than STAT and 35% higher than AODV in terms of throughput. This shows that ETA has a greater chance of identifying a trustworthy and energy effective route than TES-AODV, STAT and AODV.

Simulation results exhibit that throughput is 402.23 kbps for the suggested ETA method at 100 pkts/s, 392.45 kbps for the TES-AODV, 384.23 kbps for the STAT, whereas it is 221 kbps for the AODV and Throughput is 678.25 kbps for proposed ETA method, whereas it is 656.45 kbps, 642.44 kbps, 256 kbps for TES-AODV, STAT and AODV in case of 200 pkts/s.

Figure 8 displays an examination of the ETA method and current trust-dependent reliable routing algorithms in terms of throughput (packets/sec) versus user count. The throughput (packets/sec) and the user count is shown on both the horizontal and vertical axis in the graph, which is based on several trust centric routing algorithms. The proposed routing method found to have a higher throughput (packets/sec). Its exhibits throughput of 2.1, 2.9, 3.9, 4, 4.2, 4.4, 4.6 and 4.8, which is greater than existing approaches. Trustworthy and energy efficient nodes transfer data between source and destination without any delay and link breakages thus increases throughput. ETA exhibits 8% of increase in throughput with the involvement of trustworthy and energy efficient nodes.

Hence, this scheme shows that the misbehaving nodes can be removed from routing. Implementation of this method for routing will ensure reliable, energy efficient as well as secure transmission of packets.
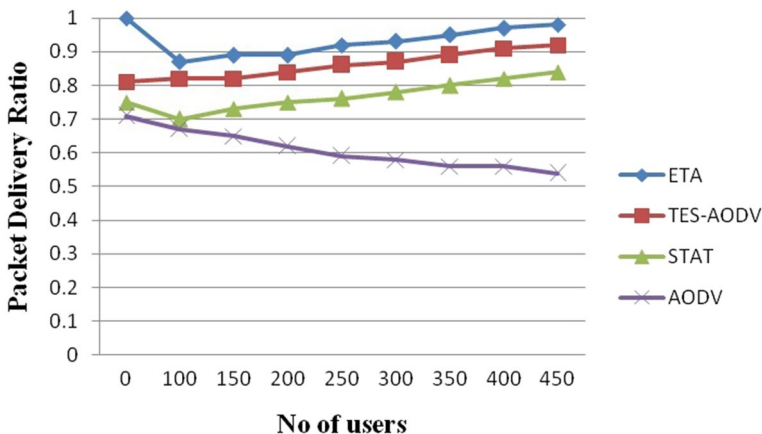
Fig. 4 PDLR versus no of users
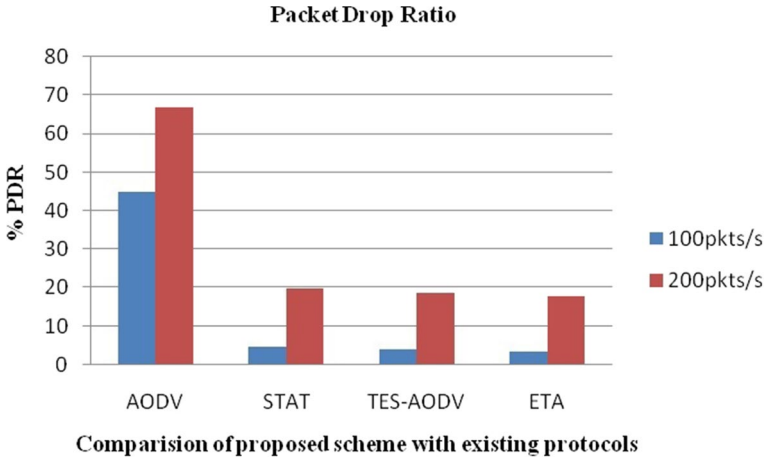
Fig. 5 PDR for 100 and 200 packets

4.1.4 Delay

Although ETA performs better than TES-AODV, STAT and AODV with respect to packet delivery ratio and throughput, as demonstrated in Fig. 9, it also performs better than above mentioned approaches in terms of delay.

From the results, it is noticed that in case of proposed method ETA, delay is noted as 163 ms, 172 ms for TES-AODV, 183 ms for STAT and 204 ms for AODV in case of 100 pkts/s. Delay is 238 ms in case of proposed ETA method for 200 pkts/s, it is 251 ms for TES-AODV, 263 ms for STAT and 284 ms for AODV. ETA finds routing path based on energy and trust calculations, still it has a shorter delay and always preferable over other approaches.
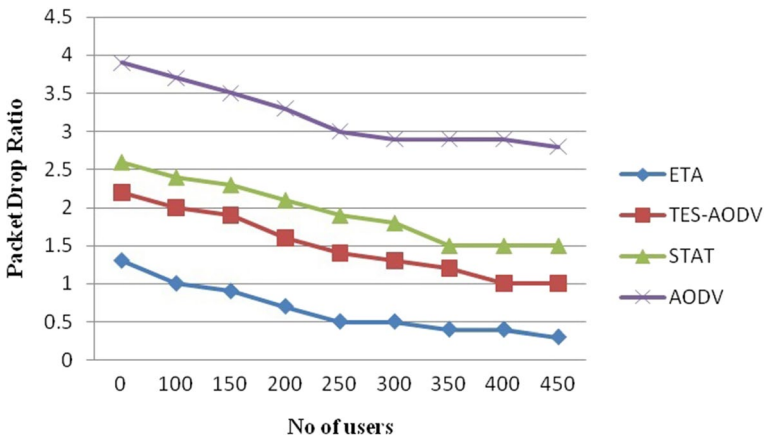
Fig. 6 PDR versus no of users

A delay-based comparison of the proposed and other trust centric routing algorithms is shown in Fig. 10. Different trust centric routing algorithms are used to create the graphical representation and the values for delay and transmission range are plotted on the vertical and horizontal axis, respectively. It has been discovered that the proposed routing protocol exhibits lower delay. The suggested ETA is found to have less delay than the existing TES-AODV, STAT, and AODV, which were achieved at 0.1, 1.2, 2.5, 2.9, 3.2, and 3.4. Identification of malicious nodes and eradicating them from the routing in the proposed ETA reduced delay about 9ms.

4.1.5 Residual energy

ETA consumes less energy compared to TES-AODV, STAT and AODV. Figure. 11 depicts the residual energy for different protocols. Simulation results depict average residual energy for the proposed method ETA as 78 J, 69 J for TES-AODV, 57 J for STAT and 46 J for AODV. ETA claims increase in residual energy of 9J compared to existing methods due to availability of trustworthy and energy efficient nodes for data transfer.

4.1.6 Latency

When compared to current methods, the proposed method's latency was shown to be lower. The comparison of the current trust-dependent routing methods and proposed one based on latency and the number of users is shown in Fig. 12. Latency and the no. of users is shown on both the horizontal-X and vertical-Y axis, respectively, for several trust centric routing methods. For the suggested routing method ETA, it is found that latency versus user count is lower. The proposed ETA is observed to have latency obtained at 10, 18, 28, 34, 41, and 44 that is lower than that of other approaches such TES-AODV, STAT, and AODV. ETA exhibits 8% of latency compared to other routing protocols.
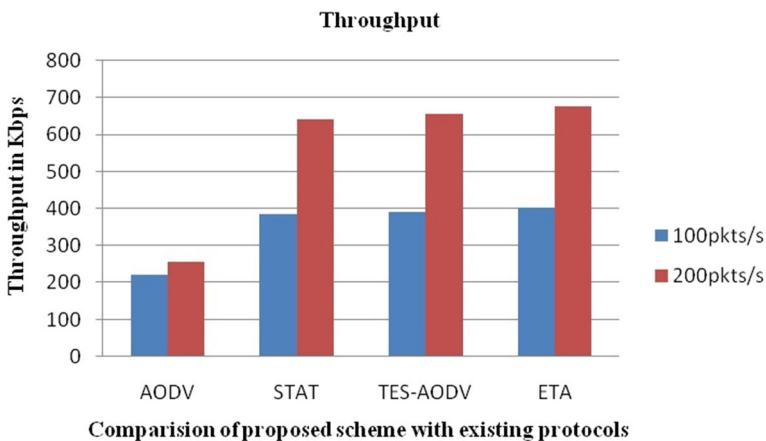
Fig. 7 Throughput for 100 and 200 packets
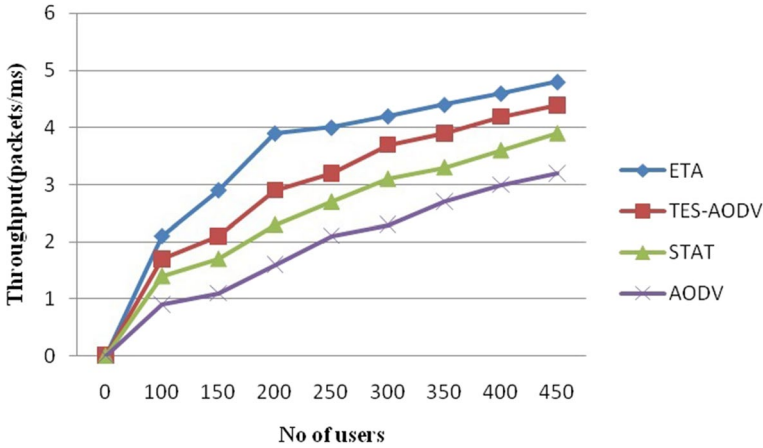
Fig. 8 Throughput versus no of users

4.1.7 Overhead

Figure. 13 displays analysis related to overhead between the proposed and current trust centric routing methods. The values for range of transmission and overhead are represented on the *X*- and *Y*-axis, respectively, and the graph is based on different trust-aware routing systems. It has been observed that the proposed routing method has reduced overhead. When compared to existing approaches, the overhead for the suggested ETA is shown to be lower at 0.8, 2.2, 3.1, 3.6, and 3.8. Routing is performed only with trusted and energy efficient intermediate nodes between source and destination. Overhead is reduced by 1.4%.
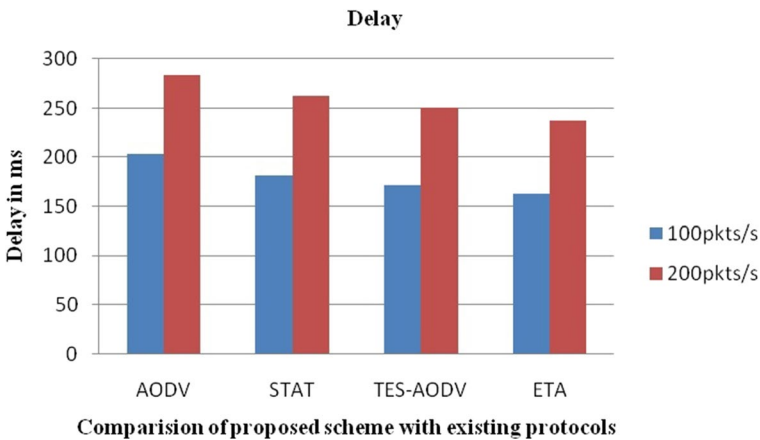
Fig. 9 Delay for 100 and 200 packets

4.1.8 Network lifetime

Figure 14 compares the proposed ETA and existing trust centric routing strategies based on network lifetime. The graphical depiction, which is based on multiple trust centric routing algorithms, shows the value of range of transmission and network lifetime on the *X*- and *Y*-axis, respectively. The investigation shows a high network lifetime for the suggested ETA technique with 1.4 h increment.

5 Discussion

The proposed ETA approach efficiently identifies the trustworthy and energy efficient nodes in the network by assessing trust and energy levels. This results in secure and reliable routing. With the help of factors like indirect, direct and previous observations, this technique calculates a node's trust value. Trust adaptive threshold value of each node is computed taking into consideration important network parameters. The resultant trust factor compared with adaptive trust threshold is used to classify nodes into trustworthy and malicious. The energy factor of trustworthy nodes is computed so that only trustworthy nodes with enough energy levels above energy threshold are allowed to participate in routing. Thus ETA establishes secure, trustworthy and reliable route for effective data transfer between source and destination. Efficiency of ETA method is showcased comparing with other protocols: STAT, TES-AODV and simple AODV protocol. The experimental results prove that proposed ETA method outperforms other schemes very well. Comparison of results between proposed and other methods is tabulated below in Table 4.

ETA exhibits 5.34% increase in packet delivery ratio, 4% decrease in packet drop ratio, 8% increase in throughput, 9% of excess residual energy, 8% of reduction in latency, delay decreased by 9%, overhead reduced by 1.4% and network
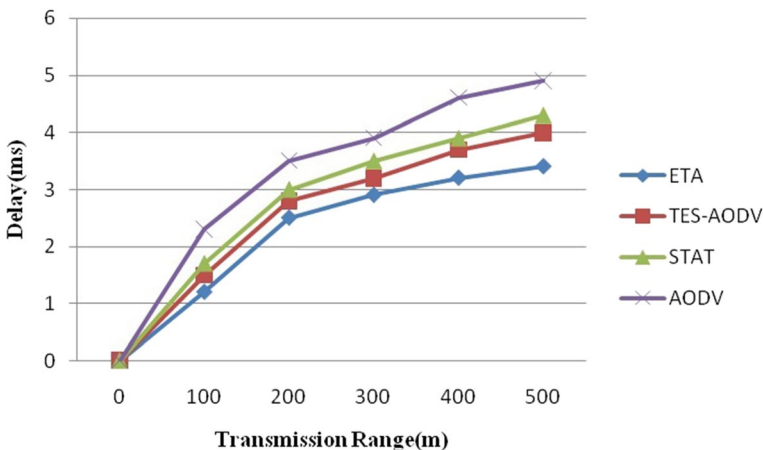
Fig. 10 Comparison of delay among various protocols
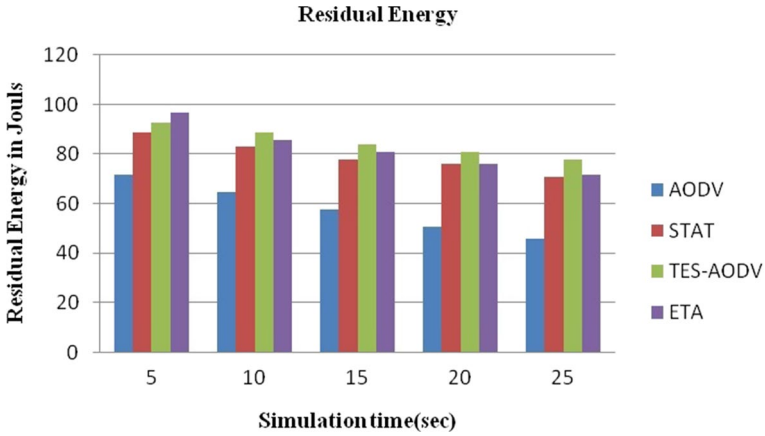
Fig. 11 Residual energy
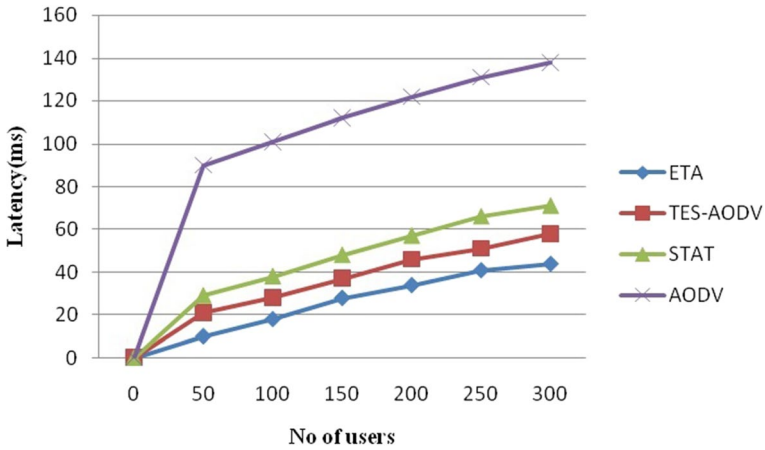
Fig. 12 Latency versus no of users

lifetime increased by 1.4 h, compared to existing protocols STAT, TES-AODV and AODV. Thus, above performance parameters proves that ETA provides secure, reliable and efficient routing between source and destination by involving energy efficient trustworthy intermediate nodes.

6 Conclusion

The proposed trust- and energy-based ETA protocol takes into account the nodes' trust and energy levels for secure routing in MANET. In this method, nodes are identified for routing depending on their trust and energy values. Adaptive trust
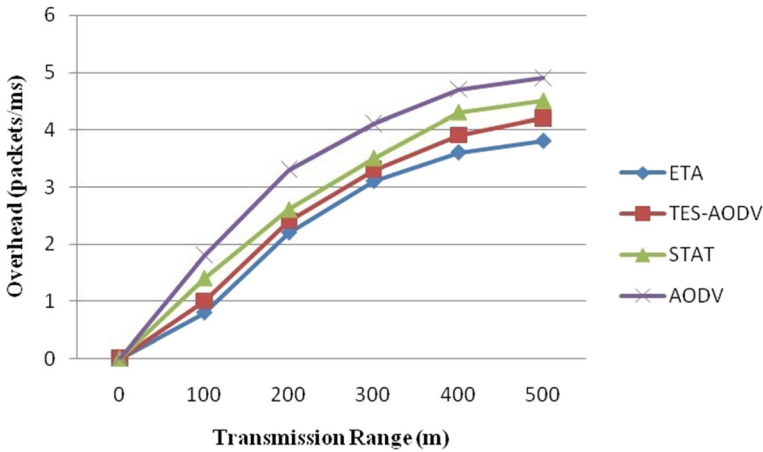
Fig. 13 Overhead versus no of users

threshold and energy threshold values are computed, and nodes are only considered the best for routing if their levels of trust and energy meets the thresholds. The ETA method is used to secure the transmissions, increasing the routing's reliability. This work is carried out and simulated using NS-2 with regard to the number of nodes and performance for 100 and 200 packets is investigated. According to the simulation results, performance metrics including PDLR, PDR, Delay, Latency, Overhead, Network Lifetime, Throughput and Residual energy have all seen a significant improvement for ETA. PDLR and Throughput improved by 5.4 and 9%, Delay and Packet loss reduced by 9 and 4%, respectively. In comparison to the standard AODV, STAT and TES-AODV protocols, ETA offers more dependable, consistent, and secure data transmission. Network overhead for the proposed ETA can be further reduced. Adaptive Trust threshold may be evaluated
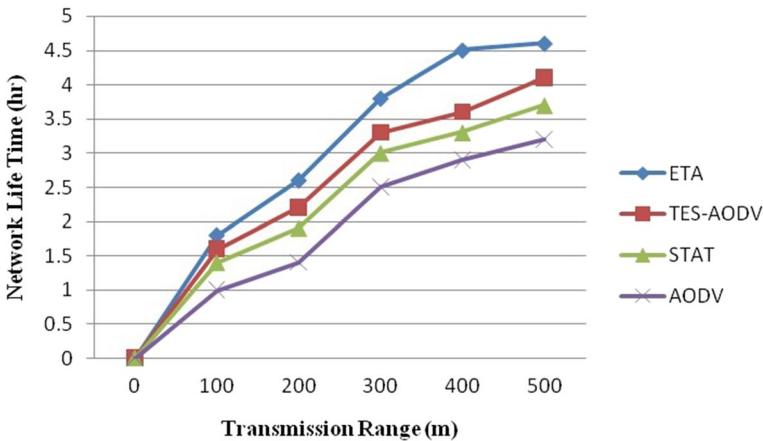
Fig. 14 Analysis of network lifetime

Table 4 Comparison of results to show efficiency of proposed ETA method

S.No	Parameter	Proposed method–ETA (%)		TES-AODV (%)		STAT (%)		AODV (%)	
		100 Pkts/Sec	200 Pkts/Sec	100 Pkts/Sec	200 Pkts/Sec	100 Pkts/Sec	200 Pkts/Sec	100 Pkts/Sec	200 Pkts/Sec
1	PDLR–packet delivery ratio	94.64	86.8	89.3	79.5	82.1	69.3	53	32
2	PDR–packet drop ratio	3.6	17.9	4.1	18.6	4.6	19.8	41	67
3	Throughput (kbps)	402.23	678.25	392.45	656.45	384.23	642.44	221	256
4	Delay (ms)	163	238	172	251	183	263	204	284
5	Residual energy (J)	78		69		57		46	
6	Latency (ms)	18		28		38		97	
7	Overhead	0.8		2.2		2.6		3.2	
8	Network lifetime (h)	1.8		1.6		1.3		0.7	

using more network conditions. The work can have a scope of extension and implementation using machine learning models to consider the trusted routing in MANETs which can be used in the real-world networks. The trust and energy values evolved in this ETA method can be used further to predict the node's behaviour in the future using machine learning techniques. Thus, the efficient routing can be guaranteed.

Declarations

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Performance Parameters of Two Stroke and Four Stroke Copper Coated Spark Ignition Engines

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ABSTRACT

Alcohols are renewable in nature. They have comparable properties with gasoline. Blending of alcohol with petrol is common technique to improve the performance of the engine. Gasoline engines are suitable for individual transport and have many advantages over diesel engines in terms of lower vibrations, less weight and more efficient. Two stroke petrol engines have higher mechanical efficiency than four stroke petrol engines. In order to improve the performance, copper coating was applied for two stroke and four stroke petrol engines. Little reports were available on comparative studies on performance characteristics of two stroke and four stroke petrol engines with methanol blended gasoline. Investigations were carried out to evaluate the performance of two stroke and four stroke of single cylinder, spark ignition (SI)engine having copper coated engine [CCE, copper-(thickness, 300 µ) coated on piston crown, inner side of cylinder head and liner fuelled with methanol blended gasoline (80% gasoline and 20% methanol by volume) and compared with conventional engine (CE) with pure gasoline operation. Performance parameters of brake thermal efficiency, exhaust gas temperature and volumetric efficiency were determined at different values of brake mean effective pressure (BMEP). Brake thermal efficiency increased, exhaust gas temperature decreased and volumetric efficiency increased with methanol blended gasoline with both versions of the engine. CCE showed improvement in the performance when compared with conventional engine (CE) with both test fuels.

Keywords

CONTROL OF EXHAUST EMISSIONS OF TWO STROKE AND FOUR STROKE COPPER COATED SPARK IGNITION ENGINES

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ABSTRACT

Alcohols are important substitutes for gasoline, as their properties are comparable to gasoline. They are renewable in nature. Investigations were carried out to determine exhaust emissions of two stroke and four stroke of single cylinder, spark ignition (SI)engine having copper coated engine [CCE, copper-(thickness, 300 μ) coated on piston crown and inner side of cylinder head] provided with catalytic converter with copper as catalyst with methanol blended gasoline (80% gasoline and 20% methanol by volume) and compared with conventional engine (CE) with neat gasoline operation. Carbon monoxide (CO) and un-burnt hydrocarbons (UBHC) are the exhaust emissions from SI engine. Breathing of these emissions causes human hazards and also they cause environmental disorders. Hence control of these emissions is an urgent task. Exhaust emissions were varied with different values of brake mean effective pressure (BMEP). The engine was provided with catalytic converter with copper as catalyst. There was provision for injection of air into the catalytic converter. CCE showed improvement in the pollutants when compared with CE with both test fuels. Four-Stroke engine decreased exhaust emissions effectively in comparison with two-stroke engine with both versions of the engine. Catalytic converter with air injection significantly reduced pollutants with different test fuels on both configurations of the engine.

Keywords: SI engine, Methanol, CE, CCE, Fuel Performance, Exhaust emissions and Catalytic converter

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https://iaeme.com/Home/issue/IJMET?Volume=13&Issue=6

1. INTRODUCTION

In the context of fast depletion of fossil fuels, the search for alternate fuels has become pertinent. Alcohols are probable candidates as alternate fuels for SI engines, as their properties are

Characterization of Ligand N'-[(1E)-1-phenylethylidene]-1, 3-benzothiazole-2-carbohydrazide by using Marvin Sketch 20.8 Software

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ABSTRACT

Marvin Sketch is the fast and accurate software used for drawing of chemical compounds and reactions. This software also provide guidance and is integrated with calculators for obtaining the suitable results of properties. Marvin sketch 20.8 software is well equipped with advanced chemical viewer for studying the chemical structures both single and multiple 2D/3D, as well as chemical reactions and its related data. It can display all the details, like molecule name, generated IUPAC name and SMILES strings of molecules. With the help of Marvin Sketch 20.8 software the compound N'-[(1E)-1-phenylethylidene]-1,3-benzothiazole-2-carbohydrazide(PEBTH) is characterized and all its properties were determined.

Keywords: PEBTH, Mass spectrum, Structure display models, pKa, Isoelectric point, Log P, Charge, Polarisability, Orbital electronegativity, Geometrical Descriptors, Conformers, Topology analysis, Huckel analysis, Refractivity.

INTRODUCTION

N'-[(1E)-1-phenylethylidene]-1,3-benzothiazole-2-carbohydrazide(PEBTH)

Synthesis of N'-[(1E)-1-phenylethylidene]-1,3-benzothiazole-2-carbohydrazide(PEBTH) as given in Fig. 1 involves three steps(i) conversion of 2-aminothiophenol to benzothiazole-2-ethyl carboxylate by esterification(ii) conversion of ester to its hydrazide(iii) conversion of benzothiazole-2-carbohydrazide(BTCH)to N'-[(1E)-1-phenylethylidene]-1,3-benzothiazole-2-carbohydrazide(PEBTH) by reaction with acetophenone.

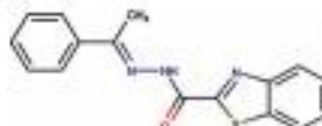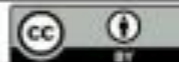
Fig. 1. Structure of PEBTH

RESULTS AND DISCUSSION

By using the Marvin Sketch 20.8 the structure of N'-[(1E)-1-phenylethylidene]-1,3-benzothiazole-2-carbohydrazide (PEBTH) was built and its name is determined as follows:

Effect of injection pressure on exhaust emissions of diesel engine fuelled with LPG

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ABSTRACT

In the context of exhaustion of fossil fuels day by day due to heavy demand with the use of agriculture sector and transport sector, escalation of fuel prices in International Oil Market causing huge economic burden on developing countries like India and rise of pollution levels with fossil fuel, the conservation of fossil fuels has become pertinent. Gaseous fuels have many merits over liquid fuels, as the pollutants emitted by gaseous fuels are low due to clean combustion, high calorific value in comparison with liquid fuels. Vegetable oils are good substitutes for diesel, as they are renewable, comparable calorific value and cetane (measure of combustion quality) number when compared with neat diesel operation. However, the disadvantages associated with vegetable oils such as high viscosity and low volatility cause combustion problems in diesel engines. They can be rectified to some extent by converting them into biodiesel. They are many methods to induct gaseous fuels such as port injection, carburetion technique, injection of gaseous fuel at the near end of compression stroke etc,. Investigations were carried out with LPG as primary fuel inducted by port injection and diesel was injected into the engine in conventional manner. Particulate matter (PM), oxides of nitrogen (NO), carbon mono oxide (CO) levels and un-burnt hydro carbons (UBHC) are the exhaust emissions from a diesel engine. They cause health hazards, once they are inhaled in. They also cause environmental effects like Green-house effect and Global Warming. Hence control of these emissions is an immediate effect and an urgent step. The pollutants of PM, NO,CO and UBHC were determined at full load operation of the engine with varied injection pressure and compared with diesel operation on conventional engine. The maximum induction of LPG was 35% of total mass of diesel as full load operation. Particulate emissions were determined by AVL Smoke meter, while other emissions were measured by Netel Chromatograph multi-gas analyzer at full load operation. These pollutants were drastically reduced with induction of LPG and further reduced with an increase of injection pressure.

Key words: Diesel, biodiesel, CE, Exhaust emissions.

Introduction

The civilization of a particular country has come to be measured on the basis of the number of automotive vehicles being used by the public of the country. The tremendous rate at which population explosion is taking place imposes expansion of the cities to larger areas and common man is forced, these days to travel long distances even for their routine works. This in turn is causing an increase in vehicle population at an alarm rate thus bringing in pressure in Government to spend huge foreign currency for importing crude petroleum to meet the fuel needs of the automotive vehicles. The large amount of pollutants emitting out from the exhaust of the automotive vehicles run on fossil fuels is also increasing as this

Recent developments in Pt-based alloy nanoparticles for oxygen reduction reaction in fuel cells

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Abstract

The significance of proton exchange membrane fuel cells (PEMFs) in economic recovery and climate action initiatives following a pandemic is growing. PEM fuel cells depend on precious-metal catalysts (often Pt or Pt-based alloys) to catalyze the reactions occurring at the electrodes. This is especially true for the cathodic oxygen reduction reaction (ORR), which is slow, represents a large source of energy loss, and brings the overall efficiency of fuel cells down. The performance, cost, and durability of these Pt-based catalysts for ORR hinder their widespread commercial application. As a realistic technique for decreasing Pt usage and related costs, researchers have concentrated intensively in recent years on producing more active and stable Pt-based alloy electrocatalysts. This review article mainly focuses on recent literature of Pt-based alloy electrocatalysts for ORR, especially the effect of nanoparticles (NPs) size, and shape and, therefore, the activity and stability of the generated electrocatalysts. The ORR activity and stability of Pt-based alloys such as Pt-Ni, Pt-Cu, and Pt-Fe, as well as other nano electrocatalysts, will be reviewed along with various synthetic approaches.

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Recent progress in the development of Platinum-based electrocatalysts for the oxidation of ethanol in fuel cells

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Abstract

Humans have an ever-increasing and ever-insatiable need for energy. The world's energy demands are currently being met by burning nonrenewable fossil fuels. Recurring challenges for civilization include developing dynamic energy cradles for a prosperous society to lessen fossil fuel depletion and environmental issues. The energy gap in the modern era can only be closed by the discovery of vast quantities of non-conventional resources. In place of dirty and inefficient fossil fuels, fuel cells provide a powerful and environmentally friendly alternative. In the realm of fuel cells, the direct ethanol fuel cell (DEFC) has garnered a lot of attention because it is a renewable fuel, easy to handle, and safe to use. High catalytic capabilities and durability make Pt-based electrocatalysts very promising. However, widespread commercial use has been hampered by their expensive price, poor stability, and Pt shortage. The keys to DEFC's practical uses are increasing the activity and durability of Pt-based electrocatalysts while decreasing the Pt content. This article will provide a summary of the most recent results about the development of Pt-based alloy electrocatalysts for ethanol oxidation. In addition, the most significant technological challenges are

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Synthesis and electrochemical oxygen reduction reaction activities of palladium-based intermetallic nano-electrocatalysts

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Abstract

Changing the atomic structure of a material to alter its characteristics is a key and powerful technique in materials research. Electrocatalytic applications are a growing field for structurally long range ordered materials. Similar electrocatalysts with a disordered structure, however, are unable to perform as well as those with an ordered structure because of the specific functionalities that may be achieved by the ordered structure. There has been a lot of interest in using highly active and stable ordered intermetallics as electrocatalysts for polymer electrolyte membrane fuel cells (PEMFCs). Electrocatalysts based on palladium have lately emerged as one of the most promising classes for the oxygen reduction reaction (ORR) in alkaline media because of their superior ORR activity and durability at lower prices than platinum. As electrocatalysts for fuel cells, palladium-based intermetallic nano-electrocatalysts (Pd-INECs) have gained a lot of interest in recent years. Pd-INECs have exceptional catalytic activity and great stability due to their well-defined composition and predictable control over structural, geometric, and electronic effects. In this short article, we will briefly go through the current state of knowledge on Pd-INECs for cathodic ORR in fuel cells. The first

Oxidative Dehydrogenation of Ethane with CO_2 over the Fe-Co/Al_2O_3 Catalyst: Experimental Data Assisted AI Models for Prediction of Ethylene Yield

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ABSTRACT: In this work, Fe-Co-based mixed metal oxides supported on Al_2O_3 are proposed for ethylene production through oxidative dehydrogenation of ethane with CO_2 (ODH-CO_2). Thermodynamic feasibility analysis followed by a systematic experimental study is performed on catalyst synthesis and its composition optimization along with process condition optimization in a fixed bed reactor. The study revealed that 5% Fe loaded on 10% Co/Al_2O_3, 700 °C, and 1:1 are the optimal composition, temperature, and molar ratio of CO_2 to ethane, respectively, achieving 29% ethane conversion and resulting in 16% ethylene yield. Further, the experimental data was used to develop different linear, nonlinear, and ensemble AI models for ethylene yield prediction through a systematic grid search and k-fold cross-validation procedure. Among all the models, the kernel ridge regression model is found to be the most accurate, exhibiting the highest R^2 value of 0.966 and lowest root mean-squared error (RMSE) of 0.032 on test data, successfully capturing the underlying nonlinear dynamics of ODH-CO_2.
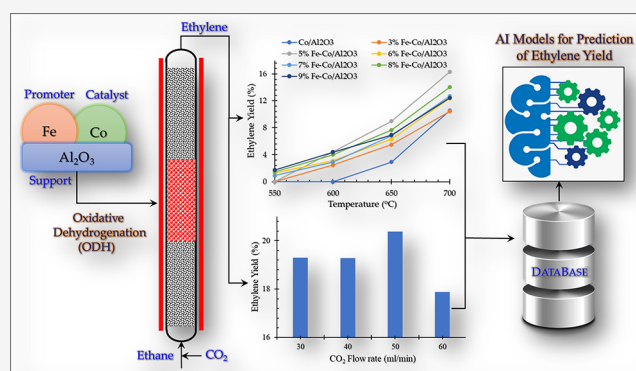
INTRODUCTION

Ethylene is one of the most important raw materials used in the production of a wide variety of chemical compounds such as polyethylene,[1] ethylbenzene,[2] acetaldehyde,[3] ethylene oxide,[4] and other derivates.[5] Conventionally, ethylene is produced through steam cracking of alkane or naphtha. This process is highly endothermic and energy-intensive, and it also suffers from rapid coke formation and contributes to the emission of CO_2 into the atmosphere.[6] To address these issues, active research is going on to develop several alternate improved processes for ethylene production, among which catalytic oxidative dehydrogenation (ODH) of ethane seems to be one of the most promising methods.[7] The specific features of ODH such as lower reaction temperature and usage of underutilized ethane from shale gas/natural gas as feed make it more attractive compared to the other methods.[8] Generally, ODH of ethane is carried out using O_2 as the oxidant, but it suffers from the problem of overoxidation of reactants that leads to the formation of CO_x as the side product,[9] which further tends to significantly reduce the ethylene yield. Moreover, using pure stream of O_2 as an oxidant also adds to the cost of the ethylene production. Such issues of ODH with O_2 are addressed recently by pursuing ODH of ethane with a mild oxidant, *i.e.*, CO_2, which not only replaces the need of pure O_2 as an oxidant but also has the advantage of utilizing one of the major greenhouse gases. Further, it also

reduces the coke formation through the reverse Boudouard reaction, thereby minimizing the problem of catalyst deactivation.[10] Considering the literature reported on ethylene production through ODHE-CO_2, it is noted that several experimental groups are working on developing various heterogeneous catalysts with the objective of improving ethylene yield and selectivity. An extensive literature review has been performed on ODHE-CO_2, and the summary is given in Table 1. It can be observed from the table that several active metals such as Cr-based,[11−13] Ga-based,[8,14,15] Ni-based,[5] Au-based,[16,17] Fe-based,[18] Co-based,[19] Ce-based,[20] and Mo-based[21] catalysts and also mixed with promotors[22−25] supported on various metal oxides such as SiO_2, ZrO_2, TiO_2, MgO, Al_2O_3, etc., were tested for ODHE-CO_2. Nakagawa et al.[26] were among the first to perform the ODHE-CO_2 using Ga-based and Cr-based catalysts and achieved the maximum ethylene yields (Y_{C2H4}) of 20 and 10%, respectively, in comparison to the 2−3% yield achieved without the catalyst at a temperature and molar
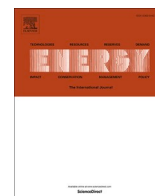
Waste to fuel: Synergetic effect of hybrid nanoparticle usage for the improvement of CI engine characteristics fuelled with waste fish oils

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ABSTRACT

Reducing waste products into energy sources is valuable and essential for the waste-management policies of governments. Globally fish waste and their by-products have been widely dumped in dustbins. The utilization of such wastes for producing high-grade fuel for diesel engines is discussed in this research. This investigation extracted fish oil from fish wastes and produced biodiesel through transesterification method. Then TiO_2 and CeO_2 nanoparticles were added in mono and hybrid forms to biodiesel of fish oil blends to improve the poor fish biodiesel properties. The prepared test fuels were characterized and compared with conventional diesel fuel. All these fuels were tested in a single-cylinder, water-cooled diesel engine at varying engine loads from 0 to 100% with intervals of 25%. The engine response is handled in terms of the engine performance, combustion, and emission characteristics. The results revealed at full load that the TiO_2 mono nano fuels outperformed CeO_2 Nano fuel, FWOBD and diesel fuels, but hybrid nano fuel finally outperformed all other fuels considered in this investigation. The hybrid nano-fuel recorded 17% higher brake thermal efficiency, 7.5% higher peak pressure, 36.6% heat release rate, 16% lesser NOx emission, 15% lesser HC emission, and 5% lesser carbon monoxide emission. The metallic nanoparticles were employed as suitable catalysts for combustion at CI engines, improved engine performance, and reduced emissions significantly. In conclusion, it was well-noticed that the addition of hybrid nanoparticles into WFO biodiesel blends has more significant contribution to enhancing engine performance, combustion, and emission behaviors in comparison with the addition of mono-nanoparticle usage.

1. Introduction

The globe will undoubtedly confront an insufficiency of petroleum products in the near future. Alternative fuels can assist in preventing this scarcity. As a result, the essential to recognize alternative fuels and improve their characteristics should begin. Ramadhas et al. [1] described various vegetable oils as an alternative fuel for diesel engines. Numerous study outcomes of different researchers clearly explained the manufacturing methods, desired characteristics specifics, and properties improvisation strategies. Syed Ameer Basha et al. [2] extensively researched alternative fuel from vegetable oils, animal fats, and synthetic components. Though alternatives like electric vehicles (EVs) and hybrid vehicles were commercially introduced, the demand for diesel engine fuels and emissions from them were not reduced considerably. Many novel approaches were reported to reduce engine emissions and other emissions. Globally, using electric vehicles is recommended to reduce air quality contamination and expect the use of fuels with lower

Four Step Synthesis and Characterization of 3-hydroxy-1-methyl-4-(4-(pyridin-4-yloxy) phenethyl) pyridin-2(1*H*)-one

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Abstract

At first a solution of 4-(2-(2,3-dimethoxypyridin-4-yl)ethyl)phenol in dry DMSO was added Cs_2CO_3 at RT. Then 4-chloropyridine hydrochloride was added and stirred at 140 ºC for 2.5 h. The reaction mixture was quenched with ice-cold water extracted with diethyl ether to afford 2,3-dimethoxy-4-(4-(pyridin-4-yloxy)phenethyl)pyridine **2**. It is further treated with HBr in acetic acid at rt and stirred at 80 ºC for 1.5 h to yield 3-methoxy-4-(4-(pyridin-4-yloxy)phenethyl)pyridin-2(1H)-one **3** followed by methanol were added KOH and methyl iodide at 0ºC and stirred at rt for 16 h to obtain 3-methoxy-1-methyl-4-(4-(pyridin-4-yloxy)phenethyl)pyridin-2(1H)-one **4.** It is charged with BBr_3 and stirred for 10h to obtain 3-hydroxy-1-methyl-4-(4-(pyridin-4-yloxy)phenethyl)pyridin-2(1H)-one **5** desired product with an excellent yields depicted (**Scheme I**) in this manuscript.

Key words: 2,3-dimethoxy-4-(4-(pyridin-4-yloxy)phenethyl)pyridine, BBr_3,deprotection.

Graphical Abstract

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GENERAL ASPECTS
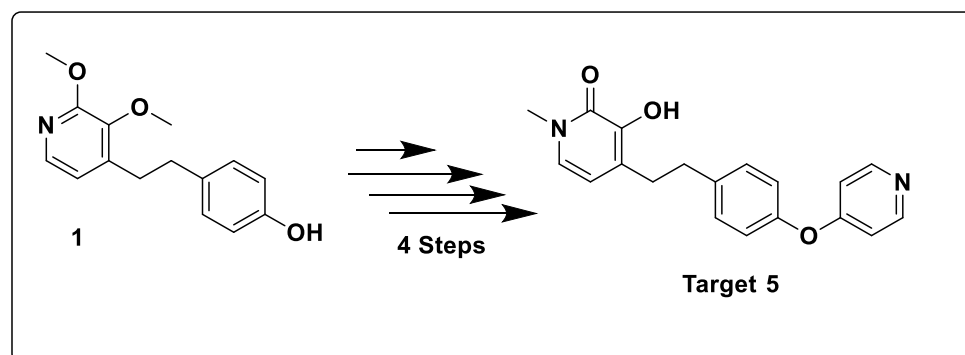
Utilization of Rice husk as an Activated Carbon Adsorbent for the Purification of Used Cooking Oil

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Abstract—The use of cooking oil on a regular basis can result in an increase in the amount of free fatty acids and peroxide in the food. As a result, prolonged exposure to spent cooking oil has been linked to harmful effects on the environment as well as human health. As a result, used cooking oil must be purified before being released into the environment. Rice husk has cellulose in the range of 30 to 40%, making it suitable for use as a carbon adsorbent's raw material in the purification of used cooking oil (UCO). This research created a carbon adsorbent from rice husk utilising a two-hour carbonization procedure at 500°C combustion temperature and chemical activation with 1 N H_2SO_4. This work was performed with a 6 g adsorbent with contact durations of 30, 60, 90, 120, and 150 min. After 150 min of contact time, the most favourable results were free fatty acids 0.0526 percent, peroxide value 0.40 meq O_2/kg and density 0.9052 g/mL.

1. INTRODUCTION

South Asia, India, and China are the top three countries in terms of rice husk biomass production. Compared to other farming bio-waste materials, rice husk has low utilization value as husk and high utilization value as ash made up largely of silica. Rice husk organic matter have been utilized as source of energy and also the non-carbon content has high value added utilization potential. Rice is that the third most significant cereal crop grown around the world with an annual production of greater than 650 million tons [1]. Rice husk that is a layer protective for rice grain is that the major by-product obtained from rice processing mill [2, 3]. Rice husks are principally composed of cellulose (32.24%), hemicelluloses (21.34%), lignin (21.44%), water (8.11%), extractives (1.82%) and mineral ash (15.05%) as well as high percentage of silica in its mineral ash that is 94.5–96.34% [4, 5]. Components of rice husk illustrated in Fig. 1.

When related to some other agro-wastes like scrap of woods and maize straw, husk of rice is notable for

Investigation of heat transfer for silver oxide (Ag$_2$O) and iron oxide (Fe$_3$O$_4$) using nano fluid over a stretch sheet

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ARTICLE INFO

ABSTRACT

The effect of velocity and convective heat transfer environments along with hybridized nano-fluid moving across irregular curved surface was examined in this article. A hybrid nanofluid and silver oxide Ag$_2$O, as well as an iron oxide Fe$_3$O$_4$ based nanofluid, were also examined. The governing model was used to generate a nonlinear ordinary differential equations. By using this, we employed the similarity transformation technique. Shooting approach with Runge-Kutta technique of order 4 (RK-4), which is a higher-order numerical approximation methodology was used to find the solution of modified ordinary differential equations system (RK-4). Fluid velocity is lowered by magnetic, curvature and slip property, while temperature was reduced by convective heat transfer, Prandtl number, and magnetic property values. Skin fraction, Nusselt number and other physical quantities of interest to engineers are discussed. These behaviors are graphically depicted alongside the numerical values, in contrast to earlier work in a tabular format with numbers.
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Selection and peer-review under responsibility of the scientific committee of the International Conference on Newer Engineering Concepts and Technology.

1. Introduction

Newtonian and non-Newtonian fluids distinguish boundary layer fluxes. The stress–strain relationship in Newtonian fluids is linear. Non-Newtonian fluid boundary layer flows have attracted much more consideration for their diverse range of application in industry, manufacturing and geothermal engineering [1]. Nuclear reactors, metallurgical activities, fibre spinning, casting, crystal formation, and a wide range of other applications are among them. Non-Newtonian fluid models cannot be described in a single link due to their reciprocal features [2]. On exponentially and linearly increasing surfaces, authors [3] examined boundary layer flow. Researchers [4] looked into the Navier-Stokes equation's parallel analysis on a stretched surface. The researchers from [5–7] discovered time-based boundary layer flow on a penetrable curved shrinking/stretched surface. The parameters of similar and dissim-

ilar responses on flow of boundary layers on a stretch curve sheet are explored by [8–9]. Researchers from [10] and [11] examined the influence of temperature-based conductance on boundary layer fluid and transmission of heat through a curve stretched sheet. The authors [12–13] demonstrated a non-Newtonian fluid on exponentially curve stretched surface along with magnetic field. Researchers from [14–16] examined the reliable method of determining an transmitting electrical micropolar fluid on a curve stretched sheet. According to [17], *n*-fluid increases the thermo-physical factors of *n*-fluid at first. In comparison to the base fluid and found that thermo-physical parameters such as heat conductivity, heat diffusivity, fraction of volume for *n*-elements, convective heat as well as viscosity support to the nano-fluid. Moreover, as shown in a number of authors have described the characteristics of nanoparticles in a variety of fluid models. Researchers from [18–19] first proposed a hybrid nano-fluid containing Cu + Fe$_3$O$_4$/H$_2$O and Cu/H$_2$O. Researchers from [20] used inverted cone to demonstrate properties of a CuAg/water mixed *n*-fluid along with convective heat transfer. Authors of [21–23] established a solution for

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ORIGINAL PAPER

Comparative study of adsorption isotherms on activated carbons synthesized from rice husk towards carbon dioxide adsorption

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Abstract

Rice husk was chemically activated with saturated KOH solution and the activation temperature was varied from 400 to 700 °C to generate activated carbons with different textural characteristics. Activated carbons were investigated for their ability to adsorb CO_2. We selected Langmuir, Freundlich, Sips and Radke-Prausnitz equations to fit the experimental CO_2 adsorption data. In order to determine the effect of using different error standards when calculating isotherm model parameters, an error analysis was conducted. The Radke-Prausnitz model shows the best fit to CO_2 adsorption and calculated adsorption capacity correlates closely with experimental data.

Keywords Rice husk · Activated carbon · Adsorption models · Error analysis · CO_2 adsorption

Introduction

Rice husk is an important biomass resource in South Asia as well as India and China. When compared to other agricultural Bio-wastes rice husk is known for low utilization value as husk and highly utilized as ash that is mostly in the form of silica. Rice husk that is a layer protective for rice grain is that the major by-product obtained from rice processing mill (Nhapi et al. 2011; Zhang et al. 2011).

Global warming has become major concern over the past few years. Increasing greenhouse gas concentrations caused the global average temperature to rise by about 1 °C every year. Among the gases responsible for the greenhouse effect, CO_2 plays the most significant role, since it stays in atmosphere for a significantly longer period of time. By 2020, CO_2 emissions will be over 36 billion tons, up from 2 billion tons in 1900 (Sai Bhargava Reddy et al. 2021). As the amount of harmful CO_2 in atmosphere continues to rise, this is critical for maintaining continued initiatives to minimize worldwide greenhouse gas emissions that cause climatic changes by developing and implementing impressive CO_2 capture methods.

Porous materials are a promising strategy to capture CO_2. In particular, advantages offered by carbon materials such as low desorption temperatures, rapid kinetics and high stability. Carbonaceous materials are very inexpensive if they are made with renewable resources or even waste. So researchers are trying to develop technologies that will enable carbon dioxide to be captured and stored, particularly adsorption technologies are treated as really promising at present (Singh et al. 2017). CO_2 capture is possible with the use of solid adsorbents, which have recently been studied: porous polymers (Sun et al. 2015), zeolites (Nguyen et al. 2016), monoliths (Günay et al. 2007), carbon nanotubes (Elmorsi

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Influence of nano-TiC content on the properties of Al2024 aluminium metal matrix composites

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ABSTRACT

Owing to their superior mechanical qualities, aluminium-based MMCs are finding widespread application in a variety of industries, including aviation and the automobile industries. Nano-fortification of Aluminium MMCs comprises carbides of silicon, tungsten, boron, and tungsten carbide, and carbon-based nanoparticles such as CNTs, graphene, and so on. In this current study an examination on the mechanical characteristics of Al2024 had been conducted after infusing them with the titanium carbide nanoparticles (nano-TiC) at different mass proportions. Stir cast method had been deployed during the fabrication of Al2024/nano-TiC specimens. The specimen was tested to assess its mechanical qualities, such as its tension behaviour and hardness. Investigations had been performed immediately with the specimens after they had been moulded using stir cast. The findings of the experiments showed that the ultimate strength, yield strength as well as the hardness of the material rose as the mass fraction of nano-TiC particles elevated till 2.0%. However, the aforementioned mechanical characteristics were not boosted, rather diminished slightly at 2.5% addition of nano-TiC. It can be attributed to the clustering of nano-TiC at their higher concentrations. Overall results of several experiments had shown that the ultimate tensile strength has increased by 21.01 percent, the yield strength has increased by 54.55 percent, and the hardness has increased by 34.55%, respectively with 2.0% inclusion of nano-TiC in Al2024.
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Selection and peer-review under responsibility of the scientific committee of the International Conference on Newer Engineering Concepts and Technology.

1. Introduction

Aluminium based metal composites (Al MMCs) are having the ability to yield useful characteristics, such as light weight, durability, high specific rigidity, good tribological quality, and manageable thermal expansion [1,2]. These capabilities allow Al MMCs appealing for diverse fields in the aviation industry, the automotive sector, and the defense industry [3,4]. μm-sized grains were typically employed to increase the maximum strength of the matrices; nevertheless, the flexibility of the MMCs considerably decreases with increasing particle volume fraction [5,6]. It is of curious to utilize submicron grains to reinforce the matrices whilst preserving elasticity, high thermal creep resistant, and higher endurance [7]. It is also of curious to employ submicron materials to improve durability. Specifically, Al2024 MMC has been proposed by many of the scholars for a variety of engineering applications, since they are possessing a number of qualities that make it particularly attractive, including a maximum fatigue strength [8,9]. Nevertheless, it has also been suffered with a few drawbacks, including the facts it could possibly be fabricated through the stir casting process. As a consequence of this, the qualities that aluminium 2024 possesses allow it to be utilized in the production of aircraft structures, like the flaps and wing span [10,11]. In a number of experiments, investigators had manufactured this substance after incorporating it with a variety of components, including nano-sized particles of metal carbides, ceramic carbides, coal ash and so on [12,13]. Contrarily, some other investigators have blended this Al2024 with other aluminium-based alloying substances, for examining the variations in physical behavior such as tensile and

CHALLENGES AND IMPACT OF GREEN CHEMISTRY CONCEPTS ON SUSTAINABLE ENVIRONMENTAL DEVELOPMENT

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Abstract

Principles of green chemistry are becoming understood to be crucial for the chemical industry's sustainable growth. However, implementing green chemistry is challenging due to a number of factors, such as lack of knowledge, expense, technical problems, regulatory barriers, and a lack of government backing. To encourage the use of green chemistry concepts in business and academia, we want to identify these obstacles and provide solutions in this research. We also look at the creation of novel green chemicals and processes, as well as the environmental and financial effects of using green chemistry concepts. Our research shows that encouraging the use of green chemistry requires recognizing and overcoming its obstacles, and that putting its ideas into practice may benefit the environment and the economy

Keywords: Green chemistry, sustainable development, implementation challenges, environmental impact, economic impact.

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The Development of Terminal Alkynes in Water Using DEMATEL Method

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Abstract. In organic chemistry, an alkyne is an unsaturated; Hydrocarbon is at least one carbon-three carbon has a bond. All three alkynes are unsaturated have a bond containing hydrocarbons, Alkynes have the general formula CnH2n-2 and three the bond is called 'acetylenic bond'. is called The functional group in the alkyne is a Carbon-carbon is three binding. Aromatics are π bonds odd number of electron in the system Planar with pairs, fully coupled and are cyclic structures. In which test to conclude from analysis and Evaluation Laboratory (DEMATEL) of complex system components a cause-and-effect chain is considered correct One of the best to identify. It values relationships Interdependence between factors and identification through visual structural modeling Important to see. Alternative: Propene (C3H6), Butene (C4H8), Pentene (C5H10), Hexene (C6H12), Heptene (C7H14). Evaluation Preference: Propene (C3H6), Butene (C4H8), Pentene (C5H10), Hexene (C6H12), Heptene (C7H14). The result it is seen that Hexene (C6H12) is got the first rank where as is the Pentene (C5H10) is having the lowest rank. The value of the dataset for Alkynes in Test and evaluate decision making the lab shows that it results in Hexene (C6H12) and top ranking.
Keywords: organic chemistry, alkyne, MCDM Method.

1. Introduction

In organic chemistry, an alkyne is an unsaturated one is a hydrocarbon that has at least one carbon- There is a triple bond involving carbon. Alkynes have a triple bond are unsaturated hydrocarbons containing alkynes The general formula is CnH2n-2 and three The bond is called 'acetylenic bond' is called Alkynes are present carbon-carbon triple bonds Organic molecules made up of functional groups and those with The empirical formula of CnH2n−2 is written. They are unsaturated hydrocarbons. Alkenes are –ENE Alkynes have the suffix –yne Use the result; There is only one alkyne in the molecule this suffix is used when the functional group in an alkyne is one carbon-carbon three is binding. Aromatics are π bonds odd number of electron in the system Planar with pairs, fully coupled and are cyclic structures. Alkynes are traditionally called acetylenes are called, Although the name acetylene refers specifically to C 2H 2 , which is the IUPAC nomenclature Used formally called ethane. Decision Making Test and Evaluation Laboratory (DEMATEL) the cause-and-effect chain elements of a complex system are considered a useful method for identification. This is assessing relationships between factors and Identify what is important through a visual structural model to see Results Testing and Evaluation Laboratory (DEMATEL) method complex and interrelated problem groups Analyzed and proposed to solve. Its ability to verify interdependencies between variables and tries to improve them by providing a specific diagram. The To assess the causal relationships of construction accidents DEMATEL method is used. This combination is human to the imprecise and subjective nature of judgments is used. Fuzzy set theory is real Interval sets rather than numbers uses. Linguistic terms converted into fuzzy numbers.

2. Alkynes

PtCl4 exhibits great Catalytic activity higher electrophilicity than PtCl2 and activity due to high solubility. Functional Ft molecules, phenols, protected amines; the reaction can be extended to halides and esters. In the aromatic ring Electron-releasing groups are usually this Ft Increases the reactivity of molecules; Aroma ring At least one electron to the required reaction Donor Committee [1]. The review provides carried out under palladium catalysis Using processes to prepare compounds Using alkynes as starting materials An overview of leading to various chemicals Different reactions are included in such review Fully of all possibilities Trying to hide to accept detail as an enormous task will be [2] The from terminal alkynes to the classical textbook method Presynthesis of metal acetylides is required. Alkyl Grignard reactions, Alkyl lithium as reactions and metal settings, air and are often more sensitive to water, and tolerated under several functional groups Cannot. These conditions and thus "security" needed. Acids to eventually quench the reaction should be included. [3] From terminal alkynes to the classical textbook method Presynthesis of metal acetylides is required. Alkyl Grignard reactions, Alkyl lithium reactions and metal amides Therefore, such reactions are often air and water the sensitivity is high, and multi-functional under groups cannot be tolerated. These conditions and thus requires "protection". To mitigate the reaction Acids should be added. [4] Nickel catalysts are anti-acidic C-H of terminal alkynes that is useful for the functioning of bonds

Investigations on MWO$_4$ (M = Cu, Zn, Cd and Sn) nanostructures for detecting toluene gas at room temperature

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ARTICLE INFO

ABSTRACT

Constructing the room temperature (RT) based semiconductor gas sensors is pivotal for its commercialization. In this investigation, four well-known tungstate based CuWO$_4$, ZnWO$_4$, CdWO$_4$ and SnWO$_4$ nanomaterials were prepared by the hydrothermal method. These materials were characterized by XRD, FESEM, TEM, EDX, DFT, BET surface area, XPS, FTIR and UV-Vis DRS. The selectivity alongside the response of these compounds were tested by sensing gases like 1-butanol (C$_4$H$_{10}$O), acetone (C$_3$H$_6$O), ethanol (C$_2$H$_6$O), benzene (C$_6$H$_6$), toluene (C$_6$H$_5$CH$_3$) and xylene (C$_8$H$_{10}$). The gas sensing studies performed on these compounds conclusively disclose that these sensors have adequate sensitivity and response to detect the tested gases at RT. Among these compounds, owing to unique crystal structure α-SnWO$_4$ sensor exhibits an enormous selectivity with a response of 12.32 towards the detection of toluene and the detection limit is 5 ppm. Compared to the other compounds, SnWO$_4$ offers the shortest conducting pathways viz. O-Sn-O-Sn/O-W-O-W-O which facilitated the effective charge transport for sensing toluene gas at RT.

1. Introduction

An upsurge in the economic growth resulted from the rapid rate of industrialization have led to the extensive emission of toxic, flammable and volatile organic compounds (VOCs) like toluene, xylene, benzene, 1-butanol, ethanol and methanol etc. [1,2]. As a consequence, an imbalance occurs in the climate which is extremely harmful to the health of living beings. The VOCs are found to be used excessively in wood furniture, paints, varnishes, adhesives and cosmetics etc. [3]. Nevertheless, the prolonged exposure to the above-mentioned gases even at very low concentrations (ppm) may affect the vital internal organs and eventually causes various cancers [4,5]. Among VOCs, the toluene (up to 200 ppm) inhalation may cause skin irritation, lacrimation, irregular heartbeat, dementia, ataxia, insomnia and various neurologic deficits [6]. A short time exposure to the toluene above 200 ppm may cause drowsiness, headache, nausea, visual impairment and many more to quote and even a continuous exposure with a high ppm level may lead to death also [7]. Therefore, it is the most pressing requirement of the present time to detect this gas and warn the living beings in the

industries surroundings in order to reduce the threat from this gas. To detect these gases, the various techniques like gas chromatography, laser absorption spectroscopy and gas sensors were developed [8,9]. Nonetheless, the gas sensors based devices have been considered as promising to detect these gases because of its flexibility, inexpensive, light-weight, portable and less power consumption [10]. At present, the gas sensors based on semiconductor metal oxides (SMO) have been drawing the wide attention of researchers.

Tungstate based SMO's have potential applications in photo-luminescence, optical fibres, scintillators, photocatalysts, lithium-ion batteries, solar cells, gas sensors and supercapacitors etc. [11] because of their significant physical, chemical, electrical and optical properties. Among tungstate groups, CuWO$_4$ (indirect band gap, 2.2 eV), ZnWO$_4$ (direct band gap, 3.91 eV), CdWO$_4$ (indirect band gap, 3.27 eV) and SnWO$_4$ (indirect band gap, 2.1 eV) have been well studied for several applications because of their functional properties [12–15]. Importantly, these are cost-effective, high chemical stability and non-toxic. It should be noted that all of these compounds are n-type semiconductors (SC). CuWO$_4$, ZnWO$_4$ and CdWO$_4$ have common wolframite structure

Room temperature sensing of ammonia and formaldehyde gases through novel anisotype heterojunction of p-Co$_3$O$_4$/n-Gd$_{0.1}$Ce$_{0.9}$O$_{2-\delta}$ as highly responsive and stable sensors

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HIGHLIGHTS

- NH$_3$, CH$_2$O gases of each 5 ppm were predominantly detected by these sensors at RT.
- 2:1 Co$_3$O$_4$/GDC and 1:2 Co$_3$O$_4$/GDC exhibited rapid response than parent compounds.
- A$_{1g}$ mode from Raman analysis revealed the formation of defects in heterostructures.
- O$_2^-$ species played crucial role than O^{2-} and O$^-$ at RT in chemisorption and in gas sensing.
- Heterostructures exhibited the high repeatability, stability, sensed multiple gases.

GRAPHICAL ABSTRACT
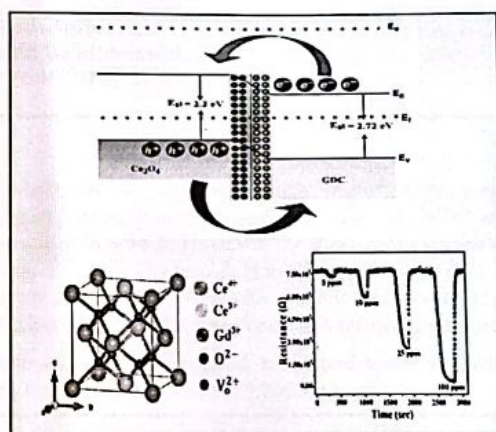
ABSTRACT

The development of the room temperature (RT) gas sensors is absolute need. Hydrothermally and sol-gel derived Co$_3$O$_4$ and Gd$_{0.1}$Ce$_{0.9}$O$_{2-\delta}$ (GDC) were used to fabricate the novel heterostructures in the ratio of 1:1 Co$_3$O$_4$/GDC, 2:1 Co$_3$O$_4$/GDC and 1:2 Co$_3$O$_4$/GDC. These samples were scientifically analysed through X-ray diffraction (XRD), Field emission scanning electron microscope (FESEM), Energy dispersive X-ray (EDX) spectra, X-ray photo-electron spectroscopy (XPS), Fourier transform infrared spectroscopy (FTIR), Raman, UV–Vis-Diffuse reflectance spectra (DRS) and photoluminescence (PL). XRD, XPS together with FTIR and Raman spectra are the testimonial of the formation of Co$_3$O$_4$, GDC and their heterostructures. Interestingly, the performed gas sensing studies

Magnetic field-induced narrow first-order and metamagnetic phase transitions of Nd$_5$Ge$_3$

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ABSTRACT

We report on the magnetic behaviour of Nd$_5$Ge$_3$ by investigating through magnetization, neutron diffraction and muon spin relaxation measurements. Temperature dependent-magnetization, muon depolarization rate (λ), initial asymmetry (A_0) and the stretched exponent (β) show a clear anomaly at the Néel temperature $T_N \sim 54$ K. However, the short-range correlated ferromagnetic interactions below T_N are inferred from the diffuse scattering mechanism as revealed by zero-field neutron diffraction data. Narrow first order phase transition is due to the competing interaction of a high temperature weak-antiferromagnetic and low temperature glassy states. Magnetic field-induced reentrant spin glass state from a magnetic glass state is observed, before it transforms to a ferromagnetic state.

I. INTRODUCTION

Nd$_5$Ge$_3$ is reported to exhibit dual magnetic transitions; AFM order ($T_N \sim 50$ K) and a second AFM order ($T_t \sim 30$ K).[1–3] The second AFM transition is determined on the basis of the disappearance of a critical field (H_{cr}), remanent magnetization and a cusp in $\chi(T)$ at 26 K.[2] The observation of an easy destruction of zero field cooled (ZFC)-T_t transition in field-cooled (FC) mode (in an applied field of 100 Oe) and absence of a specific heat anomaly at T_t (both under ZFC and FC) lead us to believe a spin-glass like structure coexisting with long-range AFM order. In Nd$_5$Ge$_3$, antiferromagnetic order is reported to occur at a temperature (52 ± 2) K.[1] The strongly coupled degrees of freedom in Nd$_5$Ge$_3$ are inferred from

the field-induced sudden jumps in isothermal magnetization, specific heat versus magnetic field and field-dependent resistivity below T_t by Maji et al.[3]

Maji et al.,[4] point out that the glassy state formation below T_t is due to geometric frustration originating from the triangular arrangement of Nd atoms in the 6g position, using χ_{ac}, magnetic relaxation and thermoremanent magnetization measurements. At $T < 10$ K, magnetic structure of Nd$_5$Ge$_3$ is of the spin wave type.[5] In the present work, we have reported/confirmed temperature driven first order phase transition and cluster-glass behaviour below 30 K and a weak antiferromagnetic state at 50 K. Neutron diffraction measurements suggest short-range magnetic correlations while Nd$_5$Ge$_3$ undergoes a field-induced ferromagnetic state eventually.

Full Length Article

Natural background outdoor gamma radiation levels and mapping of associated risk in Siddipet district of Telanagana State, India

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ABSTRACT

Studies on natural background outdoor environmental radioactivity levels were conducted in Siddipet district of Telangana state, India. The investigation was carried out in the major villages/mandal head quarters of the district using scintillation detector (NaI(Tl)) based μR- survey meter. The exposure rates measured on ground level and at 1 m height from ground (in μR.h^{-1}) were converted into absorbed dose rates (in nGy.h^{-1}) and annual effect doses (mSv) using appropriate conversion factors. The natural background radiation levels at 1 m height were found to vary from 139 nGy h^{-1} to 435 nGy h^{-1} with an average of 235$\pm$47 nGy h^{-1}. The background radiation levels were observed to follow the normal distribution with a little deviation at the outliers. The excess lifetime cancer risk (ELCR) was also estimated.

1. Introduction

The natural background radiation is categorized into external and internal. The external radiation is incident directly on the body while in case of internal it enters into the body by ingestion/inhalation and damages the tissues within the human body. Natural background gamma radiation is of terrestrial origin. It comes under external radiation. Internal radiation is due to radon/thoron and their progeny as well as the radiological dosage derived from primary radionuclides through food, drink, and other environmental exposures [1]. Natural background gamma radiation is of significant role in total dose due to natural sources [12]. The source of radiation exposure is the presence of primordial radionuclides existing at trace elements in soils and materials used for construction. The variability of the radiation levels is dependent of geochemical composition of rocks which cause the formation of soils. With certain exceptions, such as shale, high radiation levels are connected with volcanic rocks like granite and low radiation levels are with sedimentary rocks [2]. The existence of trace amounts of the naturally occurring radioactive elements, uranium, thorium, and potassium in soil and rocks is the main cause of external exposure in the outdoors. The presence of radionuclides in the building materials as well as the surrounding geology can be the main causes of the indoor exposures [13].

In the model villages of Erravalli and Narasannapet in the Siddipet district of Telangana state, India, studies were held to estimate the radiation levels in indoor environs under the double bed room housing project [14]. The levels of natural background gamma radiation in the indoor environs of the model villages were identified to have a few abnormalities. Further, the study revealed that indoor radiation levels in these villages were elevated and comparable to the values obtained across the nation, but comparable to the natural background gamma radiation levels observed elsewhere in the state (Hyderabad and other places) [15,5,3]. Keeping in view of the above, it was planned to extend the study to the entire district of Siddipet. The present paper deals with the natural background gamma radiation levels in different villages / mandals (administrative head quarters for a group of few villages) of Siddipet district of Telangana state in indoors and outdoors. This study will be useful in supplementing the available nationwide data and to assess the radiation burden receiving by the population of this area in finding the safe human habitat.

Platycladus Orientalis mediated green synthesis of crystalline palladium nanoparticles as a potential and promising nano catalyst in the degradation of dyes for mitigation of environmental pollution

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ABSTRACT

In the current study, PdNPs were synthesized in a greener way using *Platycladus orientalis* leaves extract (PO) as a reducing agent with stabilizing ability. UV–Vis Spectroscopy (UV–Vis), Fourier Transform Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD), Transmission Electronic Microscopy (TEM) and Dynamic Light Scattering (DLS) were implicated in the characterization of nanoparticles. The structural and the morphological studies were determined using TEM and XRD analysis while UV–Vis and FTIR studies further confirmed the presence of optical, physical and chemical properties. The images of TEM manifested spherical NPs with an average size of 8 ± 3 nm. Phytochemicals present in the leaf extract enabled the reduction of Pd^{+2} to Pd^{0} and also acted as a stabilizing agent. Later, the catalytic property of PdNPs, reduction of dyes like Rhodamine B (RhB), Methyl Orange (MO) and Crystal Violet (CV) was investigated. This green preparation method of making small spherical shaped PdNPs were successfully applied for the reduction of organic dyes.

Introduction

The profuse research efforts in the diverse fields of science are focused in the application of nanotechnology for environmental remediation and sustainability. The prime factor for ecological contamination is due to obnoxious effluents released from chemical industries. Approximately, 0.78 billion people globally were deprived of the facility of acquiring safe drinking water as avouched by World Health Organization.[1] The quality of the drinking water is continuously getting deteriorated due to the problem of rancidity and the presence of various precarious effluents released from industries like plastic, textile, leather, food processing, printing, cosmetics, paper, dyes and pharmaceutical which uses and consumes pigments and dyes, etc, in large concentrations.[2,3] Therefore, consequential huge amount of dyes released has been a major reason in causing adverse effects to environment and to human health as well, e.g. damage of the nervous system, diarrhea, skin irritation, typhoid, dysentery, polio and kidney failure. Dyes, especially the toxic ones are carcinogenic and mutagenic causing allergies and skin irritation in humans.[4,5] Developing a sustainable environment is the need of the hour in this emerging crisis. In this regard, it is imperative to develop effective and facile strategies to treat, remove and eliminate toxic industrial effluents containing dyes before being delivered into the environment. The appropriate technique in the elimination process of

these dyes face aggravating complications due to their stability, carcinogenicity, and non-biodegradable nature for longer time. In the mitigation of dye contaminants, many efficient technologies have been utilized like ozonation, membrane filtration, flocculation/coagulation, adsorption and advanced oxidation.[6]

The technologies mentioned have the problem of hazardous by products, high cost and low efficiency. Many efforts have been delved to design different techniques in obliterating-coloured dyes and in the purification of wastewater. Catalytic reduction among these techniques is the most preferred technique due to the process of being safer and more economical compared to other methods. Metal nanoparticles (NPs) have allured a greater attention compared to other metal counterparts due to their small sizes, high ordered structure, high specific surface area, excellent mechanical/thermal strength and densely populated unsaturated surface coordination sites.[7] Compared to the methodologies that have been already carried out, the concept of nanotechnology has emerged to be an advanced one with a greater potential of treating wastewater[8] with an effective approaching the treatment of industrial effluents.[9]

The fascinating feature of the current science of nanotechnology focus on bio compatible, eco-friendly, and bioengineered methods of the synthesis of metal nanoparticles. Researchers are much enthusiastic to amend universal applications of NPs in bringing out the sustainability of the

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environment[10] and degradation of organic pollutants.[11] A good range of nanoparticles have been explored in various chemical transformations and synthesis of organic compounds. In the remediation of polluted water, palladium nanoparticles work as an exceptional effective catalyst.[12]

stabilizing agent. The synthesized PdNPs were analyzed using X-Ray Diffraction (XRD), Transmission Electronic Microscopy (TEM), Dynamic Light Scattering (DLS), UV–Vis Spectroscopy (UV–vis), and Fourier Transform Infrared Spectroscopy (FTIR). Finally, the catalytic efficiency of syn-

REVIEW ARTICLE

Iodoxybenzoic Acid (IBX) in Organic Synthesis: A Septennial Review

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Abstract: This study reviews the oxidative applications of 2-iodoxybenzoic acid (IBX) in organic synthesis, focusing on C-H functionalization, hetero-hetero bond formations, ring cleavage reactions, dehydrogenation, heterocyclic ring formations, and some miscellaneous reactions in a comprehensive and critical way. It compiles the literature starting from mid-2015 to date.

Keywords: 2-Iodoxybenzoic acid (IBX), organic synthesis, oxidation, C-H functionalization, hetero-hetero bond formations, heterocyclic ring formations, critical way.

1. INTRODUCTION

After the first hypervalent iodine reagent, iodobenzene dichloride (PhICl₂), was discovered in 1886 (Willgerodt), hypervalent iodine chemistry developed into a significant field of study and application [1]. The chemistry of hypervalent iodine compounds (3- and 5-iodanes) has grown at an unparalleled rate over the past 25 years. Iodine is a good option for generating polycoordinate compounds due to its large atomic size and low ionisation potential in comparison to other halogens [2-20]. As a gentle, secure, and cost-effective replacement for heavy-metal reagents, like lead(IV), thallium(III), mercury(II), chromium(VI), and others, these multivalent iodine reagents are now widely utilised in organic synthesis. These hypervalent iodine (III) compounds are desirable oxidizing agents because of their stability and selective activities. Iodosyl benzene (PhIO) iodobenzene dichloride (PhICl₂), iodobenzene diacetate (PhI(OAc)₂), iodine trifluoroacetate [(PhI(OCOCF₃)₂], Koser's reagent-hydroxy (tosyloxy) iodobenzene (PhI(OTS)OH) (HTIB), Dess-Martin periodinane (DMP), and 2-iodoxybenzoic acid (IBX) are the widely used hypervalent iodine reagents for organic transformations. Particularly, the heterocyclic 2-iodoxybenzoic acid (IBX), a highly effective and mild oxidant that can be used for the selective oxidation of primary and secondary alcohols as well as a variety of other significant oxidative transformations, finds widespread applications in organic synthesis. The 2-iodoxybenzoic acid was discovered by Hartmann and Meyer in 1893 (1-hydroxy-1,2-benziodoxol-3(1H)-one 1-oxide, commonly abbreviated as IBX, (Fig. 1) and was forgotten for

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nearly a century, probably because of its remarkable insolubility in most organic solvents and water due to having a polymeric structure. Instead, early 20th century pharmacological research on the oxidizing effect of IBX was conducted. For instance, it has been demonstrated that IBX may oxidize haemoglobin and that giving it to rabbits by intravenous injection significantly lowered their blood pressure [21, 22]. In the bonding model, it is typically presumed that IBX has three different types of bonds. The phenyl group, which is the least electronegative ligand, is joined to the iodine atom via a typical covalent connection. Both the hydroxyl and carboxylate ligands form a linear 3c-4e bond with one of the two remaining doubly occupied, unhybridized 5p orbitals of the iodine [23, 24].

Fig. (1). Structure of IBX (1).

Greenbaum was the first to publish the procedure for oxidizing o-iodobenzoic acid by potassium bromate in aqueous sulfuric acid in 1936 [25]. This method is arguably the most frequent way to obtain IBX. Although this property was partially attributable to the presence of residues of bromate impurities, IBX has been found to be explosive upon impact or when heated above 200°C. o-Iodobenzoic acid may be effectively and efficiently oxidized using oxone on a wide scale [26]. The first successful oxidation of a number of alcohols with IBX in DMSO, the only solvent in which its solubility is

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appreciable, was reported by Frigerio and Santagostino in 1994 (Fig. 2) [26].

Fig. (2). General preparation methods of IBX [25-26].

Dess and Martin created 1,1,1-triacetoxy-1,1,1-dihydro-1,2,benziodoxol-3(1H)-one 1-oxide, a different hypervalent iodine reagent in 1983 using IBX [27]. IBX ranks high among organic acids in terms of strength. For IBX in aqueous solution, a pKa value of 2.40 was discovered using potentiometric titration methods. For IBX in DMSO, the equivalent value was discovered to be pKa DMSO = 6.65 [28]. IBX can be kept at 25°C for longer than six months without experiencing any substantial degradation as long as the light is kept out of the container. In contrast to Dess-Martin periodinane, it can be easily obtained, is stable to moisture, and may be processed in an open flask without the need for special safety measures, such as an inert environment or dry solvents. IBX is soluble in most solvents at high temperatures, allowing it to continue oxidising alcohols. The use of solvents like DCM, DCE, ACN, and EtOAc may require higher temperatures for the reactions. The best results were attained using EtOAc or DCE as the solvent since the byproducts are insoluble at room temperature and can be easily removed by filtration. In order to create a less explosive variant of IBX, SIMAFEX created stabilized IBX, also known as SIBX. Carboxylic acids like benzoic acid and isophthalic acid stabilize commercial IBX. In various solvents and transformations, it was discovered that this new formulation was just as potent and focused as IBX

examples being the Suzuki-Miyaura and Chan-Evans-Lam couplings, the Petasis reaction, and the Hayashi-Miyaura conjugate addition. Organoborons are among the most frequently used compounds in organic synthesis and organometallic chemistry, with uses in other fields, such as medicine and material science. Wang et al. reported on the one-pot oxidative difunctionalization of readily available alkenyl MIDA (N-methyliminodiacetyl) boronates to produce halogenated and trifluoromethylated α-boryl ketones [41a]. The synthesis of these new, densely functionalized organoborons, which contain carbonyl, halogen/CF₃, and boronate moieties that are both synthetically and functionally beneficial, is difficult but has a lot of potential.

Due to the special qualities that fluorine confers, there is a rising interest in building blocks that contain fluorine. Alkenyl MIDA boronates were oxidatively fluorinated under the ideal reaction conditions of selectfluor (1.5 equiv.), stabilized IBX (SIBX, 0.5 equiv) [41b], H₂O (10.0 equiv.), and AcOH (0.4 equiv.) in CH₃CN at 70°C and 1 atm of oxygen (Scheme 1). The fluorine atom was only ever detected in the boryl group, indicating a highly regioselective reaction.

PAPER

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Synthesis of titanates for photomineralization of industrial wastewater and organic pollutants†

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In the current study, a tunnel-type titanate nanomaterial ($Na_2Ti_3O_7$, NaTO) was converted into $PdTi_3O_7$ (PdTO) through an ultrasonication-assisted ion-exchange method. Ag nanoparticles were then deposited on the surface of PdTO through sonication to give Ag/PdTO, which exhibited improved visible-light-induced photocatalytic activity. The composition and phase of each nanomaterial were examined by X-ray photoelectron spectroscopy, powder X-ray diffraction, and various spectroscopic techniques. Using estimates from spectrophotometry and the solution of the radiative transfer equation, the optical parameters of these titanates (NaTO, PdTO, and Ag/PdTO) were reported. The specific scattering and absorption coefficients, along with the scattering phase function, were observed in the wavelength range from 250 to 650 nm. The low bandgap of Ag/PdTO, 2.42 eV, is responsible for the capture of photons of visible light for improved photomineralization of various dyes. Under the optimal settings, the photocatalytic mineralization efficacies of the dyes with Ag/PdTO and PdTO retained 98% and 60% of their starting activities after 60 min, respectively. Mechanistic studies were also conducted to understand the generation of superoxide, which is the active species in the mineralization of industrial and automobile industrial wastewater. The high photocatalytic efficiency of the Ag/PdTO system is reported.

Water impact

Newly synthesized titanates with plasmonic metal nanoparticles were utilized for the photomineralization of various cationic and anionic dyes and industrial wastewater. The new Ag/PdTO nanomaterial showed a very promising performance towards the photomineralization of both anionic (CR) and cationic (MB) dyes within 60 min. The industrial wastewater (IWW) photomineralization process was also analyzed with the LC-MS technique. The optical parameters of these titanates (NaTO, PdTO, and Ag/PdTO) were resolved by using spectrophotometric estimations and solution of the radiative transfer equation. Lastly, the proof of identity for active species photomineralization of all the pollutants was examined in the presence of several scavengers. Hence, we believe that our article is innovative, important and interesting to the readership of **Environmental Science: Advances**.

Introduction

Industrial development and mass manufacturing provide human society with numerous goods and facilities. Nevertheless, an enormous amount of pollutants and solid

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† Electronic supplementary information (ESI) available: Thermograms, FESEM images, flat band potentials, N_2 adsorption-desorption isotherms, control experimental plots for NaTO, PdTO, and Ag/PdTO, and also new compounds obtained from the photodegradation process were recorded. See DOI: https://doi.org/10.1039/d2ew00469k
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wastes are also produced in the environment mainly due to the utilization of chemicals in various manufacturing processes. Many of these chemicals are extremely poisonous and generate toxic wastes when released into the water and environment. Because of the vital role of water in life, a clean water source is needed. Thus, the ability to cleanse wastewater, mostly industrial effluents (IE), into releasable or reusable quality is extremely important for the viability of our earth.[1-4] Some pharmaceutical formulations or drug manufacturing units may discharge their wastewater into the environment and perturb the water and soil environment. Therefore, it is also essential to treat effluents before releasing them into the environment. A number of methods for the photodegradation of IE-based contaminants using ternary metal-oxides as photocatalysts have been reported.[5,6] Among them, titanium-containing ternary metal-oxides show photocatalytic action and high stability, both chemically and

photochemically, due to their suitable bandgap.[7] The bandgap energies of titanium-based oxides range from 2.0 eV to 3.1 eV,[8] which falls in the visible-light region. Several research groups have reported titanates with various types of dopants (anionic or cationic or both) for the degradation of organic dye pollutants under visible-light treatment.[9,10] It is known that the photocatalytic efficacy of a specific type of photocatalyst is determined by the active species involved in processes like charge carrier transport, light absorption, and photo-generated electron-hole pair recombination.[11,12]

Ternary metal oxides are very promising compounds for various applications, such as in photocatalysis, photovoltaic cells, photo-electrochromic displays, light-emitting devices, and sensors.[13,14] Ternary metal oxides doped with Ag have been designed for applications in electron-transporting layers, perovskite solar cells, degradation of organic pollutants, and plasmonic sensors.[15-18] Moreover, Au- and Ag-doped titanates play a significant role in photocatalysis, due to the collective oscillation of free electrons, which are generated through surface plasmon resonance (SPR) in the visible light region.[19-21] Ag-doped metal oxide nanoparticles (NPs) with different morphologies have been synthesized by using chelating compounds.[19] Even though various types of semiconductor oxides are used for the degradation of

into fine powder for analyses through powder X-ray (p-XRD), EDX, FESEM, HRTEM, and XPS techniques. The p-XRD patterns of all the samples are shown in Fig. 1.

The p-XRD pattern of NaTO matched well with the data (JCPDS No. 72-0148) reported in the literature and no extra peak was found.[27] The interlayer distance of layered NaTO coincides with the (100) plane with the highest peak at $2\theta \simeq 10°$. The edge-shared TiO_6 octahedra were linked in turn to arrange stepped Na/Pd···type $Ti_3O_7^{2-}$ layers.[28] Sodium ions existing in between these layers are very easy to replace with various metal ions, as revealed in Fig. S1.† The p-XRD patterns of PdTO and Ag/PdTO were similar and comparable with that of NaTO powder. Using Scherrer's formula, the crystallite dimensions (size) of NaTO, PdTO, and Ag/PdTO powders were determined from the line width of the intense (100) line. NaTO, PdTO, and Ag/PdTO crystallite sizes were measured to be 42, 29, and 18 nanometers, respectively. The exchange of metal ions into NaTO nano crystallites can be attributed to its distinct framework structure. The octahedron tunnels running along the b-axis enable the diffusion of metal ions into the interior of the tiny particles, resulting in the homogenous exchange of metal ions into the NaTO lattice. The shrinking of the layered structure is caused by the ion exchange process, which is evident from the shift of

REVIEW ARTICLE

Iodoxybenzoic Acid (IBX) in Organic Synthesis: A Septennial Review

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Abstract: This study reviews the oxidative applications of 2-iodoxybenzoic acid (IBX) in organic synthesis, focusing on C-H functionalization, hetero-hetero bond formations, ring cleavage reactions, dehydrogenation, heterocyclic ring formations, and some miscellaneous reactions in a comprehensive and critical way. It compiles the literature starting from mid-2015 to date.

Keywords: 2-Iodoxybenzoic acid (IBX), organic synthesis, oxidation, C-H functionalization, hetero-hetero bond formations, heterocyclic ring formations, critical way.

1. INTRODUCTION

After the first hypervalent iodine reagent, iodobenzene dichloride (PhICl$_2$), was discovered in 1886 (Willgerodt), hypervalent iodine chemistry developed into a significant field of study and application [1]. The chemistry of hypervalent iodine compounds (3- and 5-iodanes) has grown at an unparalleled rate over the past 25 years. Iodine is a good option for generating polycoordinate compounds due to its large atomic size and low ionisation potential in comparison to other halogens [2-20]. As a gentle, secure, and cost-effective replacement for heavy-metal reagents, like lead(IV), thallium(III), mercury(II), chromium(VI), and others, these multivalent iodine reagents are now widely utilised in organic synthesis. These hypervalent iodine (III) compounds are desirable oxidizing agents because of their stability and selective activities. Iodosyl benzene (PhIO) iodobenzene dichloride (PhICl$_2$), iodobenzene diacetate (PhI(OAc)$_2$), iodine trifluoroacetate [(PhI(OCOCF$_3$)$_2$], Koser's reagent-hydroxy (tosyloxy) iodobenzene (PhI(OTS)OH) (HTIB), Dess-Martin periodinane (DMP), and 2-iodoxybenzoic acid (IBX) are the widely used hypervalent iodine reagents for organic transformations. Particularly, the heterocyclic 2-iodoxybenzoic acid (IBX), a highly effective and mild oxidant that can be used for the selective oxidation of primary and secondary alcohols as well as a variety of other significant oxidative transformations, finds widespread applications in organic synthesis. The 2-iodoxybenzoic acid was discovered by Hartmann and Meyer in 1893 (1-hydroxy-1,2-benziodoxol-3(1H)-one 1-oxide, commonly abbreviated as IBX, (Fig. 1) and was forgotten for

nearly a century, probably because of its remarkable insolubility in most organic solvents and water due to having a polymeric structure. Instead, early 20th century pharmacological research on the oxidizing effect of IBX was conducted. For instance, it has been demonstrated that IBX may oxidize haemoglobin and that giving it to rabbits by intravenous injection significantly lowered their blood pressure [21, 22]. In the bonding model, it is typically presumed that IBX has three different types of bonds. The phenyl group, which is the least electronegative ligand, is joined to the iodine atom via a typical covalent connection. Both the hydroxyl and carboxylate ligands form a linear 3c-4e bond with one of the two remaining doubly occupied, unhybridized 5p orbitals of the iodine [23, 24].

Fig. (1). Structure of IBX (1).

Greenbaum was the first to publish the procedure for oxidizing o-iodobenzoic acid by potassium bromate in aqueous sulfuric acid in 1936 [25]. This method is arguably the most frequent way to obtain IBX. Although this property was partially attributable to the presence of residues of bromate impurities, IBX has been found to be explosive upon impact or when heated above 200°C. o-Iodobenzoic acid may be effectively and efficiently oxidized using oxone on a wide scale [26]. The first successful oxidation of a number of alcohols with IBX in DMSO, the only solvent in which its solubility is

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appreciable, was reported by Frigerio and Santagostino in 1994 (Fig. 2) [26].

Fig. (2). General preparation methods of IBX [25-26].

Dess and Martin created 1,1,1-triacetoxy-1,1,1-dihydro-1,2,benziodoxol-3(1H)-one 1-oxide, a different hypervalent iodine reagent in 1983 using IBX [27]. IBX ranks high among organic acids in terms of strength. For IBX in aqueous solution, a pKa value of 2.40 was discovered using potentiometric titration methods. For IBX in DMSO, the equivalent value was discovered to be pKa DMSO = 6.65 [28]. IBX can be kept at 25°C for longer than six months without experiencing any substantial degradation as long as the light is kept out of the container. In contrast to Dess-Martin periodinane, it can be easily obtained, is stable to moisture, and may be processed in an open flask without the need for special safety measures, such as an inert environment or dry solvents. IBX is soluble in most solvents at high temperatures, allowing it to continue oxidising alcohols. The use of solvents like DCM, DCE, ACN, and EtOAc may require higher temperatures for the reactions. The best results were attained using EtOAc or DCE as the solvent since the byproducts are insoluble at room temperature and can be easily removed by filtration. In order to create a less explosive variant of IBX, SIMAFEX created stabilized IBX, also known as SIBX. Carboxylic acids like benzoic acid and isophthalic acid stabilize commercial IBX. In various solvents and transformations, it was discovered that this new formulation was just as potent and focused as IBX

examples being the Suzuki-Miyaura and Chan-Evans-Lam couplings, the Petasis reaction, and the Hayashi-Miyaura conjugate addition. Organoborons are among the most frequently used compounds in organic synthesis and organometallic chemistry, with uses in other fields, such as medicine and material science. Wang et al. reported on the one-pot oxidative difunctionalization of readily available alkenyl MIDA (N-methyliminodiacetyl) boronates to produce halogenated and trifluoromethylated α-boryl ketones [41a]. The synthesis of these new, densely functionalized organoborons, which contain carbonyl, halogen/CF$_3$, and boronate moieties that are both synthetically and functionally beneficial, is difficult but has a lot of potential.

Due to the special qualities that fluorine confers, there is a rising interest in building blocks that contain fluorine. Alkenyl MIDA boronates were oxidatively fluorinated under the ideal reaction conditions of selectfluor (1.5 equiv.), stabilized IBX (SIBX, 0.5 equiv.) [41b], H$_2$O (10.0 equiv.), and AcOH (0.4 equiv.) in CH$_3$CN at 70°C and 1 atm of oxygen (Scheme 1). The fluorine atom was only ever detected in the boryl group, indicating a highly regioselective reaction.

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Pt- and Pd- based intermetallic anode catalysts for direct ethanol fuel cell (DEFC): An overview

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Abstract

Despite decades of research, the lack of highly active and durable catalysts for fuel cell operations continues to be a stumbling block in the development of advanced fuel cells. Direct ethanol fuel cells (DEFCs) attracted much tension due to simple design, high energy density and low toxicity of ethanol as compared to methanol. Ordered intermetallic compounds are an intriguing class of materials for electrocatalytic processes because of their unique chemical and physical features. Intermetallic nanoparticles (NPs) based on platinum (Pt) and palladium (Pd) for direct ethanol fuel cells have recently received a lot of interest. Pt- and Pd-based intermetallic NPs as electro catalysts have outstanding catalytic activity while also exhibiting exceptional stability under electrocatalytic conditions. The application of Pt- and Pd-based intermetallic electrocatalysts for DEFC is discussed in detail in this paper.

Introduction

The need for energy increases as the population expands. [1] It's also important to note that environmental pollution has resulted in major issues like acid rain and ozone depletion. There is a pressing need to look for alternatives to fossil fuels that are more environmentally friendly because of the predicted depletion of fossil

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Contemporary advancement on the alloy-based anodes for Sodium-ion batteries

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Abstract

Energy storage has a budding worldwide alarm over the earlier era. As a consequence of improved energy calls associated with extreme rises in the fossil gasses cost and the ecological outcomes of their usage, they advanced the demand for globally accountable alternate bases for similar production of energy and storage. Batteries utilized in entirely transportable electronic devices are probable to these worldwide apprehensions. Li^+ has a small ionic radius, permits dispersion in solids, and is attached with its extended cycle lifespan and rate ability. Lightweight element, the low redox potential of Li allows cells with superior voltage and energy density. Furthermore, growing lithium employment in medium motorized batteries will eventually increase the value of lithium compounds, so assembling large-scale storage is excessively luxurious. Abundance, low price, and appropriate redox potential made the Na-ion batteries hopeful for energy storage applications Anode resources with superior capacity and extensive cycling steadiness are required to endorse the extra progress of Na-ion batteries. Current research advancement on alloy-based resources is summarized in this review.

Introduction

The global warming consequence is a hot issue owing to the comprehensive fossil fuels utilization and the

ORIGINAL ARTICLE

Design and sustainable production of natural carbon incorporated CuO/C nanocomposite using *Cyperus rotundus* biomass

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Abstract

The synthesis of CuO/C nanocomposites was fabricated using an uncomplicated and eco-friendly method by *Cyperus rotundus* (*C. rotundus*) leaf extract. The formation of nanocomposites and their size were optimized with various factors, such as operational parameters, viz. exposure time, temperature, and concentration of the precursor, by response surface methodology (RSM). The effects of the synthesis of CuO/C nanocomposite samples and their characterization by various analytical techniques such as UV, XRD, XPS, EDX, SEM, and TEM have been reviewed and confirmed. The XRD patterns revealed that the biosynthesized CuO/C sample exhibited a monoclinic and crystalline structure. Moreover, the elements available in nanocomposites were determined as Cu 2p, O 1 s, and C1s using XPS analysis. The TEM pictures reveal the morphology of the nanocomposites as spherical in form, with an average size of 30 nm. Additionally, synthesized CuO/C nanocomposites were examined for toxic effects on the mortality of two-winged insect larvae, and they were absolutely found to be extremely active and considerably kill larvae. The molecular docking study found that the nanocomposites were able to bind to the target protein with high affinity, which suggests that they are likely to be effective larvicidal agents. Our existing analysis findings can open up a replacement void for the larvicidal analysis exploiting biosynthesized nanocomposites.

Keywords *C. rotundus* · CuO/C nanocomposites · Larvicidal activity · Molecular docking · RSM optimization

1 Introduction

As far back as a couple of decades, numerous medicinal plants have been broadly used in Ayurveda and furthermore utilized as the reducing, capping, and stabilizing agent for

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the preparation of nanomaterials. At present, nanobiotechnology is currently one of the most important research fields of modern material science involving plant items. Similarly, various plant products are being used in the preparation of nanomaterials [1–5]. Nanotechnology is one of the quickly developing sciences to create the nanosized materials [6–9]. Nanocomposites show bigger surface area, which are of enthusiasm for applications consecutively from sensors, impetuses, power devices, sun powered cells, biological activities, PC transistors, electrometers, synthetic sensors, and remote electronic basis and memory schemes [10–18]. In earlier studies, the synthesis of nanocomposite materials and its biological activities were reported by many scientists [19–21]. The different inorganic nanomaterials have been fabricated using nanoscience, nanotechnology fields, antifungal, antibacterial, and other biological agents in various fields [22, 23]. The nanomaterials provide a broader spectrum of biological activity due to its morphology like size and surface area [24]. The CuO nanostructures are gaining more importance in biological activity due to its good effect on bacterial and fungal strains and very less toxicity to animal cells [25], especially CuO nanostructures with carbon

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Crop Recommendation System Using Improved Apriori Algorithm

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Abstract— A crop suggestion system is a technologically advanced tool that helps farmers choose which crops to plant in a certain location or with precise environmental circumstances. These systems use a variety of data sources and analytical methods to give farmers customized crop recommendations. This work presents the Crop Recommendation System Using an Improved Apriori Algorithm, which is an Apriori-based crop recommendation system. The goal of the system is to assist farmers in making well-informed choices about which crops to grow and what fertilizers to use depending on the properties of the soil and environment. With consideration for crop variety, climate, and soil nutrient content, the suggested method is an enhanced version of the Apriori algorithm. Tests of the updated algorithm on a dataset of soil samples from different parts of India revealed that it could correctly suggest the optimal crop. The model's output, association rules, is a suggestion system that farmers can use to boost crop productivity while lowering input costs. The method suggested operates in three phases: In the first stage, preprocessing the data is carried out to gather the input parameters that are crucial for determining the recommendation system. In Stage 2, the recommendation system's association rules are extracted by using an iterative approach to determine the threshold support count and confidence. Stage 3: The recommendation system's knowledge base is formed by pruning the top 8 apriori rules depending on priority. From the experiments, it is evident that the improved apriori algorithm-based extracted recommendation system is an interesting development in precision agriculture that could raise farming practices' sustainability and efficiency.

Keywords- Rice, Maize, Mango, Crop Recommendation, Apriori Algorithm.

I. INTRODUCTION

India has a diversified agricultural economy, with many different crops growing in different parts of the nation due to differing agro-climatic conditions. India's farmers select their crops taking into account the country's climate, soil composition, consumer demand, and personal tastes [1]. The following are some of the several crops that Indian farmers love to grow: **Rice:** Grown extensively throughout India, especially in places like West Bengal, Punjab, and Uttar Pradesh, rice is a staple food. It is usually grown in areas with heavy rainfall or access to irrigation since it needs a lot of water. **Wheat:** Grown in Punjab, Haryana, and Uttar Pradesh, among other northern Indian states, wheat is another staple crop. It is sown in the Rabi season and is a winter crop. **Corn, or maize:** Cultivated across India, but especially in Andhra Pradesh, Karnataka, and Madhya Pradesh. It is utilized as cattle feed as well as for human consumption. **Millets** are drought-resistant crops that are cultivated in arid and semi-arid regions of India, such as Rajasthan, Maharashtra, and portions of Karnataka and Andhra Pradesh [1]. Millets include finger millet (ragi), pearl millet (bajra), and sorghum (jowar). **Pulses:** Several states, including Madhya Pradesh, Uttar Pradesh, and Maharashtra, grow pulses like chickpeas (gram), lentils (masoor), and pigeon peas (tur). In Indian cuisine, pulses are a vital source of protein. **Cotton:** Grown in areas like Gujarat, Maharashtra, and Andhra Pradesh, cotton is a significant cash crop. India ranks among the world's top producers of cotton [2]. **Sugarcane:** Grown in states like Uttar Pradesh, Maharashtra, and Karnataka, sugarcane is widely farmed for its sugary yield. **Oilseeds:** Edible oil production is the purpose of cultivating oilseeds such as sunflower, groundnuts, and soybeans. Many states, notably Gujarat, Maharashtra, and Madhya Pradesh, grow these crops. **Spices:** Known as the "Land of Spices," farmers in states like Kerala, Karnataka, and Andhra Pradesh grow a vast array of spices, including black pepper, cardamom, turmeric, and chili peppers.

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India is one of the world's leading producers of fruits and vegetables, with areas like Punjab and Haryana focusing on the production of citrus and apple-based foods [2]. **Coffee and tea:** Karnataka, Kerala, and Tamil Nadu are the main growing regions for coffee, while Assam, West Bengal, and Kerala are known for their tea plantations. **Cash Crops:** Various states cultivate cash crops for commercial use, such as sugarcane, rubber, and tobacco. analyses large amounts of data and generates recommendations using data analytics and machine learning algorithms [3]. fertilizers to use on their crops. To provide personalized recommendations to farmers, the system considers various The system can be linked to sensors and other data sources to provide real-time advice based on current weather and soil conditions. In recent days' modern agriculture is using sensors to know crop and soil details.

A crop recommendation system is a computer-based tool that assists farmers in making informed decisions about factors such as soil type, weather conditions, crop type, and nutrient requirements.

Increased crop yields, lower input costs, improved soil health, and reduced environmental impact are all advantages of using a crop and fertilizer recommendation system. Farmers can optimize their fertilizer use and reduce waste and pollution by receiving personalized recommendations. AgroCares, CropIn, and the International Plant Nutrition Institute are among the companies and organizations developing and implementing crop and fertilizer recommendation systems. These systems are being used to help farmers increase productivity and sustainability in various parts of the world, including the United States, Europe, and Asia. Overall, a crop recommendation system is a promising tool for farmers looking to optimize their use of fertilizers and improve their crop yields while reducing their environmental impact [4]. As technology advances, we can expect more sophisticated and accurate recommendation systems to be developed to meet the needs of farmers worldwide.

Several kinds of sensors that are intended to track and gather data about various facets of farming and the environment can detect agricultural data. Modern precision agriculture relies heavily on these sensors to assist farmers in making data-driven decisions that maximize crop yields, minimize resource use, and boost overall productivity.
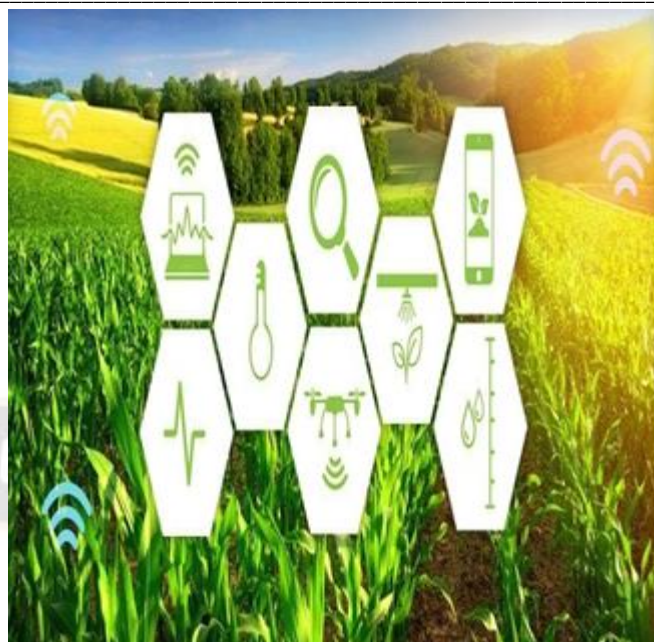
Fig. 1. Crop and Fertilizer recommendation based on soil and climate changes

II. MOTIVATION

Many studies have shown that crop and fertilizer recommendation systems can significantly increase crop yields while also lowering farmers' input costs. A study conducted in India, for example, discovered that using a recommendation system increased yields by 14% while decreasing fertilizer use by 22%. The quality and quantity of data used, the algorithms and models used to generate recommendations, and the user interface and ease of use for farmers all have an impact on the accuracy and effectiveness of crop and fertilizer recommendation systems [5].

While crop and fertilizer recommendation systems have many advantages, they also have some drawbacks and limitations. These systems, for example, can be costly to implement and maintain, and they may necessitate significant technical expertise to function properly. Overall, the literature suggests that crop and fertilizer recommendation systems can be a valuable tool for farmers looking to optimize fertilizer use and improve crop yields. More research is needed, however, to fully understand the factors that influence the accuracy and effectiveness of these systems, as well as to develop more sophisticated and user-friendly recommendation systems that farmers can easily adopt [6]. Crop classification and yield prediction are common applications for decision trees. These models are based on a hierarchical structure of decision nodes that divide data into smaller subsets based on specific criteria, resulting in a prediction. Neural networks are a type of machine learning model inspired by the human brain's structure. These models can predict crop yield, analyze nutrients, and categorize crops. Support vector machines

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(SVMs) are a type of machine learning algorithm that can be used to predict crop yield and classification. SVMs work by determining the best decision boundary between different classes of data and mapping the data into a higher-dimensional space using a kernel function [7].

Random forest is an ensemble learning technique for improving prediction accuracy by combining multiple decision trees. These models are frequently used to forecast crop yields and assess nutrient levels. Deep learning is a subfield of machine learning that uses multiple-layer neural networks to learn complex data representations. Deep learning models have been used to predict crop yield, detect disease, and characterize plant phenotypes [8]. Bayesian networks are probabilistic graphical models that represent the relationships and conditional dependencies between variables. These models have been used to predict crop yields and manage nutrients. Overall, machine learning techniques have yielded promising results for crop and fertilizer recommendation, with many studies demonstrating increased accuracy and efficiency over traditional methods. However, the technique used is determined by the specific problem and data available, and more research is required to determine the most effective approaches for various applications [9]. Though the decision trees are good enough in crop recommendation the outcome of these models are complex to decode and need some prerequisite knowledge to understand. The proposed work in the paper conveys the outcome of apriori association rules in the form of classification rules, like if –then –else rules which are easily understood by the farmers. This set of rules recommends that farmers select the best crop based on soil and weather features [10].

III. LITERATURE REVIEW

Crop recommendation systems are based on the collection of data from various sources, such as soil samples, meteorological conditions, past crop yields, and local agricultural practices. Sensors, satellite imagery, and other methods are utilized to facilitate data collection. (Savary et al., 2012; Zhang et al., 2017) [10] [11]. Then, using sophisticated algorithms and machine learning models, data analysis is conducted while accounting for variables including crop-specific requirements, temperature, precipitation, pH levels, and type of soil (Anaya-Romero et al., 2017; Alippi et al., 2019) [12][13. Then, using the data that has been analyzed, these systems determine which crops are suitable for which farms or places. They take into account factors such as pest resistance, nutrient requirements, and crop growth cycles (Braun et al., 2010; Tekinerdogan et al., 2019) [14]. Personalized crop recommendations are produced after the study, and farmers are frequently provided with a list of appropriate crops that are graded according to their potential yield and profitability in the specified location (Das et al.,

2017; Pan et al., 2019) [15]. According to Liu et al. (2019) and Nalwanga et al. (2020), these guidelines provide a basis for well-informed decision-making concerning crop selection, planting schedules, and agronomic practices, ultimately assisting in resource optimization and risk reduction. Aside from giving real-time guidance on pest management, fertilization, and irrigation based on continuously updated data and meteorological information, some systems also provide continuous monitoring and feedback throughout the growing season (Wu et al., 2018; Yang et al., 2019) [16]. To improve accessibility, these systems can be accessed via many platforms such as web-based interfaces, Smartphone applications, or SMS services. This guarantees that farmers with different levels of technological literacy can still use the systems (Savary et al., 2012; Zhang et al., 2017) [17].

Crop recommendation systems encounter several obstacles and constraints. First, as their efficacy is largely dependent on the quantity and quality of data, they are prone to errors when there is a lack of data or when the data is not representative of the real world [18]. Second, some systems suggest intricate machine learning models or algorithms, which could be difficult for farmers or organizations with little technical know-how or funding to install and maintain [19]. Furthermore, the high resource needs of some technologies, like as satellite images or sensor networks may prevent small-scale or resource-constrained farmers from adopting them. Furthermore, when studies fail to sufficiently explore the applicability of their methods in broader agricultural settings, scalability difficulties may surface. Moreover, the reliance on internet connectivity for data updates and recommendations may result in the inefficiency of these systems in locations with sporadic or restricted internet access [20]. A critical component, model correctness, depends on the caliber and volume of training data, and some studies might not fully validate their models. Precision agriculture raises several ethical and environmental issues that should be carefully considered, such as the overuse of chemical inputs and the replacement of traditional farming methods [20]. Farmers may also accept technology differently than other users due to cultural norms, lack of faith in technology, and availability of support and training. The dynamic and unpredictable character of agriculture, which is impacted by pests, market fluctuations, and climate change, needs appropriate system adaptation, which some publications may not sufficiently address.

IV. METHODOLOGY

In this paper, we have proposed an advanced Apriori algorithm that extracts the classification rules to recommend the best crop to farmers based on soil and properties. An important factor in identifying significant links between items in transactional databases is the Apriori algorithm, which is the foundation of association rule mining. Known for its use in

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market basket analysis in particular, this algorithm is excellent at detecting products that are commonly bought together, providing insightful information about consumer behavior.

Fundamentally, Apriori makes use of the "apriori property," which states that all of an item set's subsets must likewise be frequent if an item is frequent. This characteristic facilitates the rapid creation of candidate item sets while eliminating those that don't meet the minimal support requirement. Using pseudo code, this procedure is concisely described as follows: candidate and frequent item sets are carefully created, counted, pruned, and aggregated until no new frequent item sets appear. An essential tool for identifying patterns and correlations in a variety of fields, such as market analysis and recommendation systems, the algorithm's power comes from its capacity to sort through enormous amounts of transactional data. It does this by using the apriori characteristic to expedite the search process.

The data set (crop recommendation data set) was obtained from Kaggle which includes seven input parameters and one class label attribute. The experimental design is based on 2200 records from 22 different crops. Table 2 lists the input parameters considered for the experiments. Table 1 tabulates the various crops and the number of records with a specific crop's class label. Using a heuristic approach, all numerical values of input parameters are converted into categorical values during the data preprocessing step. A range of soil and environmental factors are presented in the table, each having continuous and categorical values. These variables include temperature, humidity, pH value (pH), rainfall, nitrogen content (N), phosphorous content (P), and potassium content (K). While the category values divide these parameters into "Low," "Medium," and "High" categories based on predetermined criteria, the continuous values show the actual measurements or ratios of these parameters. These classifications make it easier to understand and use these vital measures in practice when evaluating soil quality and environmental conditions for things like land management, environmental monitoring, and agriculture.

The data set is divided into 22 subsets. Each subset contains 100 records, one for each crop chosen for the experiment. A heuristic approach is a problem-solving or decision-making strategy that uses practical rules of thumb or shortcuts to find solutions or make decisions more quickly and efficiently, often in situations where a perfect or exhaustive solution is not feasible or would require too much time and resources. Heuristics are mental strategies or cognitive tools that help individuals simplify complex problems and navigate through uncertainty. They are particularly useful in situations where people need to make quick decisions or when faced with incomplete information.

TABLE 1. DATA SET DETAILS

S. No.	Class Label Name	Number of Records
1	Rice	100
2	Apple	100
3	Banana	100
4	Chickpea	100
5	Coconut	100
6	Coffee	100
7	Cotton	100
8	grapes	100
9	jute	100
10	Kidney beans	100
11	Lentil	100
12	Maize	100
13	Mango	100
14	Moth beans	100
15	Moonbeam	100
16	Muskmelon	100
17	Orange	100
18	Papaya	100
19	Pigeon peas	100
20	Pomegranate	100
21	Watermelon	100

TABLE 2. INPUT PARAMETERS

S. No.	Input Parameter Name	Details	Continuous values (Categorical value)		
1	N	The ratio of Nitrogen content in the soil	<=50(Low)	>50 &&<=100 (Medium)	>100(High)
2	P	The ratio of Phosphorous content in the soil	<=50(Low)	>50 &&<=100 (Medium)	>100 (High)
3	K	The ratio of Potassium content in the soil	<=70(Low)	>71&&<=140 (Medium)	>140(High)
4	Temperature	Temperature in degrees Celsius	<=20(Low)	>21&&<=32(Medium)	>32 (High)
5	Humidity	Relative humidity in %	<=35(Low)	>35&&<=70 (Medium)	>70 (High)
6	Ph	ph value of the soil	<=5(Low)	>5&&<=7 (Medium)	>7 (High)
7	Rain Fall	Rainfall in mm	<=90(Low)	>90&&<=180 (Medium)	>180 (High)

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Pseudo code:

The Apriori algorithm is based on the "apriori property," which states that if an item is frequent (i.e., it occurs with a minimum support threshold), all of its subsets must also be frequent. This property is leveraged to efficiently generate candidate item sets and prune those that do not meet the minimum support threshold.

Initialization:

Initialize a list of candidate itemsets, C, with frequent

items of size 1.

Initialize a list of frequent itemsets, L, with frequent items

of size 1.

Generate Frequent Itemsets:

while L is not empty:

// Generate candidate itemsets of size k+1 from frequent

itemsets of size k.

Ck+1 = Apriori-Gen(L)

// Count the support of each candidate itemset

by scanning the transaction database.

for each transaction in the database:

for each candidate item in Ck+1:

if the candidate item is a subset of the transaction:

Increment the support count of the candidate

itemset.

// Prune candidate itemsets that do not meet the

minimum support threshold.

Lk+1 = {candidate in Ck+1 | support(candidate)

>= min_support}

// Add frequent itemsets of size k+1 to the list

of frequent itemsets.

L = L ∪ Lk+1

Repeat the process until no new frequent itemsets

can be generated.
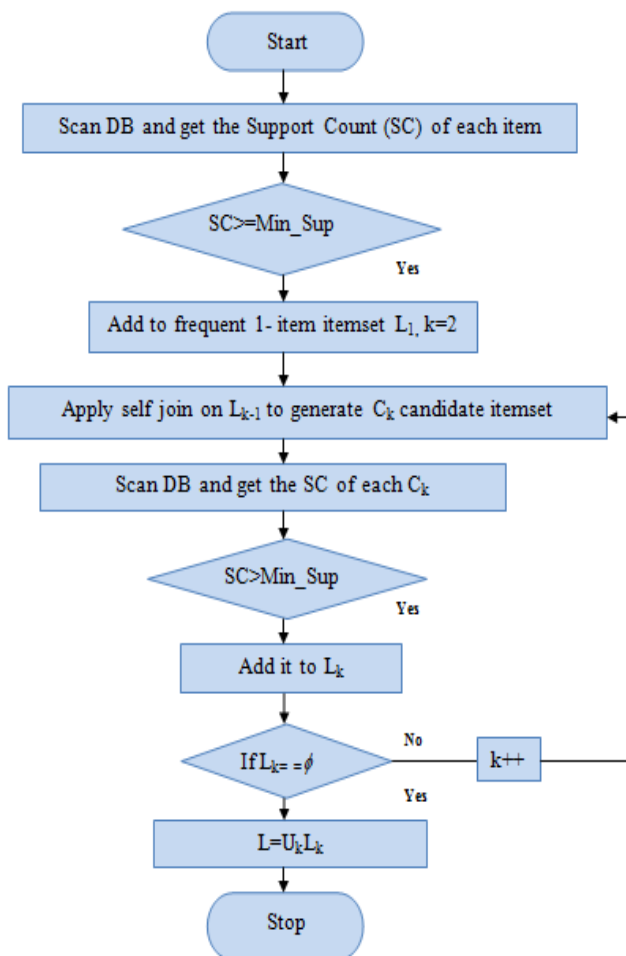
Figure 2: Flow diagram of Apriori Algorithm

V. IMPLEMENTATION & RESULTS

The Apriori algorithm is a well-known association rule mining technique for identifying frequent itemsets in a transactional database. It seeks out interesting relationships between different items in a dataset, such as products that are frequently purchased together in a store or items that are frequently viewed together on an online retail website. The Algorithm is driven by two metrics: support and confidence. Support quantifies an itemset's frequency and is defined as the proportion of transactions that contain the itemsets. Confidence is defined as the proportion of transactions containing both items over the number of transactions containing the first item and measures the likelihood of one item being purchased given the purchase of another item. The Experimental setup is done initially at support 0.6 and confidence 0.9, and an iterative heuristic approach is used to extract the association rules. The best top 8 rules are extracted at support count 0.4 and confidence 0.9. They are considered as best rules as their consequent part of the rule covers almost all input parameters considered for the experiments and also covers most of the input records. The rules recommending the best crop for the farmers are given below.

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a) R1:N=Medium&&K=Low &&temperature=Medium &&humidity=High&&ph=Medium &&rainfall= High ➔rice

b) R2: N=Low && P=High &&ph=Medium && rainfall=Medium ➔ apple

c) R3:P=Medium && K=Low && temperature=Medium && humidity=High &&ph=Medium && rainfall=Medium ➔banana

d) R4: N=Medium && P=Low && K=Low && temperature=Medium &&ph=Medium ➔maize

e) R5: N=Low && P=Low && K=Low && temperature=High&& humidity=Medium && rainfall=Medium ➔mango

f) R6: K=Low && humidity=High &&ph=Medium && rainfall=Medium && P=Low ➔orange

g) R7: P=Medium && temperature=High && humidity=High &&ph=Medium ➔papay

h) R8:temperature=Medium&&humidity=High &&ph=Medium && rainfall=Low && K=Low ➔watermelon

VI. CONCLUSION

Based on the Apriori algorithm's experimental setup and association rule mining, the algorithm has generated eight recommended rules for suggesting the best crop for farmers based on certain input parameters. Each rule consists of a set of conditions (antecedent) that indicate the input parameter values and a consequent part that suggests the best crop to grow. The rules are ranked based on their support and confidence values. Example Rule 1 (R1): If Nitrogen (N) is Medium, Potassium (K) is Low, Temperature is Medium, Humidity is High, pH is Medium, and Rainfall is High, then the recommended crop is Rice. Rule 2 (R2): If Nitrogen (N) is Low, Phosphorus (P) is High, pH is Medium, and Rainfall is Medium, then the recommended crop is Apple.

These rules are extracted from the transactional database and have been chosen as the best rules based on their ability to cover a significant portion of the input parameters considered in the experiments and cover a substantial number of input records. Farmers can use these rules as guidelines to make informed decisions about the most suitable crops to grow based on specific environmental conditions and soil nutrient levels.

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Comparison of Periodic Pattern Mining Algorithms on Temporal Datasets

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Abstract: The identification of periodic patterns is of great significance in revealing hidden temporal patterns and regularities across various domains, including finance, healthcare, and social networks. As the availability of large-scale temporal datasets continues to grow, the selection of an appropriate periodic pattern mining algorithm becomes crucial for efficient and accurate analysis. The objective of this research paper is to conduct a comparative evaluation of various periodic pattern mining algorithms applied to temporal datasets. The algorithms under consideration include Apriori-based methods such as Modified-Apriori and LPP-Apriori, as well as Tree-based approaches such as LPP Breadth, and LPP-FP Growth. We have assessed the performance of these algorithms across different datasets, focusing on metrics such as Execution Time, LPP Count, and memory usage.

Keywords: LPP-Apriori, LPP-FP-Growth, Modified-Apriori, Periodic Patterns, Timestamps.

1. Introduction

1.1 Introduction to Periodic Pattern Mining

Periodic pattern mining is a data mining technique that focuses on discovering recurring patterns in temporal datasets. Temporal datasets contain data points associated with timestamps or time intervals, representing events or observations that occur over time. By analyzing these datasets, we can discover hidden regularities and temporal dependencies, providing valuable insights into the underlying dynamics and patterns of various phenomena.

The analysis of temporal data has gained significant importance due to the increasing availability of large-scale datasets in diverse domains such as Retail, finance, healthcare, social networks, transportation, and more. These datasets capture time-varying information, which often exhibits periodic or cyclic behaviour. Examples of periodic patterns include daily stock market fluctuations, Market Basket Analysis, weekly social media trends, seasonal disease outbreaks, and monthly electricity consumption patterns.

The discovery of periodic patterns is crucial for understanding the inherent periodicity in temporal data and extracting meaningful knowledge from it. Periodic pattern mining algorithms are designed to search for recurring patterns that repeat at regular intervals or exhibit cyclical behaviour.

1.2 Motivation for comparing periodic pattern mining algorithms on temporal datasets

Comparing periodic pattern mining algorithms on temporal datasets is essential to identify the best algorithm for extracting recurring patterns from time-dependent data. This comparison is motivated by the need for algorithm selection, performance evaluation, scalability, accuracy, generalization, and advancement of the field. Such comparisons enable researchers and practitioners to make informed decisions, enhance algorithm design, and facilitate effective analysis of temporal data in various domains.

1.3 Research Objectives and Methodology

The research objectives are:

- Compare and evaluate periodic pattern mining algorithms on temporal datasets.
- Assess performance, capabilities, and limitations of selected algorithms.
- Determine algorithm suitability for various temporal data and applications.
- Identify strengths and weaknesses in pattern detection accuracy, scalability, and efficiency.
- Contribute to advancing periodic pattern mining research and algorithm design improvements.

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Methodology:

To accomplish the research objectives, the following methodology is employed:
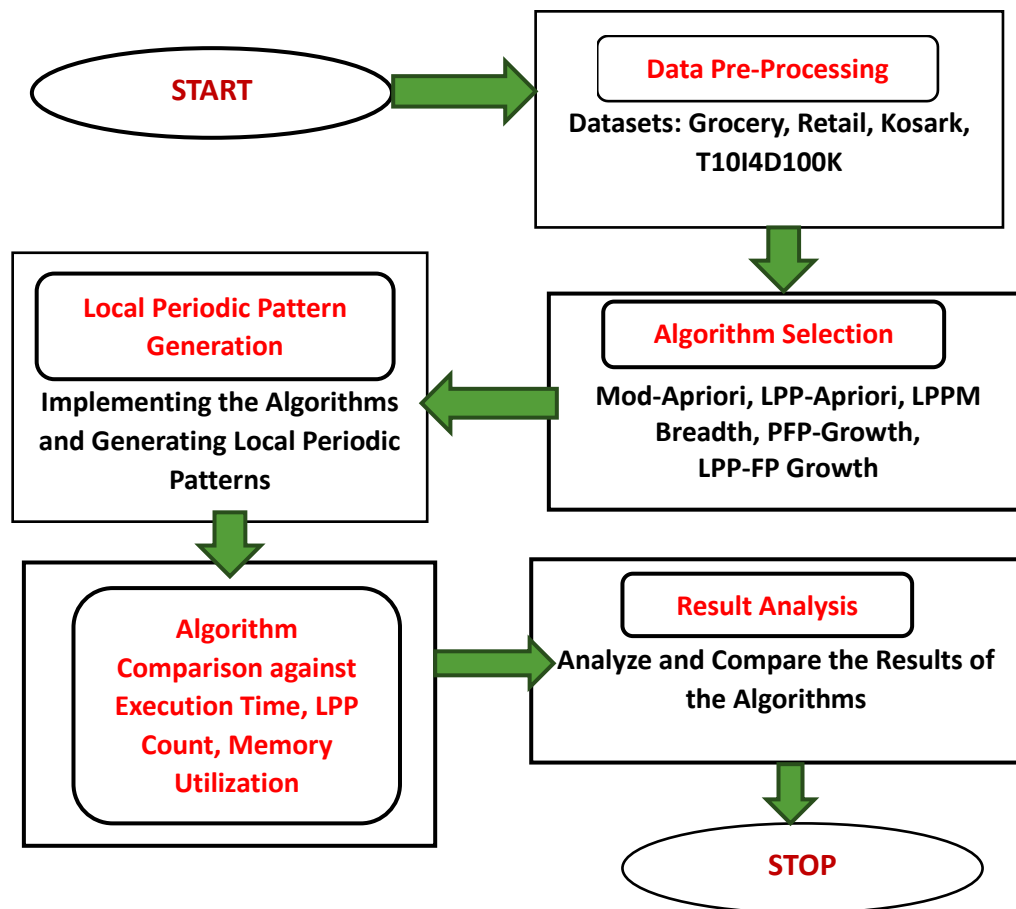
Fig 1.0 Proposed Methodology

By following this methodology, in this research paper we contribute the review of related work in the section2. In section 3 we present the description of our previously proposed algorithms. Section 4 follows the Results and discussion on comparative analysis of the algorithms. Section 5 concludes the research paper with the scope of future research directions.

2. Related Work

In the field of periodic pattern mining on temporal datasets, several studies have been conducted to compare and evaluate different algorithms. These works have contributed to the understanding of algorithmic performance, scalability, and applicability in various domains. The following is a review of some relevant related works:

Temporal data mining, as explored by Antunes and Oliviera (2001)[1], represents a significant expansion of traditional data mining techniques. By incorporating the temporal aspect, this approach allows for the extraction of more intriguing patterns that are influenced by time. Within temporal data mining, there are two main directions, as highlighted by Roddick and Spillopoulou (1999) [2]. The first direction focuses on uncovering causal relationships among events that are oriented in time. These events are arranged in sequences, where the cause of an event always precedes the event itself. The second direction involves identifying similar patterns within the same time sequence or across different time sequences.

An important expansion of the mining problem involves incorporating a temporal aspect. When a transaction occurs, its timestamp is automatically recorded. In datasets of this nature, certain patterns may exist that are specific to particular time periods rather than spanning the entire dataset's duration. Such patterns can provide valuable insights into customer behaviour. In their work (Ale and Rossi, 2000)[3], Ale and Rossi propose a method for extracting association rules that hold within the lifespan of a given item set, rather than the

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lifespan of the entire dataset. However, this method does not take into account the time intervals between successive transactions involving an item set. It is not designed to identify patterns with a periodic nature.

In [15], a novel method was presented by the author to detect periodicities based on calendar intervals (annual, monthly, and daily) and interval-based temporal patterns.

In research [4], Fourier-Viger expanded the traditional problem of mining periodic patterns to discover common periodic patterns across multiple sequences. Two new measures, the standard deviation of periods and the sequence periodic ratio, were introduced. Two algorithms, MPFPS BFS and MPFPS DFS, were proposed to efficiently mine these patterns using breadth-first search and depth-first search, respectively.

While traditional techniques for frequent itemset mining are valuable, they are limited in extracting periodically appearing patterns in databases. However, in domains like market basket analysis, understanding the periodic behavior of items provides important insights for marketing strategies and inventory management. Tanbeer et al. [5] introduced the concept of Periodic Frequent Patterns (PFPs) to address this issue in transactional databases. They utilized a compact tree-based data structure called PF-tree and a pattern growth mining technique to extract complete sets of periodic frequent patterns based on user-defined periodicity and support thresholds.

In another study [6], Philippe Fournier-Viger proposed a solution to the limitations of periodic pattern mining algorithms that discard patterns with single periods exceeding a user-defined threshold. They introduced three measures: minimum periodicity, maximum periodicity, and average periodicity. These measures offered more flexibility, and an efficient algorithm named PFPM (Periodic Frequent Pattern Miner) was proposed to discover all frequent periodic patterns based on these measures. However, this approach couldn't identify patterns that were periodic only during specific time intervals or sold during specific non-predefined periods, which is common in real-life scenarios.

Adhikari [13] incorporated transaction frequency (TF) and database frequency (DF) concepts to mine locally frequent item sets and two types of periodic patterns (cyclic and acyclic) in a two-phase algorithm.

While the occurrence frequency of patterns is considered important in many applications, the temporal regularity of patterns can provide additional valuable insights. Rashid et al. [14] proposed an alternative definition of PFPs that considers the variance of interval time between pattern occurrences. They used a pattern-growth approach with user-defined minimum support and maximum variance thresholds to find regularly frequent patterns. However, this method may generate uninteresting patterns and is influenced by outlier periods.

Esther Galbrun [17] proposed an approach for mining periodic patterns from event logs using a Minimum Description Length (MDL) criterion.

Titarenko [16] presented a method for fast implementation of pattern mining algorithms with time stamp uncertainties and temporal constraints, providing an integrated approach for efficient code generation.

A study [7] introduced HOVA-FPPM, an approach based on the Apriori method with hashed occurrence vectors, to find flexible periodic patterns. However, this method requires multiple dataset scans to discover the periodic patterns.

In [8], the problem of efficiently identifying patterns with interesting behavior, such as regularly repeating occurrences within a time interval, was addressed. The author extended an existing approach derived from frequent pattern mining to operate without user-specified periodicity. The proposed algorithms could identify time intervals, periodicity, and frequency of occurrence of all periodically occurring patterns within a user-defined tolerance. However, this method discovered more fragmented patterns and was more susceptible to noise. The issue of interestingness was not addressed.

Literature [18-20] discussed the extraction of gradual patterns from temporal sequences using periodic patterns and from ordered datasets under temporal constraints.

While many algorithms exist for identifying periodic frequent patterns, most assume that the periodic behavior remains consistent over time. Philippe Fournier [9] proposed a method to discover a novel type of periodic pattern in a sequence of events or transactions, called Local Periodic Patterns (LPPs) which are patterns (sets of events) that have a periodic behaviour in some non-predefined time-intervals. Two novel measures Max-So-Perd. (Maximum Spillover Period) which allow detecting time-intervals of variable lengths where a pattern is continuously periodic, while the Min-Dur. (Minimum Duration) ensures that those time intervals have a minimum duration. These measures are used to assess the periodicity and frequency of patterns in time intervals. To discover all LPPs, the paper proposed an efficient algorithm, named LPP-Growth. It respectively adopts a pattern-growth approach by extending the FP-Growth algorithm.

Based on the literature review provided, it can be inferred that considering varying time intervals can result in the extraction of different frequent patterns, which can yield valuable insights. In this research, our focus is on identifying valid time intervals in which frequent patterns exist and determining their periodicity.

Our study involves comparing the efficiency of novel techniques for mining local periodic patterns and their associated time intervals from temporal transactional datasets.

To initiate our research, we built upon the considerations presented in a base paper [10]. Inspired by this work, we introduced a new notation called TC (Time Cube) to represent time hierarchies in the mining process. Subsequently, we implemented this novel algorithm called Modified-Apriori, which incorporates the Apriori property while introducing two new threshold values: support and density. This algorithm successfully discovers frequent itemsets along with their corresponding time intervals, merging those with neighbouring time intervals. We evaluated the algorithm's performance through experiments conducted on synthetic datasets, and during this evaluation, we identified a major limitation: the algorithm requires the user to specify the periods (time intervals) as a user-defined parameter.

To overcome this limitation, we extended our research and proposed a novel algorithm called LPP-Apriori in our previous research paper [11]. LPP-Apriori is capable of extracting various types of periodic patterns present in temporal datasets without the need for users to predefine the periods. In this method, we treated timestamps as a hierarchical data structure and extracted periodic patterns along with a list of time intervals in which they appear frequently or periodically. To determine the count of periodic patterns in different time intervals, we utilized a set operation known as Set-Superimposition, proposed by Baruah (1999), for string periods associated with itemsets. However, it was observed that this algorithm also had limitations. The assessment of periodicity relied on a strict measure called Maximum Periodicity, which assumed that a pattern must have a periodicity below a threshold value to be considered periodic. This strict measure posed a problem as real-life data often exhibits variability between periods within a pattern. Consequently, if a pattern had a single period length exceeding the Maximum threshold, it would be discarded. Thus, this method was overly strict and unable to detect patterns that are periodic only within specific time intervals rather than the entire dataset.

To address these limitations, a novel technique is required to identify local periodic patterns that consider timestamps and exhibit flexibility by finding periodic patterns within time intervals. Three challenges need to be tackled:

1) Avoiding the use of a strict definition of periodicity to discover local periodic patterns, necessitating the design of novel measures that consider the changing periodic behaviour of patterns.
2) Identifying non-periodic time intervals where patterns exhibit periodicity, requiring the identification of starting and ending points for these time intervals.
3) Efficiently finding desired patterns while minimizing the consideration of a large number of candidate patterns. Effective search space pruning techniques are essential to exclude unpromising patterns and non-periodic time intervals, as considering a large number of candidates can lead to lengthy execution times and excessive memory consumption.

To overcome these challenges, we expanded our previous method, the LPP-Apriori Algorithm, and introduced a novel technique called LPP-FP Growth Algorithm in our earlier research paper [12]. This new technique, motivated by [34], aims to identify local periodic patterns that exhibit periodic behaviour within non-predefined time intervals. The LPP-FP Growth Algorithm introduces two novel measures for assessing periodicity and frequency in time intervals:

Maximum Spillover Period (Max-So-Perd), which detects time intervals of varying lengths where a pattern exhibits periodic behaviour that may vary.

Minimum Duration (Min-Dur), a threshold ensuring that these time intervals have a minimum duration.

In the following section, we provide a brief description of our earlier proposed Algorithms.

3. Periodic Pattern Mining Algorithms

3.1 Modified Apriori:

MazaherGhorbani and Masoud Abessi, in [17] proposed a novel technique for mining frequent itemsets from temporal data. The authors proposed an efficient algorithm that focuses on discovering frequent patterns along with their associated time intervals within transactional databases.

The approach begins by introducing time cubes (TC) as a new notation to incorporate time hierarchies into the mining process. Subsequently, the authors developed an algorithm based on two thresholds: support and density, the latter being a novel addition. Frequent itemsets are identified, and those with neighbouring time intervals belonging to the same frequent itemsets are merged. This technique assumes that patterns can exist in some or all time intervals. To achieve this, a time cube analysis of frequent patterns is conducted. The entire dataset is partitioned into various time cubes, such as (hour, day, month), (day, month, year), etc., and the

Apriori algorithm is applied to these time cube data. The concept of temporal support value is utilized. The minimum support threshold is employed to assess the frequent itemsets. However, due to uneven distribution of records within time intervals, some occasions may have very few records, resulting in potentially invalid discovered patterns lacking sufficient evidence to demonstrate their validity throughout the entire time interval. This issue leads to an overestimation problem. To address these challenges, an additional threshold called Density is proposed. Density not only ensures the validity of the patterns but also eliminates time intervals with few transactions, thereby mitigating the overestimation of timespans.

Nevertheless, the algorithm described in the paper has certain limitations. The processing time is significant as the itemsets need to be mined for each time cube. Additionally, one limitation of the algorithm is that the time intervals are user-defined, potentially restricting its flexibility and adaptability.

3.2 LPP Apriori:

LPP Apriori, an improved version of the Modified Apriori algorithm, was developed to mine periodic patterns in temporal datasets. In a previous research paper [11], we introduced LPP Apriori to overcome the limitations of the Modified Apriori algorithm. Our approach leverages timestamp data to identify frequent itemsets and their corresponding time intervals.

In this method, we treat time as a hierarchical structure and dynamically extract local periodic patterns by considering time intervals without requiring explicit user input. During the scanning process, the algorithm automatically identifies time intervals where patterns exhibit frequency. By utilizing the Spillover Period and Maximum Spillover Period of itemsets, the algorithm constructs time intervals for periodic patterns. These intervals are pruned based on user-defined thresholds for Minimum Duration and Minimum Support. The algorithm generates candidate periodic patterns iteratively and prunes infrequent ones according to the specified thresholds.

While LPP Apriori offers a straightforward and intuitive approach, scalability can be a concern when dealing with large datasets since multiple scans are required to generate and validate candidate patterns. Furthermore, a major limitation of LPP Apriori lies in its strict evaluation of periodicity using the Maximum Periodicity measure. This criterion assumes that a pattern must have a periodicity below the given threshold to be considered periodic. However, real-life data often exhibits variability between periods. Unfortunately, if a pattern has a single period exceeding the Maximum threshold, it is discarded. Consequently, this strict measure fails to capture patterns that are periodic only within specific time intervals rather than spanning the entire dataset.

To address these limitations, we have extended our research with a novel technique called LPP-FP Growth, which is discussed in the subsequent section.

3.3 LPP FP Growth

Tree-based algorithms such as LPPM Breadth, LPPM Depth, and LPP-FP Growth offer effective solutions for discovering periodic patterns in temporal datasets. These algorithms leverage tree structures to efficiently capture and extract recurring patterns. In this section, we present a detailed description of our proposed LPP-FP Growth algorithm [12].

The LPP-FP Growth algorithm utilizes three important parameters: Max-Perd, Max-So-Perd, and Min-Dur. The Max-Perd parameter allows users to specify the maximum expected time between consecutive occurrences of periodic patterns. With the Max-So-Perd parameter, patterns can temporarily exceed the Max-Perd threshold if the cumulative spillover (surplus) remains below the Max-So-Perd value. This parameter enhances flexibility compared to traditional periodic frequent pattern mining algorithms that rely solely on the maximum periodicity constraint. Lastly, the Min-Dur parameter defines the minimum length of time intervals and is utilized to discard short intervals. It is crucial to set these parameters appropriately, as they depend on the dataset characteristics and user preferences.

The LPP-FP Growth algorithm operates in two steps:

    (i) It first compresses the input database into a tree structure called the time-interval periodic frequent tree (LPP-tree).

    (ii) It then recursively mines the LPP-tree to discover all Local Periodic Patterns (LPPs).

Inspired by the tree-based pattern-growth approach of the FP-Growth algorithm, the LPP-FP Growth algorithm has been specifically adapted for the task of mining LPPs.

3.3.1 LPP-Tree Structure

The algorithm consists of two main components: a prefix-tree and an LPP-list. The LPP-list contains entries with two fields: an Item Name and a Periodic Time-Interval List (PTL). The prefix-tree, known as the LPP-tree, draws inspiration from the structure of the FP-tree used in FP-Growth for transaction storage. Similar to the FP-tree, the LPP-tree organizes transactions as paths within a tree, where each node represents an item.

However, there is a significant distinction between the FP-tree and the LPP-tree. In the LPP-tree, nodes explicitly store occurrence information about items in transactions to efficiently calculate the PTL of patterns. Specifically, a timestamp list known as the TS-list is stored in the last node of every transaction within the LPP-tree. As a result, the LPP-tree maintains two types of nodes: Ordinary Nodes and Tail Nodes.

3.3.2 Mining LPP-Tree

Once the LPP-tree has been constructed, the proposed algorithm no longer requires scanning the original database to discover Local Periodic Patterns (LPPs). This is because all the crucial information for LPP mining is stored within the LPP-tree. To identify LPPs, our algorithm utilizes a depth-first search approach, similar to the FP-Growth algorithm, to explore the itemset search space. The exploration begins with LPPs that consist of a single item, which are stored in the LPP-list.

The algorithm performs a depth-first search exploration, taking as input the initial LPP-tree (T), user-defined thresholds such as Maximum Period, Maximum Spillover Period, and Minimum Duration, and an itemset (α) for LPP identification. By pruning itemsets that lack periodic time-intervals, the algorithm can uncover all LPPs while minimizing unnecessary search efforts.

4. Implementation & Experimental Setup

In this section, we discuss the implementation of our proposed Algorithms LPP-Apriori, LPP-FP Growth and existing algorithm in research literature Modified Apriori and LPPM-Breadth. Here we evaluate the performance of the algorithm in terms of execution time, local pattern count, and memory utilization. The performance of our proposed algorithm is compared with earlier local periodic pattern algorithms based on Apriori based Approach and Tree based Approach. These proposed algorithms are implemented in Python 3.10.2 on Intel® Core™ i5-10210U CPU @1.60 GHz on Windows 11 operating system. We have collected the data from FIMI-Frequent Itemset Mining Dataset Repository (http://fimi.uantwerpen.be/data/)& from UCI Machine Learning Repository (https://archive.ics.uci.edu/ml/datasets/Online+Retail+II).

We conducted the experiments on different datasets including Grocery, Kosark, Retail, and T10I4D100K.

4.1 Description of Data sets
1. Grocery

This is the groceries data with the list of items bought by customers. From the left side is the number of items in a basket then Item 1, 2, 3, etc. stands for list of the item. The dataset contains 10027 transactions by customers shopping for groceries. The data contains 169 unique items. The data is suitable to do data mining for market basket analysis which has multiple variables. We have taken subset of this data from https://www.kaggle.com/datasets/irfanasrullah/groceries web page.

2. Kosark

This dataset was provided by Ferenc Bodon and contains (anonymized) click-stream data of a Hungarian On-Line New Portal. This is a very large dataset containing 990 000 sequences of click-stream data. The dataset was converted in SPMF format using the original data from: http://fimi.ua.ac.be/data/. We have downloaded a subset of this data from https://www.philippe-fournier-viger.com/spmf/index.php?link=datasets.php web page.

3. Retail

This dataset was donated by Tom Brijs and contains the (anonymized) retail market Basket data from an anonymous Belgian Retail Store. The data is collected over three non-consecutive periods. The total amount of receipts being collected equals 88,162. The average number of distinct items (i.e. different products) purchased per shopping visit equals 13 and most customers buy between 7 and 11 items per shopping visit.

4. T10I4D100K

This dataset was generated using the generator from the IBM Almaden Quest research group. It is available on the http://fimi.uantwerpen.be/data/ web page.

The characteristics of the above dataset(s) after formatting into a temporal dataset are shown in the following table.

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Table 1 Characteristics of Dataset(s)

SNO	DATASET	NO. OF TRANSACTIONS	NO. OF ITEMS	MIN. TRANS. SIZE	MAX. TRANS. SIZE
1	Grocery	10027	86	1	11
2	Kosark	44953	18287	1	699
3	Retail	88162	16470	1	76
4	T10I4D100K	100000	870	1	29

4.2 Incorporating Temporal Features in datasets

As the dataset is non-temporal so it cannot be directly used. We have incorporated the temporal features in the dataset so that it can be a temporal dataset and can be used by our proposed Algorithm. We developed a program for this. The program takes starting date and time (Timestamp), the number of Transactions or records in the dataset, and synthetic data as inputs. It then generates the series of Timestamps equal to the number of transactions and merges the generated Timestamps with the dataset as the first column entry in the dataset. Dataset features such as the number of items, number of transactions, average transaction length, and time span of the dataset can be set by the user. The Algorithms for pre-processing the data is given below:

To pre-process data by converting non-temporal data into temporal or timestamp data and handling missing values, has been done with the following steps:

1. Identify non-temporal data: Analyze the dataset and identify columns that contain non-temporal data but can be converted into temporal or timestamp data. For example, columns containing dates or time information represented in a non-temporal format.

2. Convert non-temporal data to temporal format: For each identified column, apply appropriate data conversion techniques to convert the non-temporal data into a temporal or timestamp format. This has been done by parsing and reformatting the values using Python's datetime module or specific date/time libraries.

3. Handle missing values: Missing values are common in datasets and can impact the quality of data analysis. Considered the following technique to handle missing values:

Imputation: Since the missing values are significant or removing them would result in data loss, we have considered imputing or filling in the missing values with Zero or NaN Values.

4. Fix the Number of Columns:

To fix the number of columns in a text file using Python, you can follow these steps:

Step1. Read the text file.

Step2. Split each line of the file by the delimiter (such as a comma or tab) to obtain the individual columns.

Step3. Check the number of columns in each line.

Step4. If the number of columns is less than the desired number, append empty values to make up the difference.

Step5. If the number of columns is greater than the desired number, truncate the list of columns to the desired length.

Step6. Join the columns back together using the delimiter.

Step7. Write the modified lines to a new file or overwrite the original file.

5. Update or save the pre-processed data

Finally, we have updated the original dataset with the pre-processed values or save the pre-processed data to a new file for further analysis.

We have implemented the proposed Algorithm Mod-Apriori in Python 3.10.2 on the windows 10 Operating System. The executive summary and the experimental results of the Proposed Algorithm implemented on different formatted temporal data sets are discussed in the following section.

4.3 Implementation Results

We have implemented the proposed Algorithm Mod-Apriori in python 3.10.2 on the Windows 11 Operating System. The executive summary and the experimental results of the Proposed Algorithm implemented on different formatted temporal data sets are discussed in this section. The frequent patterns of Grocery Dataset along with timestamp intervals received after implementing the LPP-Apriori Algorithm is shown below as an example. The Generated Frequent Patterns with Time intervals are:

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Frequent One Itemset			
Item	Starting Date	Ending Date Item Count	Item Support
[{'bread'}, '09-10-2000 14:00:00', '14-10-2000 04:00:00', 11, 0.2]			
[{'citrus'}, '19-02-2000 00:00:00', '25-02-2000 14:00:00', 16, 0.2]			
[{'fruit'}, '01-01-2000 00:00:00', '15-04-2002 12:00:00', 2131, 0.21]			
[{'milk'}, '01-01-2000 04:00:00', '15-04-2002 02:00:00', 2750, 0.27]			
[{'other'}, '04-11-2001 00:00:00', '15-04-2002 12:00:00', 385, 0.2]			
[{'pip'}, '22-10-2000 20:00:00', '25-10-2000 20:00:00', 8, 0.22]			
[{'rolls/buns'}, '01-01-2000 12:00:00', '18-06-2000 22:00:00', 411, 0.2]			
[{'rolls/buns'}, '22-06-2000 00:00:00', '01-09-2000 18:00:00', 185, 0.21]			
[{'rolls/buns'}, '16-08-2001 14:00:00', '16-01-2002 14:00:00', 371, 0.2]			
[{'vegetables'}, '01-01-2000 08:00:00', '15-04-2002 12:00:00', 2898, 0.29]			
[{'water'}, '13-06-2001 04:00:00', '21-06-2001 22:00:00', 23, 0.22]			
[{'white'}, '10-10-2000 00:00:00', '13-10-2000 22:00:00', 11, 0.23]			
[{'whole'}, '01-01-2000 04:00:00', '19-09-2000 14:00:00', 796, 0.25]			
[{'whole'}, '23-09-2000 08:00:00', '15-04-2002 02:00:00', 1717, 0.25]			
Frequent-TWO itemset			
Item	Starting Date	Ending Date Item Count	Item Support
[{'fruit', 'citrus'}, '19-02-2000 00:00:00', '25-02-2000 14:00:00', 16, 0.2]			
[{'fruit', 'pip'}, '22-10-2000 20:00:00', '25-10-2000 20:00:00', 8, 0.22]			
[{'milk', 'other'}, '01-10-2001 20:00:00', '07-10-2001 10:00:00', 15, 0.22]			
[{'milk', 'whole'}, '01-01-2000 04:00:00', '19-09-2000 14:00:00', 796, 0.25]			
[{'milk', 'whole'}, '23-09-2000 08:00:00', '15-04-2002 02:00:00', 1717, 0.25]			
[{'vegetables', 'other'}, '04-11-2001 00:00:00', '15-04-2002 12:00:00', 385, 0.2]			
[{'whole', 'other'}, '01-10-2001 20:00:00', '07-10-2001 10:00:00', 14, 0.21]			
[{'vegetables', 'whole'}, '03-09-2000 00:00:00', '19-09-2000 14:00:00', 41, 0.2]			
[{'vegetables', 'whole'}, '21-07-2001 08:00:00', '08-08-2001 06:00:00', 44, 0.2]			
[{'vegetables', 'whole'}, '08-09-2001 06:00:00', '12-09-2001 18:00:00', 11, 0.2]			
Frequent-THREE itemset			
Item	Starting Date	Ending Date Item Count	Item Support
[{'milk', 'whole', 'other'}, '01-10-2001 20:00:00', '07-10-2001 10:00:00', 14, 0.21]			
[{'vegetables', 'whole', 'other'}, '01-10-2001 20:00:00', '07-10-2001 10:00:00', 14, 0.21]			

We have received the same type of results after implementing the LPP-Apriori, Mod-Apriori, LPP-FP Growth algorithms on different datasets as shown above. We have not included them due to space problem.

5. Results and Discussion

In this section, we delve into the analysis of performance for the proposed algorithms, namely LPP-Apriori and LPP-FP Growth, as well as other Python-implemented algorithms including Mod-Apriori, PFP Growth, and LPP Breadth. Our analysis focuses on two key parameters: Execution time and the generation of Local Periodic Patterns. The objective of our research revolves around generating Frequent Itemsets within specific time intervals. We aim to explore how these item sets manifest across different temporal intervals, highlighting their detection limitations in non-temporal datasets.

In the second experiment, we conduct a comparative assessment of the algorithm's execution performance against our previously developed Periodic Pattern Algorithm. The algorithms are executed on each dataset while varying parameter values. The purpose is to compare algorithm performance in diverse scenarios and observe the impact of parameter settings on their effectiveness. Generally, as the values of Max-So-Per and Max-Perd increase, and Min-Dur decreases, the search space is expected to expand, potentially uncovering more patterns and resulting in longer runtimes. However, it should be noted that the performance of the same

algorithm can vary significantly across different datasets due to varying dataset characteristics, even with identical parameter values.

5.1 Execution Time

In this section, we present a comparative analysis of the runtime performance for the proposed algorithms LPP-Apriori and LPP-FP Growth, as well as the implemented algorithms Modified-Apriori, PFP-Growth, and LPP-Breadth. The table below displays the execution time taken by each algorithm, measured in seconds.

Table 2 Comparative Table of Execution Time

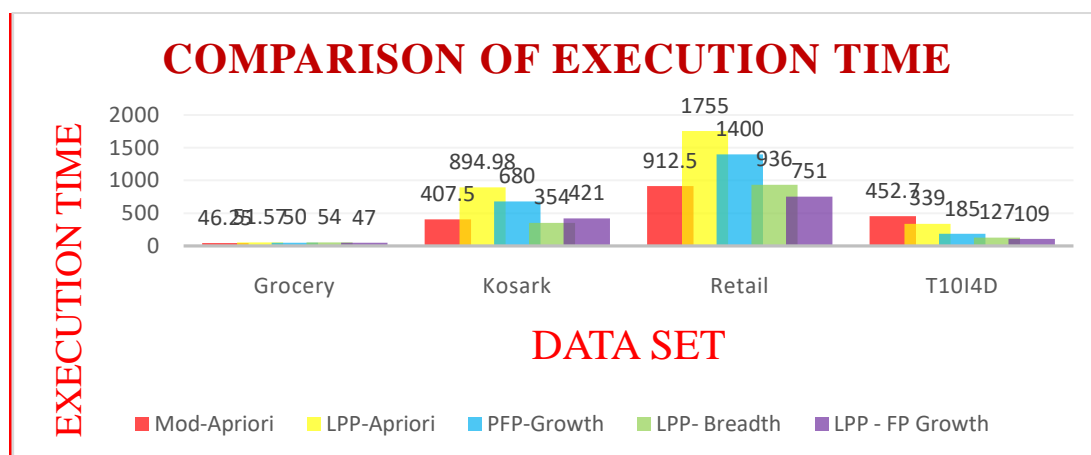| Dataset	Execution Time (Sec.)				
	Mod-Apriori	LPP-Apriori	PFP-Growth	LPP Breadth	LPP-FP Growth
Grocery	46.25	51.57	50	54	47
Kosark	407.5	894.98	680	354	421
Retail	912.5	1755	1400	936	751
T10I4D	452.7	339	185	127	109

Fig2 Comparison of Execution Time

Based on the comparative graph above, it is evident that the LPP-FP Growth Algorithm exhibits shorter execution times compared to LPP-Apriori, Mod-Apriori, PFP-Growth, and LPP-Breadth Algorithms. The LPP-FP Growth algorithm demonstrates superior speed compared to the other algorithms. The graph reveals that it takes 751 seconds for execution on the Retail dataset, which is smaller in size compared to the T10I4D dataset where it takes 109 seconds. This disparity can be attributed to the Retail dataset generating a higher number of periodic patterns and being denser in nature. Therefore, we can conclude that the LPP-FP Growth algorithm excels in runtime efficiency compared to the other algorithms. The objective of improving the algorithm's runtime efficiency has been successfully achieved through the implementation of LPP-FP Growth.

5.2 Memory Usage

In the third experiment, we compared the peak memory consumed by our proposed algorithm LPP-FP Growth, LPP Apriori and earlier algorithms Mod-Apriori, PFP-Growth, LPP Breadth. The statistics of these algorithms is shown in the following table.

Table 3Comparative Table of Memory Usage

Dataset	Memory Usage				
	Mod-Apriori	LPP-Apriori	PFP-Growth	LPP Breadth	LPP-FP Growth
Grocery	59	115	165	162	147
Kosark	297	629	345	321	282
Retail	602	1342	363	480	560
T10I4D	642	1432	456	392	125
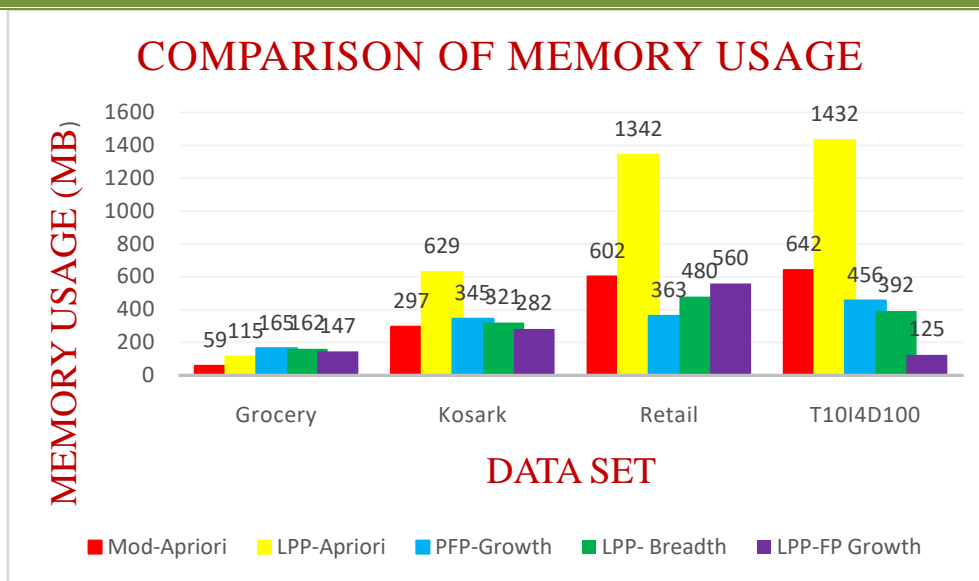
Fig3 Comparative Graph of Memory Usage

From the above Figure it is observed that our proposed Algorithm LPP-FP Growth consumes less memory than the other Algorithms. So we can conclude that the LPP-FP Growth is memory efficient than other Algorithms. The reason behind this is it uses a compact tree structure for representing the database, and timestamps are only saved in tail nodes.

5.3 LPP Count
In this we discuss the comparative results of our proposed algorithms LPP-Apriori, LPP-FP-Growth and implemented algorithms Mod-Apriori,PFP-Growth and LPP Breadth for the Local Periodic Patterns generated by the algorithms. The following table shows the LPP-count of algorithms on various datasets.

Table 4Comparative table of LPP Count

Dataset	LPP Count				
	Mod-Apriori	**LPP-Apriori**	**PFP-Growth**	**LPP Breadth**	**LPP-FP Growth**
Grocery	16	26	58	65	73
Kosark	12	38	24	38	41
Retail	23	13	84	89	94
T10I4D	12	22	46	52	55

Fig4 Comparative Graph of LPP Count

Based on the comparative chart provided, it can be observed that the LPP-FP Growth Algorithm outperforms Mod-Apriori, LPP-Apriori, LPP-Breadth, and PFP Algorithms in terms of generating a greater number of Local Periodic Patterns. This indicates that the LPP-FP Growth Algorithm effectively prunes uninteresting patterns and focuses on detecting the recurring and relevant local patterns.
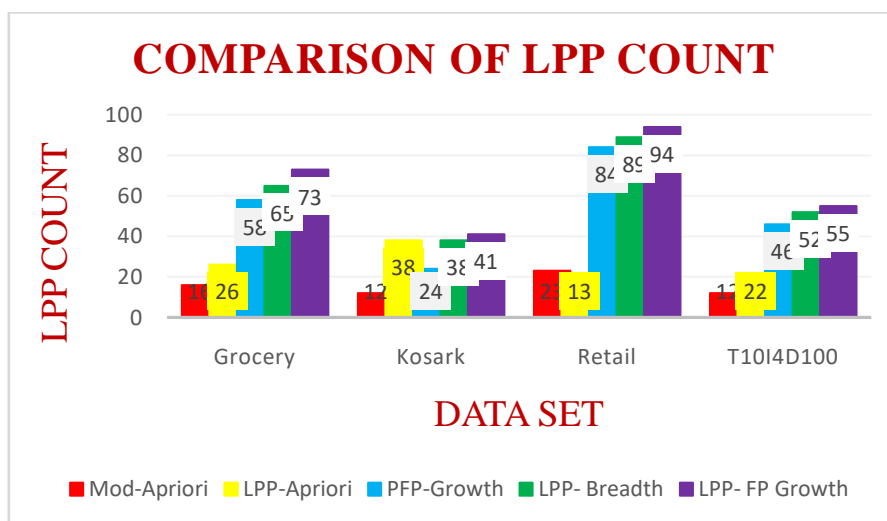
Through the aforementioned comparisons, it is evident that the LPP-FP Growth Algorithm excels in various aspects, including Execution time, Memory usage, and the generation of meaningful Local Periodic Patterns. The comparative results demonstrate that the LPP-FP Growth algorithm utilizes less memory, produces a higher number of LPPs, and exhibits faster runtime performance compared to the other algorithms, namely LPP-Apriori, Mod-Apriori, LPP-Breadth, and PFP-Growth algorithms.

5.4 Pattern Count Analysis of LPP FP Growth

In this section we analysed the LPP Count of LPP FP Growth Algorithm on the Grocery Dataset by varying the parameters Maximum Period, Maximum Spill Over Period, and Minimum Duration. The results obtained are shown in the following table.

Table 5 LPP Count Analysis

Max-Perd	Max.Spillover Perd.	Min.Dur	LPP count	Execution Timein Sec.	Memory Usage In MB
3	3	7	12	67.88	150.21
3	3	10	6	63.9	148.28
5	5	7	57	28.45	160.43
5	5	10	41	28.57	156.07

From the above table, it is observed that by increasing the Maximum Period and Maximum Spillover Period and decreasing the Minimum duration the LPP Count is increased, i.e. we can generate more number of Local Periodic Patterns by varying these parameters. The impact of these measures on the number of LPPs discovered is comparable to their effect on the runtime of the algorithms. This is due to the fact that modifying these parameters affects the size of the search space, which tends to increase or decrease in proportion to the number of patterns.

5.5 Pattern Analysis

In order to evaluate the effectiveness of the proposed LPP Apriori Algorithm, an analysis of patterns discovered in the Grocery dataset, consisting of customer transactions, was conducted. The objective of this experiment was to determine whether the algorithm identifies interesting patterns that offer insights into customer shopping behavior. By adjusting the parameters, it was discovered that setting Max.Perd to 2 days, MaxSoPerd to 2 days, and Min.Dur to 10 days resulted in the identification of several noteworthy patterns. A selection of these patterns is presented in the following table.

Table 6 Pattern Analysis

[{'vegetables', 'whole-Milk'}, '03-09-2000 00:00:00', '19-09-2000 14:00:00', 41, 0.2]
[{'vegetables', 'whole-Milk'}, '21-07-2001 08:00:00', '08-08-2001 06:00:00', 44, 0.2]
[{'vegetables', 'whole-Milk'}, '08-09-2001 06:00:00', '12-09-2001 18:00:00', 11, 0.2]

As depicted above, the first pattern highlights the periodic sale of Vegetable and Milk products occurring during specific time intervals: from '03-09-2000 00:00:00' to '19-09-2000 14:00:00', from '21-07-2001 08:00:00' to '08-08-2001 06:00:00', and from '08-09-2001 06:00:00' to '12-09-2001 18:00:00'. This pattern reflects the purchasing behavior of customers during these time periods. It is noteworthy that this pattern exhibits periodicity only for a short duration within the entire year and repeats within the same time intervals across multiple years (2000 and 2001). Consequently, traditional periodic frequent pattern mining algorithms, which primarily focus on identifying patterns that are periodic throughout the entire year, would disregard this pattern. Moreover, it is important to note that this pattern encompasses multiple distinct periodic time intervals within the same year.

Overall, it has been noted that the algorithms exhibit satisfactory performance and possess the ability to identify intriguing patterns within real-world data that traditional models, which primarily emphasize periodicity throughout the entire database, fail to uncover. The suggested algorithms have the capability to unveil patterns within time intervals that are not predetermined, with each algorithm demonstrating superior performance under

specific circumstances. There are various potential avenues for future research, including exploring alternative forms of localized periodic patterns, accommodating streaming data, and devising techniques for automated parameter selection.

6. Conclusion

This study presents an innovative comparative analysis of Local Periodic Pattern Mining Algorithms, specifically Modified Apriori, LPP-Apriori, PFP-Growth, LPP-Breadth, and LPP-FP Growth. The assessment of these algorithms is conducted using three real-world datasets and one synthetic dataset. The evaluation focuses on three key aspects: Execution time, Memory Utilization, and the generation of Local Period Patterns. The results reveal that the LPP-FP Growth algorithm outperforms other periodic pattern mining algorithms in terms of Execution time, Memory Consumption, and the generation of local periodic patterns. The experimental evaluation across various datasets demonstrates the efficiency of the LPP-FP Growth algorithm, highlighting its ability to discover valuable patterns that traditional periodic pattern mining algorithms fail to identify.

In future research, there would be intriguing to adapt the suggested algorithms for implementation within big data frameworks, incorporating technologies like GPUs, multi-threading, and other high-performance computing approaches. Such adaptations would enable the processing of larger databases in shorter time frames. Another intriguing avenue for exploration involves extending the proposed model to handle non-static databases, such as incremental databases and data streams. Furthermore, there is the possibility of extending the model to accommodate other types of patterns, such as sequential patterns and rules, or designing automated methods for parameter selection.

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Research Article

Analysis of Deep Learning Methods for Healthcare Sector - Medical Imaging Disease Detection

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Abstract: In this paper, artificial intelligence (AI) and the ideas of machine learning (ML) and deep learning (DL) are introduced gradually. Applying ML techniques like deep neural network (DNN) models has grown in popularity in recent years due to the complexity of healthcare data, which has been increasing. To extract hidden patterns and some other crucial information from the enormous amount of health data, which traditional analytics are unable to locate in a fair amount of time, ML approaches offer cost-effective and productive models for data analysis. We are encouraged to pursue this work because of the quick advancements made in DL approaches. The idea of DL is developing from its theoretical foundations to its applications. Modern ML models that are widely utilized in academia and industry, mostly in image classification and natural language processing, include DNN. Medical imaging technologies, medical healthcare data processing, medical disease diagnostics, and general healthcare all stand to greatly benefit from these developments. We have two goals: first, to conduct a survey on DL techniques for medical pictures, and second, to develop DL-based approaches for image classification. This paper is mainly targeted towards understanding the feasibility and different processes that could be adopted for medical image classification; for this, we perform a systematic literature review. A review of various existing techniques in terms of medical image classification indicates some shortcomings that have an impact on the performance of the whole model. This study aims to explore the existing DL approaches, challenges, brief comparisons, and applicability of different medical image processing are also studied and presented. The adoption of fewer datasets, poor use of temporal information, and reduced classification accuracy all contribute to the lower performance model, which is addressed. The study provides a clear explanation of contemporary developments, cutting-edge learning tools, and platforms for DL techniques.

Keywords: deep learning, deep features, medical image classification, DL techniques, healthcare sector analysis

MSC: 68T05

1. Introduction

In this age of algorithms, numerous industries, including manufacturing, transportation, and government, have seen significant transformations due to the frameworks of machine learning (ML) and various deep learning (DL) techniques. DL has had a significant impact on many scientific fields in recent years [1]. With respect to the advancements in AI (artificial intelligence) technology, the world is currently growing quickly. The use of AI techniques in healthcare is increasingly common for precise illness diagnosis, patient risk assessment, and clinical research. These approaches vary from ML to DL. AI is concerned with how intelligent robots act to mimic human behavior and use algorithms that can be successfully developed using machine technology. The current models for disease classification in healthcare systems either involve ML or DL.

Since it helps with diagnosis and medication analysis, precise medical picture classification has become increasingly important in the last few years. One of the most crucial concerns in the field of image detection is the classification of images for medical purposes. The main goal is to categorize medical images into different categories to aid clinicians in identifying the precise ailment and use them for further research. Medical picture classification often involves two phases. Getting useful features out of the image is the first step. The next stage is to build models to categorize the clinical data using the features.

Given the complexity of the data, it has become more appealing to apply ML and different techniques of data mining, such as deep neural networks (DNNs), to analyze such data. To develop trustworthy assessment methods utilizing ML models and data-driven techniques, establishing the correlations between all the various patient data formats is a fundamental challenge.

This systematic literature review is intended to supplement existing research by providing the following contributions to the DL approach in medical image data processing. In this review work, we divided DL techniques utilized between 2015 and 2019 into two groups: single DL and hybrid DL. Single-supervised learning refers to techniques that only use DL architecture to create their models. On the other hand, hybrid DL refers to processes that combine DL with other classical ML models. This is how we compare the benefits and drawbacks of DL techniques to models that use both traditional ML algorithms and DL design.

In the last ten years, numerous ML and various AI concepts have been employed to efficiently evaluate the vast amounts of data in the healthcare industry. For instance, a statistical regression-based methodology was proposed to create an automated early detection system for heart disease [2]. Medical imaging has also used ML to automatically identify object attributes [3]. DNN-based techniques are garnering a lot of attention among the many ML models, especially when it comes to the analysis of large datasets. DL approaches, which go through a number of stages in the learning process, are used to filter data through a cascade of layers. DNN models outperform many conventional ML models because, as they process enormous volumes of data, they become more accurate. Processing of natural language and image processing have both shown outstanding performance using DNN-based techniques [4-7].

In light of the success of DL techniques in other disciplines and their swift ongoing improvement in the proposed methodology, these models are quickly emerging as the most innovative and fascinating tools to analyze health records. DL models using biomedical and healthcare data have been used in a wide range of projects. As an illustration, Google DeepMind [8] and IBM Watson [9] have created a computer-based support system that helps analyze healthcare information [10]. The left ventricle (LV) may be segmented using short-axis cardiac magnetic resonance imaging (MRI) with the help of a deformable model, and this model's parameters have been effectively encoded using DL [11]. A separate DL model based on RBM (restricted Boltzmann machines) in medical imaging was utilized to extract biomarkers from MRI data [12].

Here, the overall effectiveness of each method is described in more detail, and mainly the learning curve of the present DL healthcare is again highlighted. Recently, the survey of deep electronic health record (EHR) [13] identified unique deep-gaining knowledge of strategies that can be hired on digital fitness records (EHR). They mentioned the medical packages utilized by unique DL fashions and diagnosed numerous barriers to modern-day DLs consisting of version interpretability, statistical heterogeneity, and the absence of familiar benchmarks. At last, deep EHR concludes the brand-new fashions and diagnosed results for destiny.

In diverse, deep EHR critiques of unique deep gaining knowledge of strategies on digital fitness records, our assessment paper specializes in hybrid deep gaining knowledge of strategies tailor-made to early disorder detection. While our survey indicates a few impediments for single and mixed DLs in the health area, as well as deep EHR, it

highlights multiple barriers for DLs using EHR. Our analysis employs the same contemporary categorization measures to highlight the area under the curve (AUC), precision, and responsivity of single-hybrid DL, somehow like deep EHR, and basically points to criteria of DLs including AUC and other accuracy parameters like P (precision), R (recall), and F1 score. This assessment document examines the length of current DL-schooling, health care systems (HCSs) in contrast to deep EHR. While a few research studies have comparable research and assessment metrics, outcomes aren't without delay similar because of the proprietary nature of the data sets.

Personalized treatment is increasingly dependent on the analysis of medical data. For instance, customized cancer treatment aims to give proper care to sick patients by considering a variety of patient-specific factors, including genetic variations, the patient's environment, imaging genetics, current medications, and lifestyle. A vast and complicated amount of health data has been collected in the last ten years by current technologies like genomics, imaging, and lifetime monitoring, enabling researchers to give patients improved therapies. Despite the abundance of data, we still lack a thorough understanding of diseases and effective patient treatments.

For specialized bioinformatics comprehension, Lan et al. [14] provided an overview study on statistics mining and in-depth learning techniques. DL approaches are summarized, along with the advantages and disadvantages of cleaning, segmentation, grouping, and improved neural community structures. Our overview study, in contrast to this effort, deals with more original DL research that is combined with several conventional device learning methodologies. The survey of this paper additionally specializes in unique deep-gaining knowledge of strategies used to become aware of disorder detection. Even the overall performance assessment is not protected, as mentioned in [14]. Overall, the author has specialized in brand-new research that has deep-gaining knowledge of techniques for disorder detection and the evaluation of massive statistics within the subject of healthcare [15, 16]. In this assessment, four deep-gaining knowledge strategies are decided on by means of pointing to the fitness care (HCS) system within the length of the years 2015 to 2019.

Convolutional neural networks (CNNs), deep-belief networks (DBNs), auto-encoders (AEs), and recurrent neural networks (RNNs) are the four architectures under question. The disorder detection software commonly uses these structures [17, 18]. The year-wise growth and research distribution for DL articles in HCS is depicted in Figure 1. The following list can be used to summarize significant contributions are:

- A taxonomy of the most widely utilized DL techniques in the medical field.
- The tremendous insights into the precision and applicability of DL trends in healthcare solutions.
- Discussing the center technology that could reshape deep-gaining knowledge of techniques in healthcare technology.
- Presenting open problems and demanding situations in modern-day deep-gaining knowledge of fashions in healthcare.
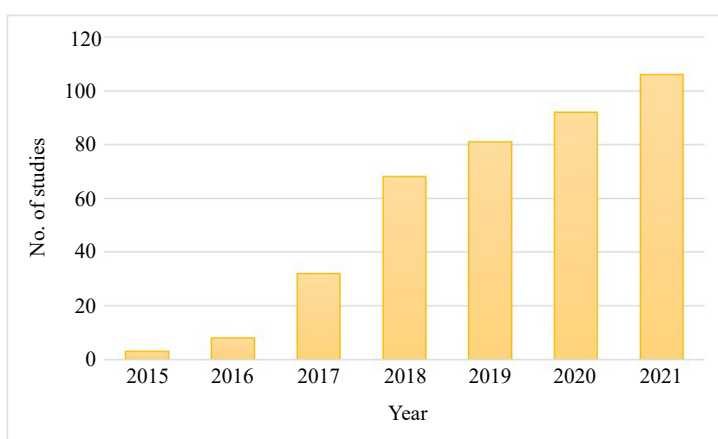

Figure 1. DL approaches for healthcare per year [14]

Table 1 indicates the analysis of different existing methods.

Table 1. Analysis of existing classification methods

Author name	Technique used	Dataset used	Merits	Demerits	Performance (%)
Alshazly et al. [19]	Deep CNN	SARS-CoV-2 and COVID19-CT	High scalability and robustness.	Non-accurate localization of abnormal image regions.	Accuracy- 92.9
Zheng et al. [20]	3D DNN	Real-time data	Storage complexity is reduced.	Inaccurate design, network training and non-utilization of temporal information.	AUC-95.9 PR-97.6
He et al. [21]	2D and 3D CNN	CC-CCII	Effective pre-processing can be carried out.	Limited classification accuracy and increased time complexity.	Accuracy-87.62
Shah et al. [22]	CTnet-10 and VGG-19 model	COVID-CT	Improved detection accuracy can be attained.	Experimentation can be done only on binary classes.	Accuracy-82.1 (CTnet-10) Accuracy- 94.5 (VGG-19)
Purohit et al. [23]	CNN	Public database from GitHub	Discontinuity information can be obtained efficiently.	FPR and testing time is high.	Accuracy-95.38

The medical image classification of these existing methods indicates various constraints that have an impact on the performance of the whole model. Due to growing complexity, poor design, and the training network, some limitations exist, such as improper localization of abnormal picture regions. The adoption of fewer datasets, poor use of temporal information, and reduced classification accuracy all contribute to the lower performance of the model, which is addressed. Moreover, a lengthy processing time is needed for performance estimation, and the likelihood of incorrect forecasts is higher. These difficulties make it impossible to classify computed tomography (CT) scans precisely.

The structure of the current review is described as follows: A variety of research techniques are described in the second section. The definition, framework, algorithm, and architecture of DL techniques are discussed in the third section. The top DL illness detection techniques are presented in the fourth section. Open questions, difficulties, and this paper's findings are offered in the fifth and sixth sections.

2. DL Framework

2.1 *Architecture and algorithms of DL*

An artificial neural network (ANN), a pair or more convolution layers, is the simplest description of a DL architecture that seeks to increase prediction accuracy [24]. In comparison to typical ANNs, DL uses a lot more hidden layers. In a typical DNN, an output is produced by processing a weighted input value with bias correction and a non-linear input vector, such as the SoftMax function. As an output, a DNN's weights are optimized during training in order to reduce the loss function [25]. Figure 2 displays the ontology of popular DL models used to examine HCS data together with a few chosen applications, particularly in illness identification.
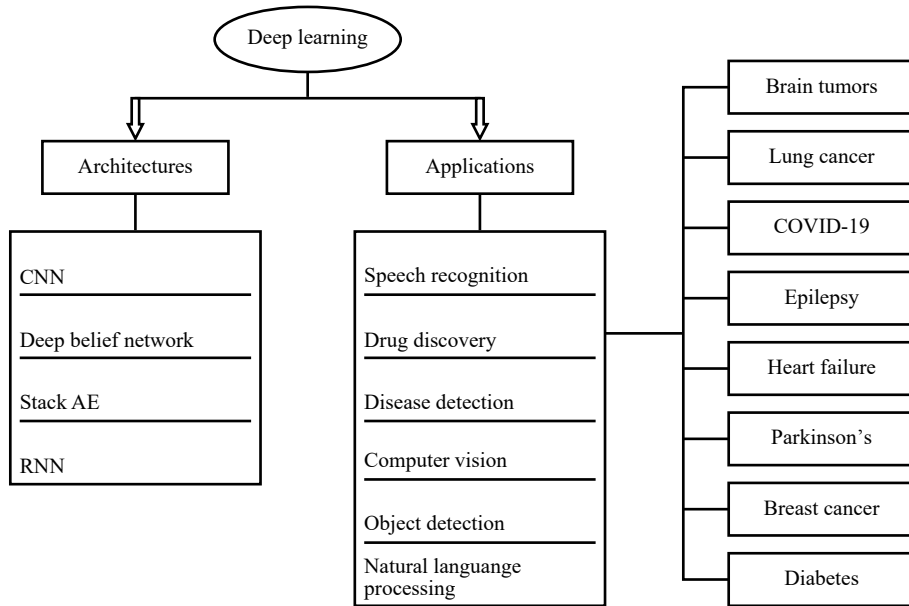
Figure 2. For the analysis of the data in health systems, prominent DL architectures are categorized [20, 21, 24]

2.1.1 *RNN*

Recognition of patterns in sequential or stream data, including voice, writing, and text, is done using RNNs [26].

Every one of the earlier inputs is saved in hidden units of a state vector, and the outputs are computed using these state vectors. RNNs compute the new output by considering both the current and prior inputs. The fundamental issue with RNNs, despite their promising performance, is the diminishing gradient during data training [27]. The structure of RNNs contains a cyclic connection. These hidden unit cyclic connections carry out the recurrent computations for processing the data input sequentially [28].

One method to address this issue is to use Gated Recurrent Units (GRUs) and Long Short-Term Memory networks, which have a long-term capacity for storing sequences [29, 30]. Figure 3 depicts the architectural layout of an RNN. Besides encouraging success using GRU to deal with the issue of vanishing gradients, the success of this strategy is very high because connections between the first two layers are undirected; they are reliant on the input data, whereas connections between all subsequent directed layers [31-33].
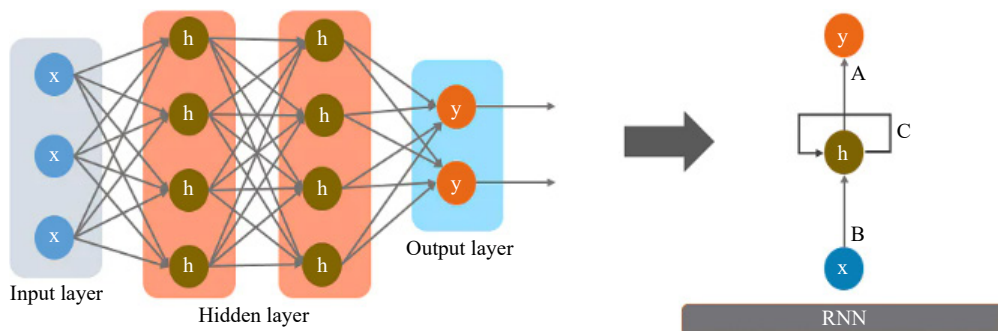

Figure 3. Architecture of RNNs [22]

2.1.2 CNN

CNN is an architecture for supervised DL. Applications involving image analysis are its principal use cases [34, 35].

CNN employs three different types of layers: convolutional (the main building block), pooling (to reduce the dimensions of feature maps), and fully connected (which is nothing but output from the other two layers). The input data as the image is processed modifies the convolutional layer with kernels or filters to create different feature maps [36]. Each feature map's size is decreased in the pooling layer to minimize the number of weights. This method is often referred to as subsampling or down-sampling [37]. There are numerous types of pooling techniques, including average, maximum, and global pooling. For the final classification following the layers, the completely linked layer is utilized for one-dimensional vectorization of two-dimensional feature maps [38-40].

Deepr [41] offers an end-to-end solution for extracting essential details from medical records and predicting anomalies. A CNN is used to anticipate unexpected readmissions following discharge by applying it to a series of discrete elements. A DL approach was later used by Gnanasankaran et al. [42] to investigate the temporal aspects of patient EHRs. The convolution operator was applied to the patient EHR matrices' time dimension in the proposed DL's second layer. To incorporate the integration of the EHR's temporal smoothness into learning, early, late, and slow fusion are used as temporal fusion strategies in the model [43].

A CNN design with two convolutional layers is shown in Figure 4. A pooling or subsampling layer came after each fully connected layer. A fully linked layer and a final output layer both receive the output of the final pooling layer.
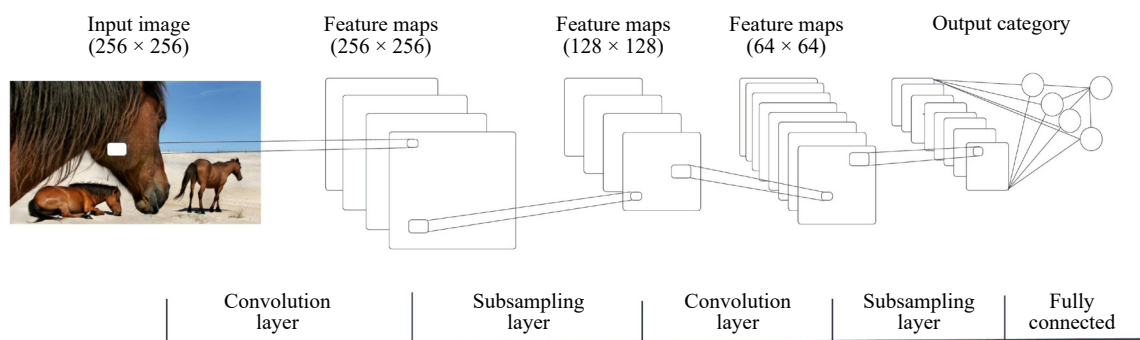

Figure 4. CNN architecture [40]

2.1.3 The deep belief networks (DBNs)

The DBNs are capable of learning high-dimensional data manifolds. Directed and undirected connections are seen in DBNs, a multi-layer hybrid network [44]. While all other connections between levels are directed, The upper two layers do not directly connect to one another. DBNs could be thought of as a pile of greedily trained Boltzman machines with restrictions (RBMs) [45]. The RBM layers communicate with one another as well as with earlier and later layers [46-48]. A feed-forward network and multiple RBM layers serve as feature representations in this model [49]. RBM merely contains two layers: a hidden and a visible layer [50]. The structure of the DBN methodology, which was adapted from [51], is shown in Figure 5. In this diagram, "v" represents deep belief mode's stochastic visible variable. The architecture of the DBN technique, which was adapted from [51], is shown in Figure 5, where v is the deep belief model's stochastic visible variable.
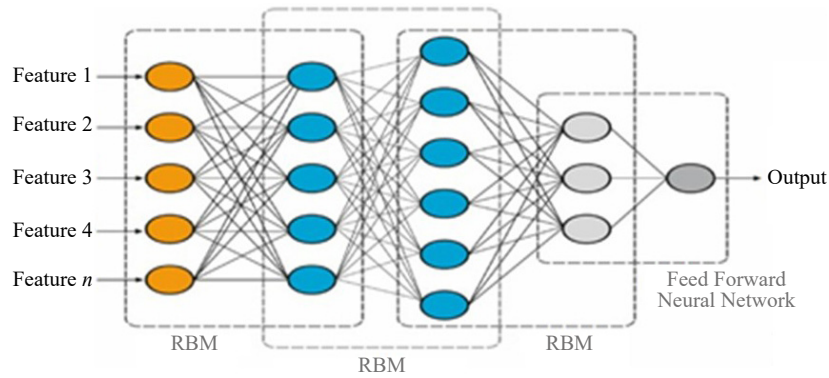
113

Figure 5. Architecture of DBN [51]

2.1.4 *AE*

An ANN called the AE seeks to efficiently code the data. As a result, it can be applied to network startup or feature reduction. It does this by translating the information through a network of linked neurons to itself. Unsupervised learning is categorized as AE, which encompasses sparse autoencoder (SAE), variational autoencoders (VAE), and denoising auto encoder (DAE) [52]. A neural network called AE with denoising, which was developed from AE, mostly considers collecting features from various noisy and unclear datasets. The DAE has three layers: encoding, decoding, and input layers. DAE may be used to produce advanced features. Stacked Denoising Auto-Encoder (SDAE) is a different DL technique that has always just been applied for reducing dimension, which is nonlinear in nature. The architecture of the DAE approach is shown in Figure 6, according to [53].
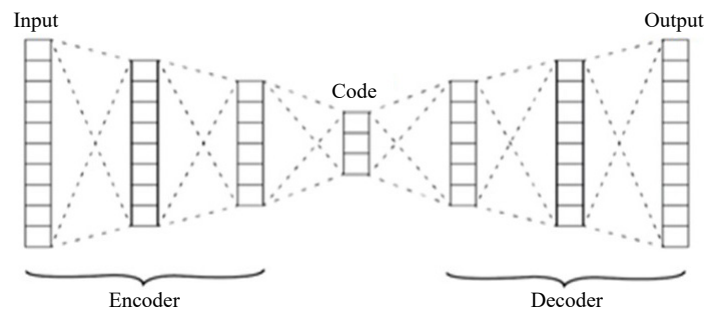

Figure 6. Architecture of AE [53]

Table 2. Review of the study on how DL designs utilized in the health system sector are influenced by neural networks

Architecture	Summary
RNN	RNNs are helpful for processing data streams [53]. The value of every output depends on the preceding iterations, and they are made up of a single network that completes the identical task for each sequence element. Due to vanishing and expanding gradient issues, RNNs could only go back a few steps in the original formulation. By modeling the obscured state, which contains cells that decide what information to keep in memory based on the input value, the current memory, and the prior state. In applications involving natural language processing, these modifications achieved excellent results [54] and are effective at capturing long-term interdependence.
CNN	CNNs were designed using the visual brain anatomy of cats [55, 56]. CNNs use feature merging after local contacts and associated weights across the units to get translation-invariant descriptors. The basic CNN design consists of one pooling and convolutional layer, optionally continued by a completely connected layer for monitored prediction. To model the input space more accurately, Over ten convolutional and pooling layers are frequently used in CNN architectures. The best applications of CNNs have been created by computer vision [57]. CNNs often require a large data collection of labeled documents in order to be properly trained.
AE	An AE is a model of unsupervised learning in which the input and target values are identical [58]. A decoder that maps the input into a low-dimensional representation and reconstructs the input value from this low-dimensional representation that makes up an AE is nothing but a decoder. The goal of AE training is to reduce reconstruction errors. It is possible to find important patterns in the data by requiring the implicit representation's dimension to vary again from the input. AEs are frequently regularized by including noise in the original data and are mostly utilized for learning low-dimensional representation.
Deep Boltzmann machines (DBMs)	Using data from the input space, a DBM is a stochastic model that is generative and adopts a posterior probability [52, 53]. confined to the requirement that its neurons form a bipartite graph; Boltzmann machines are known as DBMs. There are only symmetric interactions between pairs of nodes in each of the two categories; there aren't any interactions among nodes within a group. In comparison, Boltzmann machines have a general class, which permits hidden unit connections; this constraint enables more effective training techniques.

3. DL: Medical imaging and detection of disease

This section comprises a variety of DL algorithms used in the medical field to distinguish between healthy and unwell people. Finally, here, some of the effectiveness of DL is highlighted for differentiating between infectious and healthy individuals.

3.1 *Medical imagery*

In image processing, namely in the analysis of central nervous system MRI scanning to forecast Alzheimer's disease and its variants, DL was first applied to clinical data [54]. CNNs have been used for the automated segmentation of cartilage and the prognostication of osteoarthritis in low-field knee MRI data in other medical fields. Despite using 2D photos, this method outperformed a cutting-edge technique that used manually chosen characteristics with a 3D multiscale. Additionally, supervised learning was used for the evaluation of patients with benign versus malignant breast masses from CT and to segment chronic regions in multi-channel 3D MRI [55].

In a more recent study, Yin and Zhang [56] employed CNNs, which help to recognize the various retinal fundus, diabetic retinopathy, achieving more specificity and sensitivity across around nine to 10,000 different test photos in comparison for certifying the ophthalmologist's annotations. On a huge data set for a variety of skin cancers, CNN also produced categorization results that were on par with those of 21 board-certified dermatologists.

3.2 *Disease categories*

Here, we examine various approaches based on different categories of disease. This section focused on the significant DL techniques, along with performance variations and applications in various categories of disease.

First, those that have received extensive DL model research. Second, those who used DL models to address problems or produce encouraging outcomes.

The DL approaches utilized to combat these diseases are covered in full below.

3.2.1 *Breast cancer*

After that, [59] presented DL architecture with two layers to classify benign and malignant breast cancers using

shear wave elastography, which contains a Boltzmann machine that is confined and also one that is point-wise gated. The method's accuracy, specificity, AUC, and sensitivity were compared to statistical parameters that characterize image intensity and texture. A computer-aided disease diagnosis machine using DL techniques to identify, divide, and categorize masses in mammograms was introduced by the authors in [57, 58]. They thought about three steps — detection, segmentation, and classification — to do this:

For mass detection, a series of DL-process including convolutional, deep belief, and conditional random field (CRF) was suggested. To boost the performance of handcrafted features, it was suggested to use a DL classifier for mass recognition and a deep structure output for mass separation. CNN received training to divide the mass into two categories. The handcrafted features were used to estimate a regressor in the first phase, and the CNN model was tweaked in the second phase. Figure 7 illustrates the method's architectural layout.
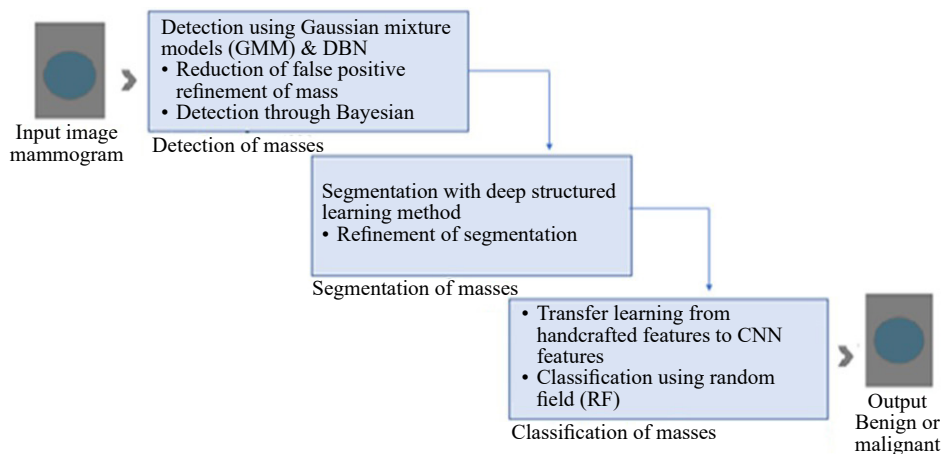

Figure 7. Architectural layout of DL [58]

3.2.2 *Electroencephalography (EEG) imagery signals*

This section's main goal is to demonstrate the importance of DL techniques in terms of performance variation by considering classification. Deep belief networks were utilized by the authors of [56, 57], brain activity EEG waveforms according to categories. The DBN results show that even on raw data, this model's prediction task requires less time than those of support vector machine (SVM) and K-nearest neighbors (KNN) classifiers. Later, [58] proposed a brand-new method for categorizing electrocardiogram (ECG) signals, which are typically DL-based.

The resulting hidden representation layer in this model was then covered with a regression layer to produce a DNN after the feature learning phase. Less expert participation and a quicker online retraining phase boosted this novel method's accuracy compared to prior approaches.

The classification of breast cancer with both migratory and non-mitotic nuclei images was presented in [60] using a unique technique of data balancing utilizing the CNN model. Considering the substantial overlaps between cell divisions and non-mitoses, a CNN model is used in this model to deal with a classification example. K-means with a blue ratio histogram were developed in the second stage to under-sample the skewness in the majority of classes with little information loss. The study's findings showed that the model decreased training time while also increasing CNN's mitotic detection rate. The CNN model's construction in two phases is shown in Figure 8.
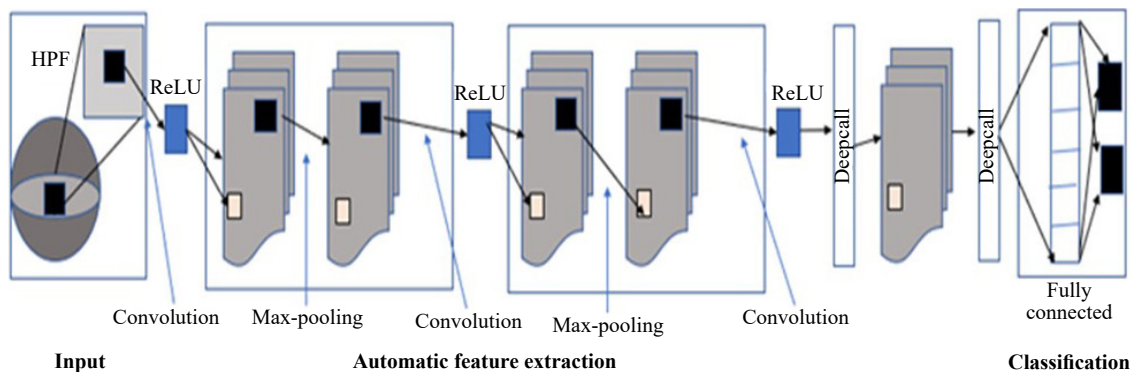
116

Figure 8. CNN model's construction with two-layer phases [55, 60]

3.2.3 *Multiple sclerosis*

To categorize mental workload, a denoising-stacked AE was created [56, 61]. Both within-session and across-session conditions were considered when calculating the classification's accuracy. Then, using various feature selection and noise corruption models, this is the new classification, which was contrasted with conventional categorizers for mental effort. Later, delayed multiple sclerosis (MS) patterns called lesion patterns were extracted from represented pictures using a CNN approach [59, 61]. It was suggested in [62] to apply a DBN and random forest on myelin images as well as T1W images where MS pathology can be found in brain tissue that appeared normal with an MRI. To develop a latent feature representation, DBN with four layers (Figure 9) was applied to 3D images of normal-appearing gray matter (NAGM) and normal-appearing white matter (NAWM) in this model. Then, the picture patches were chosen using a voxel-wise t-test.
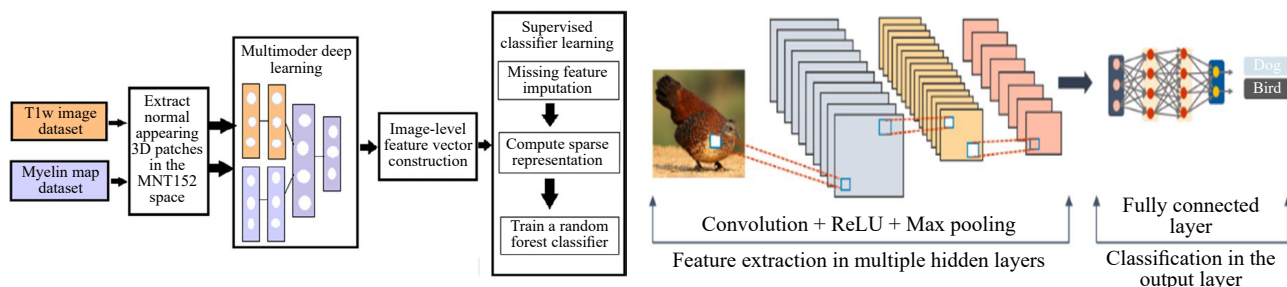

Figure 9. Modeling DBN with four layers [56, 57, 61]

3.2.4 *Brain cancer*

In [63], a multi-scale CNN-based approach to tissue segmentation for brain MRI was proposed. Different levels of irregularity were used to test the methodology. The findings demonstrate precisely divided brain lesions. Transparency in models is a significant problem in the clinical sector that has an impact on the prediction of patient therapies and real-world medical decision-making [64]. A new DL model for segmenting brain tumors was proposed in [65] in a distinct study by fusing fully CNN and conventional random fields (Figure 10).

To train the model, three different phases were used. Image slots were first used to train the fully connected neural networks (FCNN). Second, CRF-RNN was trained by image pixels. Finally, the entire network was tuned using the picture slices [65, 66]. The four steps of the method include pre-processing, fragmenting picture slices with DL models that incorporate FCNNs and CRF-RNNs, extraction of features, and identification.
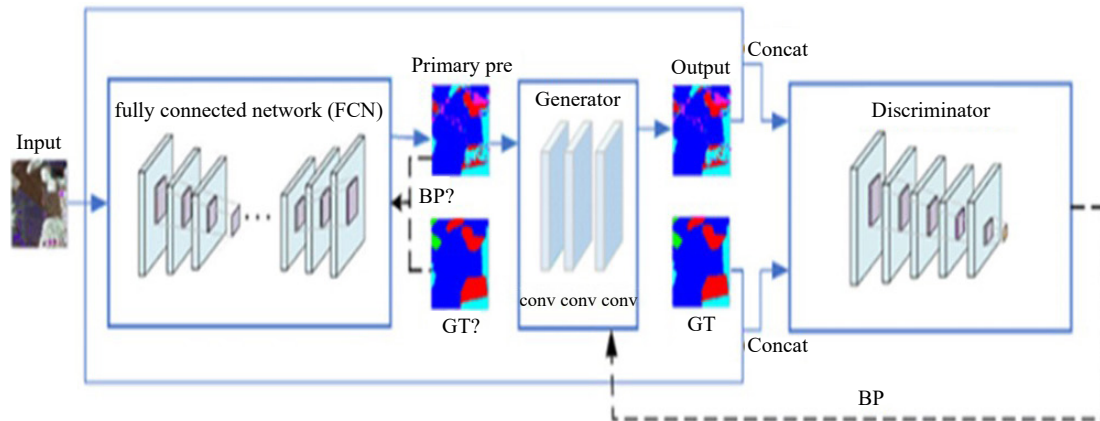
Figure 10. A fully integrated CRF and CNN [63, 64]

3.2.5 *Hybrid disease detection*

To identify three different cancer types [67] — LACAR (lung small/large adenocarcinoma), SACAR (stomach-related adenocarcinoma), and BICAR (breast-related invasive carcinoma) — hybrid DL approaches are used. They used studies of various gene expressions to pick the key genes in this model. Five CNN classifiers were trained using these chosen genes, and the combined output was then obtained. They showed that, in comparison to a single classifier or the algorithm for qualified majority, their approach can improve the reliability of cancer diagnosis across all tested datasets of RNA-Seq. The authors of [67] suggested a technique for automatically classifying gastric cancer using a CNN. Three deep structural algorithms with multichannel release of information (ROI) — stacked denoising AE, DBN, and CNN — were used in a different study [68] to diagnose lung cancer.

3.2.6 *Epilepsy diagnosis*

To diagnose epilepsy using the encephalogram signals, the authors of [69] explained a new system for computer-aided diagnosis that makes use of CNN. Its precision, efficiency, and responsiveness are contrasted with those of other ML techniques. The CNN method uses thirteen layers to develop a complicated and robust model to identify seizures. To the best of our knowledge, this is DL's only substantial application to the diagnosis of epilepsy.

3.2.7 *Heart disease*

Although this condition is common, DL has not been utilized frequently for it. The most important application of DL is to help identify this condition, as is done in [70]. For instance, [70] used an RNN to detect heart failure. To identify cardiac disease by examining the relationships between gated recurrent units, they suggested an RNN model using events that were time-stamped and a case-and-control observation window [71, 72].

3.2.8 *Eye disease*

A framework of ML for enhancing clinical decision-making systems was proposed in [73], along with an unsupervised deep feature learning method. To identify red lesions in fundus images, a combination of DL and domain expertise was developed in [74]. The addition of handcrafted features culminated in the learning process for CNN architecture. According to reports, this combination performs better than other separate classifiers [74].

The Sutter-PAMF dataset is utilized. The outcome shows a detection accuracy of 77.68 percent. It also displays the RNN technique for brain tumor detection. The Cancer Genome Atlas (TCGA) project provided the gene expression data that was utilized.

3.2.9 *COVID-19*

A viral illness called COVID-19 has infected billions of people worldwide and spread to additional countries at an accelerated rate [75, 76]. The World Health Organization (WHO) initially referred to this dangerous infection as SARS-CoV-2, and later COVID-19 became more well-known [77]. Fever, coughing, and a loss of taste or smell are some of the main COVID-19 symptoms that people experience [78, 79]. Chest pain, shortness of breath, diarrhea, headaches, sore throats, and other symptoms are among the main ones. The Nidovirales family includes COVID-19, which is regarded as a positive-sense non-segmented RNA virus. The COVID-19 illness spreads in an unanticipated way around the world, and on January 30, 2020, the WHO declared this epidemic a PHEIC (Public Health Emergency of International Concern) [80, 81]. According to the data study, there were 4,592,893 COVID-19 fatalities and 222,180,532 infections. According to records, nearly 198,785,372 people have been treated for COVID-19 as of September 7th, 2021.

3.3 *Summary of dataset used in healthcare*

In this area, we highlighted some important datasets that were applied to various DL algorithms for the detection of disease and healthcare. The most common healthcare or cancer dataset utilized with DL techniques is mentioned in Table 3.

Table 3. Most common healthcare dataset utilized with DL techniques

Paper Number	Dataset	CNN	RNN	DNN	DAE	DBN	KNN
P2 [46]	Lung image dataset	√			√	√	
P3 [55]	MITOS12, TUPCAC16	√					
P4 [57]	MRI dataset for relapsing-remaining MS					√	
P5 [58]	INBreast	√					
P6 [60]	MITBIH, SVDB and INCART			√	√		
P7 [61]	DDSM	√					
P8 [65]	BRATS	√	√				
P9 [64]	Dataset related popular disease from WebMD						√
P1 [66]	LUAD, STAD, BRCA			√			
P10 [71]	Electronic health record dataset		√				
P11 [74]	MESSIDOR and e-ophtha, DiareTDB1	√					
P12 [82]	Bonn University Dataset	√					
P13 [83]	PPMI, SNUH	√					
P14 [88]	Gastric cancer dataset	√					
P15 [92]	Myelin and T1W					√	

According to Table 3, the CNN algorithm has been implemented in more databases than any other. Take the MITOS12 system, which is offered by the ICPR competition's organizers and consists of five slides from different individuals that have been H&E stained and labeled by a skilled pathologist. For MITOS12 and TUPAC16, the CNN has been used. The University of South Florida (USF) makes their DDSM database available. Four breast photos are provided for each case in the DDSM, together with patient data.

3.4 *Summary of dataset used in healthcare*

Based on the design of the DL approaches used for illness detection, we discuss the results of the studies reported in this part. Then, we examine each study's advantages and disadvantages. We first go over each study in detail before

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contrasting it with the other techniques listed in Table 1. To assess the effectiveness of DL approaches, the entire number of DL articles listed in Table 1 were examined for two crucial factors: accuracy and area under the curve. Finally, we emphasized the methods that have the greatest influence on detection rates.

Acharya et al.'s [69] analysis of a dataset of EEG signals from Bonn University using a ten-fold merge procedure and the CNN technique. Results from this study were compared to those from other related studies that were identified in the literature. The findings from the investigation are suggested in [69]. These are the accuracy (a) and sensitivity comparison findings between different CNN models and various approaches established in the mentioned database (b).

To assess time-stamped events, a gated recurrent unit-based RNN was developed by Choiet al. [70]. The model's performance was compared to that using AUC values as the key metric, supporting vector machines, CNNs, K-nearest peers, etc. Figure 11 compares RNN's AUC for prediction between three and nine months to other approaches.
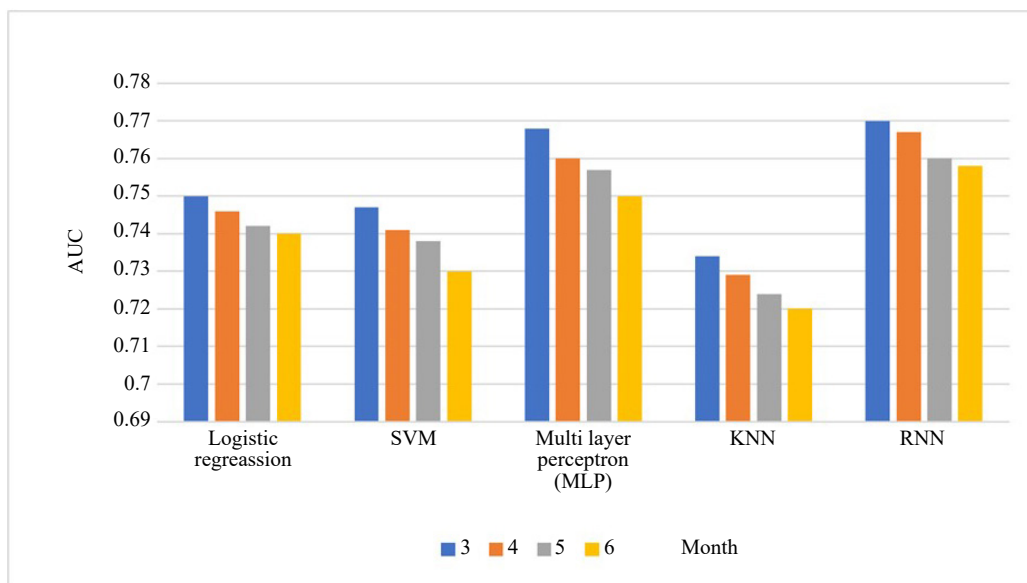

Figure 11. Comparing RNN's AUC for predictions between three and six months to different approaches [69, 70]

An automatic CNN technique for diagnosing Parkinson's disease was created by Choi et al. [71]. Accuracy, specificity, and sensitivity were compared between the visual interpretation and PD Net. The PPMI test set photographs were visually examined by two different readers who were unaware of the diagnosis and clinical details [72]. DAT binding was visually labeled as "normal" or "abnormal" on images. Readers' accuracy and that of PD Net were compared. The outcomes are displayed in Figure 12.

A Random Forest-based CNN was created by Dhungel et al. [58] for the INbreast dataset application in two settings: manual and minimal involvement. The outcomes in terms of accuracy for different CNNs and the area under the curve are displayed in Figure 13.

The CNN, which is based on the random forest technique used in manual configuration and supported by different CNN techniques in the setting with the least amount of user intervention, shows excellent accuracy of detection in Figure 13. This indicates that the RF's ability to classify data using an ensemble learning technique has a favorable impact on the CNN method. As a result, this capability raises the accuracy of the CNN technique [58].
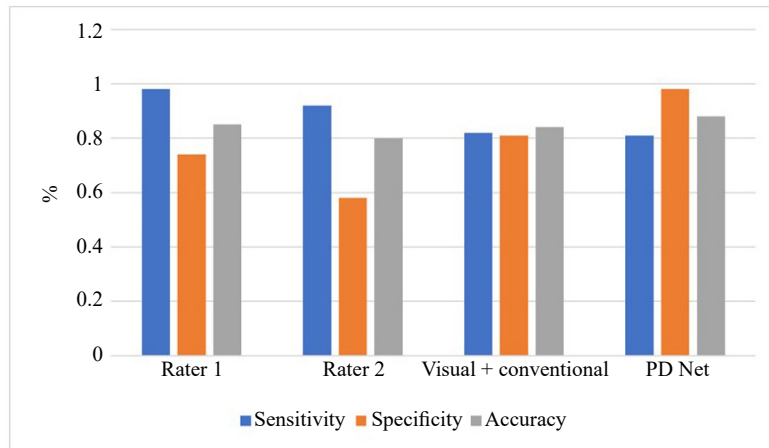
120

Figure 12. Results of sensitivity, specificity, and accuracy [71]
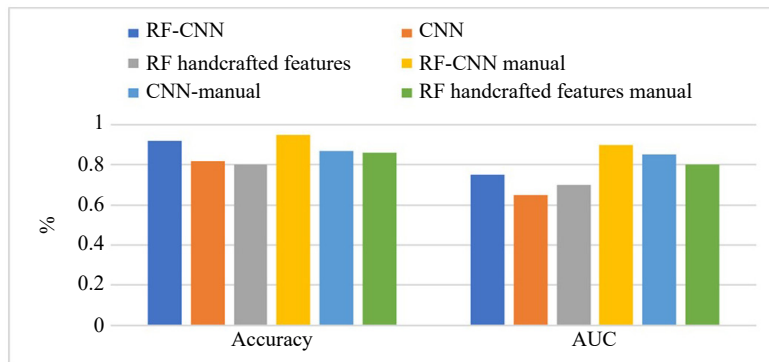
Figure 13. Outcomes of different CNN [58]

To estimate the rates of patients' survival using electronic medical information, Miotto et al. [73] introduced the deep patient unsupervised representation deep patient (URDP) technique. In terms of accuracy and area under the curve of the receiver operating characteristic (ROC) curve, the URDP approach was compared to other methods created in this area. The outcomes are shown in Figure 14.

Figure 14. Comparison of URDP with other approaches [61]

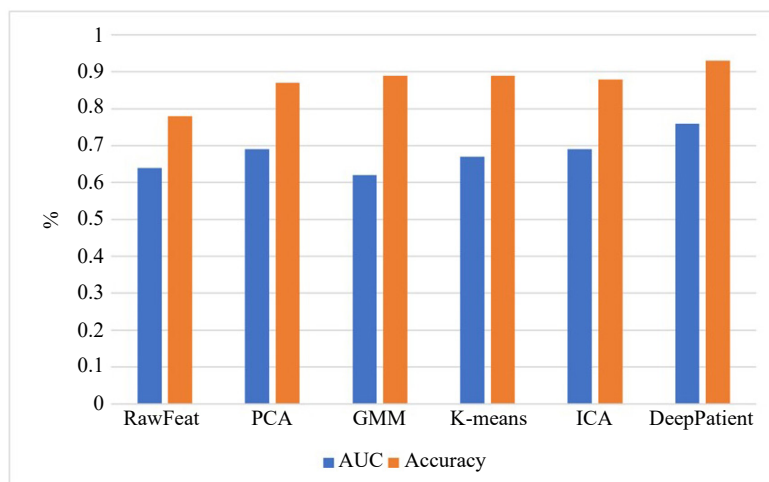An ensemble DL technique was created by the author of [74] Orlando et al. for the detection of a red lesion in fundus pictures. Figure 15 displays the results of CNN, hybrid CNN-hybrid CNN framework (HCF), and hand-crafted features in terms of sensitivity and AUC.
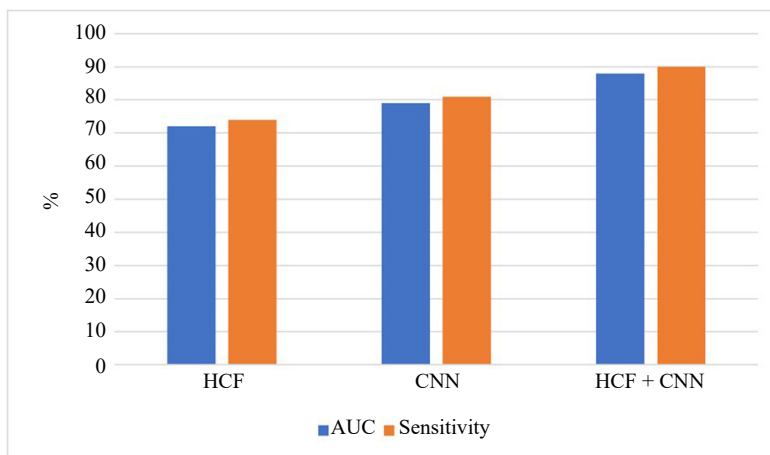

Figure 15. Results of CNN and hybrid CNN-HCF [74]

Based on the above findings, this review examines the value of mixed mode techniques since they combine several reliable models to create a classifier that is more accurate [75]. The hybrid method offers greater sensitivity and AUC in comparison to single methods, as demonstrated in Figure 20. The application of hybrid approaches in DL is highlighted in this work [76, 78].

An AE for denoising stacked and adaptive versions of SDAE algorithms for categorizing the levels of mental pressure was developed by Yin and Zhang [56]. Using EEG data that was obtained on different days, the procedures were practiced and evaluated. Figure 16 displays the study's findings in terms of sensitivity, specification, and accuracy.

According to the findings in Figure 16, when working on EEG features with cross-sessions, adaptive SDAE outperforms SDAE [79]. By examining the findings from this article, it becomes clear that A-SDAE is superior in situations involving the computing cost for iterative tuning, the best step length, and the data augmentation technique. A live web server is created using this method [80].
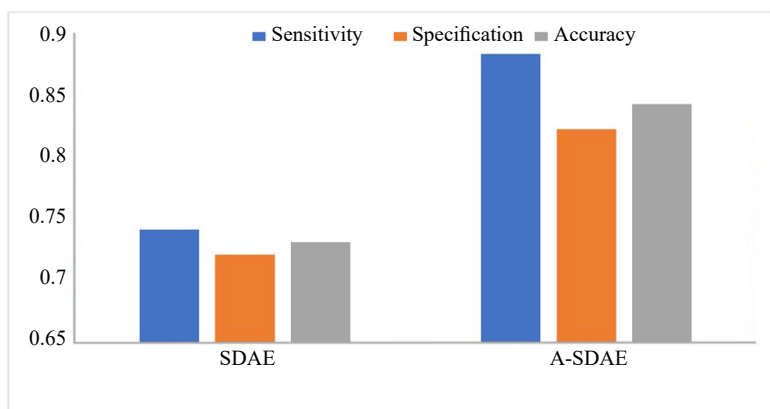

Figure 16. The review of findings of SDAE and A-SDAE [56]

To illustrate modeling in terms of AUC, reliability, and responsiveness, respectively, of output and performance,

present DL approaches. It may be inferred that DBN's use of the CNN methodology has contributed the most to this field. This might be because of the features and nature of these techniques. Additionally, these two techniques have the greatest propensity to be combined with other techniques [81].

4. Challenges and opportunities

Although deep architectures have delivered some hopeful results, a number of problems remain that must be fixed before classifiers in medical can be applied therapeutically. We particularly call attention to these grave issues:

Quality of data: Medical information are extremely varied, confusing, rough and insufficient, in contrast to other fields where the data is organized and clean. With such expansive and varied data sets, it is challenging to train a reliable DL model. Several issues, such as data sparsity, complexity, and missing values, must be taken into account [82].

Complexity in domain: Compared to other application sectors, the problems in the bioscience and healthcare industries are more complicated. It is still unknown precisely what causes the majority of the disorders and how they evolve because of their tremendous heterogeneity [83]. In a meaningful therapeutic setting, the patient count is commonly limited, hence we are not allowed to accept an infinite number of patients [84].

Data volume: DL refers to a class of computer models that require a lot of manual labor. One typical example is fully linked multi-layer neural networks, where it is necessary to precisely anticipate a number of network properties. The basis for reaching this goal is the presence of a massive amount of data. It is sometimes advised to utilize at least ten times as many cases in a network as parameters, despite the lack of specific guidelines for the minimum amount of training materials that must be used [85]. DL's effectiveness in industries where enormous volumes of information can be quickly obtained is another aspect.

Interpretability: Even though DL models have demonstrated effectiveness along a diverse range of domains, they are occasionally perceived as "black boxes" [86]. In other, more deterministic areas like image identification, where the end user can unbiasedly check the tags assigned to the photos, this might not be a problem, but in the healthcare industry, this is a concern, and It is crucial to comprehend the algorithms' qualitative as well as quantitative performance. This form of model interpretability — namely, identifying the phenotypes that are driving the predictions — is essential for persuading medical practitioners to follow the predictive system's advice [87].

Feature enrichment: Due to the restricted number of patients worldwide, we must collect various features as we can fully describe each patient and develop creative ways to analyze them all at once. The data input for creating features should consider, but not be restricted to, EHRs and other social media wearable technology, surroundings, observations, virtual communities, transcriptomes, such as the genome, omics data, and so on [88]. A significant and difficult research problem would be how to use such extremely varied data effectively in a DL model.

Integrating expert knowledge: For health care issues, the current expert information for medical issues is priceless. The integration of expert details in the DL process to direct it in the appropriate way is a crucial research area topic due to the restricted quantity of medical data, their diverse quality issues [89]. For instance, it is advisable to mine online clinical/medical encyclopedias to find trustworthy knowledge that may be incorporated into the deep architecture and improve the system's overall performance. The ability to employ both labeled and unlabeled samples make semi-supervised learning, an efficient method consider for learning from many unlabeled a small number of tagged samples, very promising [90].

Temporal modeling: Because time is a significant factor in many healthcare-related issues, particularly those involving EHRs and monitoring equipment, to better comprehend patient circumstances and provide timely support for medical decision-making, it is imperative to train a thing DL model [91]. As a result, temporal DL is crucial for resolving problems in the healthcare industry. To do this, we believe that RNNs and layouts with capacity will greatly enhance clinical feature sets.

5. Conclusion

DL has shown enormous potential as an emerging technology for solving difficult healthcare issues. In this study, we concentrated on healthcare issues that DL has been applied to with positive outcomes. DL-based methods have been

shown to be efficient tools for dealing with ailment detection in the preprocessing, edge detection, extraction of features, categorization, and grouping processes. In this paper, the detection of disease in healthcare systems served as the focal point for evaluating the technical features of ML and DL architectures [92]. The effectiveness of these techniques was discussed in terms of algorithm parameters and the precision of disease identification. Finally, the top DL technique architectures used in healthcare were examined and commented on.

We may conclude from this review that DL-based hybrid and ensemble approaches outperform single techniques in terms of accuracy. The existing classifier models [93] like ANN, adaptive neuro-fuzzy inference systems (ANFIS), CNN, and multi-objective differential evolution-based CNN (MODE_CNN) have obtained 88.8%, 90.39%, 92%, and 93.60% accuracy rates, respectively. DL techniques require a lot of memory and time, which is a drawback. Thus, creating and implementing ideal processes in healthcare systems is a significant problem [93, 94]. By integrating more procedures simultaneously and irrespective of the different types of datasets, these methods result in an enhancement of the process.

DL techniques require a lot of memory and time, which is a drawback [95]. Designing and implementing the best practices in healthcare systems is thus a significant task.

Researchers may concentrate on creating and integrating effective technologies in the future to meet the technical specifications for all types of decision-making algorithms, including those with DNN designs [96, 97]. As stated throughout this research, it is also required to enhance the current neural network models' topologies to create more efficient systems. Therefore, it is essential to develop well-defined, general architectures that can deal with many types of health data to tackle complicated challenges in healthcare systems [98-102].

Ethical approval

This study was approved by our institution and does not require ethical approval for reporting individual cases or case series.

Conflicts of interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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Improving Phishing Website Detection with Machine Learning: Revealing Hidden Patterns for Better Accuracy

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Abstract: Phishing attacks remain a significant threat to internet users globally, leading to substantial financial losses and compromising personal information. This research study investigates various machine learning models for detecting phishing websites, with a primary focus on achieving high accuracy. After an extensive analysis, the Random Forest Classifier emerged as the most suitable choice for this task. Our methodology leveraged machine learning techniques to uncover subtle patterns and relationships in the data, going beyond traditional URL and content-based restrictions. By incorporating diverse website features, including URL and derived attributes, Page source code-based features, HTML JavaScript-based features, and Domain-based features, we achieved impressive results. The proposed approach effectively classified the majority of websites, demonstrating the efficiency of machine learning in addressing the phishing website detection challenge with an accuracy of over 98%, recall exceeding 98%, and a false positive rate of less than 4%. This research offers valuable insights to the field of cyber security, providing internet users with improved protection against phishing attempts.

Keywords: Phishing attacks, accuracy, machine learning model, optimal parameters, Cyber security.

I. INTRODUCTION

The internet has revolutionized the way we conduct business, communicate, and access information. However, this digital transformation has brought about a dark side: cybercrime. Among the numerous cyber threats, phishing attacks have emerged as a primary concern for individuals and organizations alike. Phishes employ social engineering techniques to manipulate human vulnerability, luring unsuspecting victims into revealing sensitive information or performing actions that can have dire consequences [1][2].

Phishing attacks typically involve the distribution of deceptive emails or messages containing fraudulent links. Once recipients fall into the trap, cybercriminals exploit this opportunity to gain unauthorized access to victims' accounts, leading to financial loss, identity theft, and other severe ramifications. Despite efforts to mitigate this menace, the

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proliferation of phishing websites and the evolution of sophisticated tactics have made traditional detection methods less effective [3].

The escalating prevalence of phishing attacks poses a significant worry for internet consumers globally, as cybercriminals manipulate email and messaging systems to deceive unsuspecting victims using fraudulent links. Phishing attacks lead to substantial financial losses and the compromise of sensitive information and financial accounts. Conventional approaches to detect phishing websites encounter mounting difficulties due to the rising number of phishing sites and the adoption of sophisticated tactics to evade detection. This literature review examines previous research on machine learning-based methodologies to enhance the identification of phishing websites, aiming to tackle these challenges and protect internet users from the pervasive threat of cybercrime [4].

1.1 Challenges with Traditional Methods

Traditional approaches for detecting phishing websites have long relied on techniques like visual verification, content-based analysis, and maintaining blacklists of known phishing URLs. Although effective in the past, these methods struggle to keep pace with the ever-increasing number of phishing sites and the cunning techniques employed by phishers. Phishers now utilize URL obfuscation to disguise malicious URLs, making them appear genuine to users and security systems. Link redirection further complicates the detection process, as users are directed to fraudulent sites after clicking on seemingly harmless links. Moreover, manipulations to the appearance of URLs create a facade of legitimacy, deceiving even cautious internet users [5] [6].

1.2 The Machine Learning-Based Approach

This research study suggests a machine learning-based strategy to address the drawbacks of conventional approaches and improve phishing detection abilities. Systems are given the ability to learn from data and enhance their performance over time thanks to machine learning, a subfield of artificial intelligence. Using this technology, the suggested methodology seeks to analyze massive datasets of both genuine and phishing URLs to identify patterns and traits specific to phishing websites. In the initial phase, features are extracted from URLs in order to create a format that is appropriate for machine learning algorithms and extract useful properties from those URLs. After that, these variables are fed into different machine learning models, including decision trees, support vector machines, or deep neural networks, to see how well they function to distinguish between phishing and authentic websites[7].

II. LITERATURE REVIEW

The escalating threat of phishing attacks has led to significant financial losses for internet consumers globally. Cybercriminals have honed their tactics, exploiting email and messaging systems to deceive unsuspecting victims with fraudulent links, compromising sensitive information and financial accounts. Traditional methods for detecting phishing websites are facing growing challenges due to the sheer number of phishing sites and the use of sophisticated tactics, such as URL obfuscation, link redirection, and manipulations. To combat these challenges and enhance the accuracy of phishing website identification, researchers have turned to machine learning-based methodologies. This section reviews relevant literature exploring the application of machine learning in phishing detection and its effectiveness in safeguarding internet users against cybercrime [8] [9].

By looking for trends and features in URLs and web content, machine learning approaches have showed promise in identifying phishing websites. In their study, Liu et al. (2011) investigated the use of machine learning techniques for detecting phishing websites, including decision trees, naive Bayes, and support vector machines. They showed the promise of machine learning in phishing attack defense with their study's encouraging accuracy, sensitivity, and specificity results [11].

Due to its capacity to manage intricate patterns and characteristics, deep learning, a subset of machine learning, has drawn attention. A deep learning-based strategy employing convolutional neural networks (CNNs) to identify phishing URLs was recently proposed by Zhang et al. (2019). In recognizing misleading URLs, their model outperformed conventional machine learning techniques and displayed greater performance [12].

Ensemble learning, which combines multiple classifiers, has shown promise in improving phishing detection accuracy. In a comparative study, Akhtar et al. (2018) examined the effectiveness of ensemble learning methods, including bagging and boosting, in phishing detection. Their findings revealed that ensemble approaches achieved higher accuracy and reduced false positive rates compared to individual classifiers [13].

Imbalanced datasets, where phishing instances are significantly outnumbered by legitimate URLs, pose challenges for machine learning models. In response, Chiew et al. (2020) proposed a

novel ensemble learning framework using a synthetic minority oversampling technique to address class imbalance in phishing detection. Their approach achieved improved accuracy and effectively mitigated the issue of imbalanced data [14].

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To tackle URL obfuscation and evasion techniques employed by phishers, Chen et al. (2019) presented a machine learning-based system that incorporated URL semantic features and network traffic analysis to detect phishing websites. Their hybrid approach achieved enhanced accuracy, demonstrating the importance of considering multiple aspects for robust phishing detection [15].

Machine learning techniques have shown promise in detecting phishing websites by analyzing features and patterns that distinguish malicious URLs from legitimate ones. Li et al. (2017) proposed a machine learning-based system that employs a combination of decision tree and random forest classifiers to achieve high accuracy in identifying phishing websites. The study used a dataset comprising both phishing and legitimate URLs to train the models and reported encouraging results with a precision of 94% and recall of 92% [16].

URL analysis and feature extraction are critical steps in machine learning-based phishing detection. Datta et al. (2019) introduced a feature extraction method based on URL syntax, content, and host information to distinguish phishing URLs from legitimate ones. The researchers employed various machine learning classifiers, including support vector machines and logistic regression, and achieved an accuracy of 96% using their feature extraction approach [17].

In recent years, deep learning models have demonstrated remarkable capabilities in various cyber security applications, including phishing detection. Zhang et al. (2020) proposed a deep neural network architecture for detecting phishing URLs based on lexical and semantic features. Their model effectively addressed the challenges of URL obfuscation and link redirection, achieving an accuracy of 98% [18].

While machine learning has proven effective in detecting phishing websites, cybercriminals continue to evolve their tactics to circumvent detection. Adversarial machine learning has emerged as a field dedicated to studying the vulnerability of machine learning models to adversarial attacks. Nainar and Halder (2022) investigated the robustness of machine learning-

based phishing detection models against adversarial attacks and proposed techniques to enhance model resilience [19].

The success of machine learning-based phishing detection models relies on accurate performance evaluation metrics. Ahmad et al. (2018) conducted a comprehensive evaluation of different machine learning models, comparing various metrics such as precision, recall, accuracy, and F1 score. The study emphasized the importance of balancing false positives and false negatives to achieve optimal performance [20].

2.1 Summary Table

Authors	Abstract	Methodology	Findings
Liu et al. (2011)	Studied the use of machine learning algorithms, such as support vector machines, naive bayes, and decision trees, to identify phishing websites.	Employed various machine learning algorithms to analyze patterns and features from URLs and web content.	Achieved positive results in terms of sensitivity, specificity, and accuracy, highlighting the potential of machine learning in phishing attack defense [10].
Zhang et al. (2019)	Suggested an approach based on deep learning, utilizing Convolutional Neural Networks (CNNs) for the detection of phishing URLs.	Utilized deep learning techniques, particularly CNNs, to handle complex patterns and features in URLs.	Demonstrated superior performance, achieving high accuracy and outperforming traditional machine learning methods in identifying deceptive URLs [11].
Akhtar et al. (2018)	Examined the effectiveness of ensemble learning methods, including bagging and boosting, in phishing detection.	Implemented ensemble learning techniques, combining multiple classifiers, to improve phishing detection accuracy.	Ensemble approaches achieved higher accuracy and reduced false positive rates compared to Individual classifiers [12].
Chiew et al. (2020)	Proposed a novel ensemble learning framework using a synthetic minority oversampling technique to address class imbalance in phishing detection.	Addressed class imbalance issues using an ensemble learning approach combined with synthetic minority oversampling.	Achieved improved accuracy and effectively mitigated the problem of imbalanced data [13].
Chen et al. (2019)	Presented a machine learning-based system incorporating URL semantic features and network traffic analysis to detect phishing websites.	Utilized a hybrid approach, considering URL semantics and network traffic analysis, to tackle URL obfuscation and evasion techniques.	Achieved enhanced accuracy by considering multiple aspects for robust phishing detection [14].
Ahmad et al. (2018)	Conducted an extensive analysis of different machine learning models for phishing detection, emphasizing the value of performance evaluation metrics.	Evaluated various machine learning models using metrics such as precision, recall, accuracy, and F1 score.	Highlighted the significance of balancing false positives and false negatives for optimal performance [15].

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Datta et al. (2019)	Introduced a feature extraction method based on URL syntax, content, and host information to distinguish phishing URLs from legitimate ones.	Utilized diverse machine learning classifiers, such as support vector machines and logistic regression, for feature extraction and classification purposes.	Achieved an accuracy of 96% using their feature extraction approach [16].
Li et al. (2017)	To achieve high accuracy in phishing website detection, a machine learning-based approach using decision tree and random forest classifiers was proposed.	Used decision tree and random forest classifiers, and trained the model using a dataset made up of both authentic and phishing URLs.	Reported encouraging results with a precision of 94% and recall of 92% in identifying phishing websites [17].
Nainar et.al (2022)	Investigated the robustness of machine learning-based phishing detection models against adversarial attacks and proposed techniques to enhance model resilience.	Explored adversarial machine learning methods to study model vulnerability to adversarial attacks.	Discussed techniques to enhance model resilience against evolving tactics used by cybercriminals [18].
Wang et al. (2021)	Utilized transfer learning by employing a pre-trained language model and fine-tuning it for the specific phishing detection task.	Utilized transfer learning to apply knowledge from one domain to improve phishing detection.	Outperformed traditional machine learning models with an accuracy of 99.2%[19].
Zhang et al. (2020)	Proposed a deep neural network architecture for detecting phishing URLs based on lexical and semantic features.	Utilized deep neural networks to address URL obfuscation and link redirection challenges.	Achieved an accuracy of 98% in identifying phishing URLs [20].

Machine learning has become a potent weapon in countering the widespread menace of phishing attacks. Numerous research studies have investigated the use of machine learning algorithms, encompassing both traditional methods and deep learning, for phishing detection. Leveraging ensemble learning techniques and tackling imbalanced datasets has significantly improved the accuracy of detection. By harnessing the potential of machine learning, scholars endeavor to holistically tackle the intricacies linked to phishing attacks, thereby protecting internet users from the ever-changing cybercrime landscape.

III. Problem statement

Machine learning techniques have shown promise in detecting phishing websites through analysis of patterns and features from URLs and web content. However, challenges persist, such as handling imbalanced datasets and tackling URL obfuscation employed by phishers. Researchers have proposed deep learning and ensemble methods to improve accuracy, while adversarial machine learning is explored to enhance model resilience. Evaluating performance metrics is crucial for optimal detection. Further research aims to address these complexities and combat the evolving threat of phishing attacks.

3.1 Contributions

- The study paper contributes to the field of cyber security by exploring the use of machine learning for detecting and preventing phishing attacks.
- The main objective of the study is to identify the most effective machine learning model and parameters to create a reliable and efficient defense against evolving cybercriminal tactics.
- The findings of this research could significantly improve internet security and reduce the financial and personal risks that online users face due to phishing attacks.

IV. DATASET

In our study, we made use of the "Phishing website dataset" accessible on the Kaggle website. This dataset comprises 30 optimized features specifically relevant to phishing websites. These features can be categorized into three distinct groups:

A. URL and derived features:

1. Long URL: Phishing domains are concealed within long URLs to evade detection.
2. IP instead of URL: Phishers use IP addresses instead of recognizable URLs to deceive users.
3. Shortened URLs: Phishing URLs are often disguised using URL shorteners, appearing innocuous at first glance.
4. "@" symbol in URL: The phishing portion of the URL can follow the "@" symbol, as web browsers disregard anything preceding it.
5. URLs with "//": The use of "//" can lead to redirection to a phishing site.
6. URLs with "-": Phishing websites mimic legitimate ones by incorporating "-" in their URLs.
7. Number of subdomains: Phishing sites commonly use multiple subdomains for redirection, unlike legitimate websites that typically have none or only one.
8. Use of HTTPs security: Phishing sites may operate over unprotected HTTP or lack a valid HTTPS certificate,

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while legitimate sites use HTTPS for security.

9. Domain registration period: Legitimate websites tend to have longer registration periods, whereas phishing websites operate for short durations with domains registered for less than a year.

10. Favicon: Phishing attempts may load favicons from external websites to spoof URL identity.

11. Ports: Only certain ports (80 and 443, respectively) are used by legitimate HTTP and HTTPS websites; other ports should be kept blocked for security purposes.

12. Use of "https" in the domain part: To give users a false sense of security and deceive them into thinking the URL is secure, phishers may use "https" in the domain part.

B. Based on URLs Incorporated in Website:

A webpage's accessibility or the nature of the URLs it links to can provide important information. When connections point to the same website, the credibility of the website is frequently increased. Embedded URLs were used to identify the following details:

1. Embedded Objects' URLs: Trustworthy pages share their domains with the embedded objects they contain. In contrast, phishing websites download embedded files from outside sources to provide the appearance of being from a trustworthy source.

2. Anchor Tag URL: The anchor tag in HTML is used for hyper linking. False sources in anchor tags are never found on trustworthy websites. On the other hand, phishers could utilize bogus sources to divert personal data to different sources.

3. Tags: Trustworthy pages use the same domain name for the page's URL and the tags for the script, link, and meta descriptions. These domain names frequently contain errors on suspicious websites.

4. Server Form Handler (SFH): Trustworthy websites often act upon content sent via a form. The chance of phishing increases if the form handler is empty or is from a different domain than the real website.

5. Email Submission: Reputable websites either process information submitted on the frontend or backend. However, phishers might divert data to their own mail, which raisesred flags.

6. Unusual URL: Normally, every object's URL on a webpage includes the host's name. Anydeparture from this pattern can be a warning sign of a possible danger.

C. Based on HTML and JavaScript Features:

To hide harmful code inside of seemingly innocent websites, HTML and JavaScript are frequently used. Some of the distinguishing characteristics are:

1. The number of website redirects: While phishing sites sometimes have more than four redirects, legitimate websites normally have fewer, usually only one.

2. Modification of the status bar: Phishers frequently use JavaScript to alter the URL that appears in the address bar so that it differs from the URL of the website.

3. Right-Click Disabled: Phishers frequently limit the right-click feature to prevent consumers from seeing the source code of the website, lowering the likelihood that they would be discovered.

4. Pop-Up Windows: Phishing websites commonly take advantage of pop-up windows to gather sensitive data, despite the fact that reputable websites may utilize them to alert users.

5. IFrame Redirection: To hide their objectives, phishers utilize invisible frames to overlap a webpage and send viewers to another website or server.

D. Domain-based Characteristics:

Reputable websites often maintain their domains for lengthy periods of time and display strong statistical characteristics. Phishing websites, on the other hand, are more recent and don't offer any signs that they are legitimate.

1. Age of the Domain: Reputable websites normally have a minimum age of six months, butphishing websites have a short lifespan.

2. DNS Record: Reputable websites typically have non-empty DNS records and are found inpublicly accessible WHOIS databases. Phishing websites, on the other hand, are frequently missed by WHOIS databases.

3. Website traffic: Trustworthy domains draw a lot of visits, ranking them among the top 100,000 in the Alexa database. Websites that Alexa does not recognize are probably phishing scams.

4. Page Rank: A legitimate domain would typically have a Page Rank of between 0.2 and 1, with a higher Page Rank signifying a more important domain.

5. Google Index: Google normally indexes trustworthy websites. Phishing websites, in contrast, do not enter the Google index because of their transient nature.

6. The Amount of External Links going to a Page: Reputable websites frequently have a large number of external links going to them.

7. Statistical Report-based: To identify phishing websites,

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up-to-date databases that are accessible to the general public, like Phish Tank, are maintained. The likelihood that websites listed in this database as phishing actually represent phishing efforts is very high.

V. METHODOLOGY

A. *Data Pre-processing*:

1. Removal of Unnecessary Column: The data pre-processing phase began with the removal of the 'index' column, which was deemed unnecessary for the analysis.

2. Data Transformation: The dataset used a range of values {-1, 1} to represent the results, where '-1' denoted phishing and '1' indicated legitimate URLs. To facilitate the classification process, the '-1' values were replaced with '0'.

3. Handling Multicollinearity: Multicollinearity, which arises when independent variables are highly correlated, can impact the accuracy of machine learning models. To detect multicollinearity, the 'DataFrame.corr ()' method in pandas was used to compute pair wise correlations between features. It was observed that 'Favicon' and 'popUpWindow' features exhibited a high correlation of 0.94. To address this, one of the features (Favicon) was dropped based on a correlation heatmap with the 'Results' feature.

4. Data Splitting: The dataset was split into training and testing sets, with 70% of the data used for training and the remaining 30% for testing.

B. *Model Selection*:

1. Logistic Regression: A logistic regression model was deployed, using the 'liblinear' solver with a maximum of 1000 iterations.

2. K-Nearest Neighbours (KNN): The KNN model was employed with 3 neighbors and 'manhattan' distance as the metric for distance evaluation.

3. Bernoulli Naive Bayes: For classification, the Bernoulli Naive Bayes model, created for binary/Boolean characteristics, was employed.

4. Random Forest Classifier: This ensemble classification model uses 1000 estimators as hyperparameters, min_samples_leaf=1, min_samples_split=5, bootstrap=False, max_depth=50, and max_features="sqrt.

5. Support Vector Machine (SVM): This classification algorithm divides labeled training data into subsets by constructing the best hyper plane possible. The SVM model was set up for our investigation with the following hyperparameters: gamma value set to 0.01 and C value equal to 10. The kernel was set to "rbf."

C. *Performance Assessment*:

Three crucial measures were used to gauge the models' efficacy:

1. Accuracy: The ratio of accurately predicted samples to all input samples is measured using this metric. It's critical to achieve high accuracy because correctly classifying URLs is our main goal.

2. Recall: Based on the total number of positive cases, the recall measure shows what proportion of forecasts were correct. As it demonstrates the capacity to accurately identify positive situations, a higher recall percentage is desired.

3. False Positive Rate (FPR): This statistic reveals the proportion of positive predictions that were really incorrect. Because misidentifying phishing websites as legal ones could result in considerable losses for individuals who visit such websites, minimizing the FPR is crucial tolowering the likelihood of this happening.

VI. RESULTS

Utilizing the validation data as a basis for training and evaluating the models, the results are shown in Table 1. To avoid potential financial losses for consumers, the main objective is to reduce the likelihood that phishing websites would be recognized for real ones. Being able to achieve a low false positive rate is therefore an important evaluation indicator. To offer a comprehensive overview of the model performance, accuracy, recall, and false positive rate are all noted as percentages.

1. Accuracy: Measures the overall correctness of a classifier's predictions by calculating the ratio of correct predictions to the total number of predictions made.

Formula: Accuracy = (True Positives + True Negatives) / (Total Predictions)

2. Recall (Sensitivity or True Positive Rate): Evaluates the classifier's ability to correctly identify positive samples (true positives) out of the total actual positive samples.

Formula: Recall = True Positives / (True Positives + False Negatives)

3. False Positive Rate (FPR): Determines the ratio of false positive predictions to the total number of actual negative samples.

Formula: FPR = False Positives / (False Positives + True Negatives)

Table 1: Classification Models Results (in percentage)

Model	Accuracy	Recall	False Positive Rate
Random Forest	98.32%	97.95%	4.60%
Support Vector Machine	94.20%	93.43%	6.57%
K-Nearest	93.05%	93.40%	6.60%

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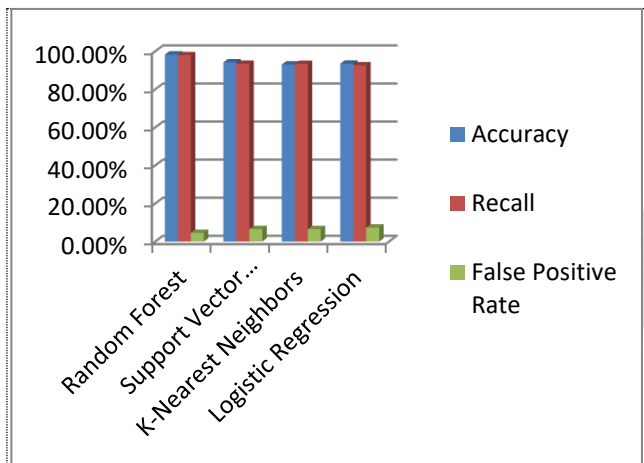|			
Neighbors			
Logistic Regression	93.50%	92.62%	7.38%
Bernoulli Naïve Bayes	91.25%	91.70%	11.32%

Figure 1: Classical models comparison

Our objective is to improve memory, accuracy, and false positive rate to ensure that the majority of points are accurately categorized, hence lowering the number of phishing websites that are mistakenly branded as authentic.

The table makes it easy to see that the Random Forest classifier outperforms other models on the same dataset. All three metrics—the best accuracy (98.32%), maximum recall (97.95%), and lowest false positive rate (4.60%)—meet our objectives. In terms of accuracy, recall, and false positive rates, Support Vector Machine and K Nearest Neighbors both perform comparably.

Only 93.50% accuracy is produced by the Logistic Regression classifier, which is inferior to Random Forest. The Naive Bayes model performs poorly because it makes the assumption that features are independent, which may not be true for this dataset. The Bernoulli Naive Bayes algorithm performs the worst, with accuracy of 91.25%, recall of 91.70%, and highest false positive rate of 11.32%.

Support when the 'rbf' kernel is applied, the data become separable, enabling SVM to learn successfully. Vector Machine performs well for linearly separable data.

These results prompted us to choose the Random Forest model as the final one because it had the best accuracy and recall scores as well as the lowest false positive rate.

VII. CONCLUSION

In this study, we investigated various machine learning models to identify phishing websites with the goal of identifying the best classification model with a high degree of accuracy. We found that the Random Forest Classifier performed remarkably well for phishing website detection

after careful investigation. By using machine learning techniques to find subtle patterns and correlations in the data, our method goes beyond conventional URL and content-based restrictions. Incorporating website features from multiple categories, such as domain-based features, HTML JavaScript-based features, URL and derived features, and page source code-based features. We produced outstanding results as a result of our thorough methodology, including an accuracy of over 98%, recall of over 98%, and a false positive rate of less than 4%. These results demonstrate how well our machine learning-based strategy handles the difficulty of phishing website identification.

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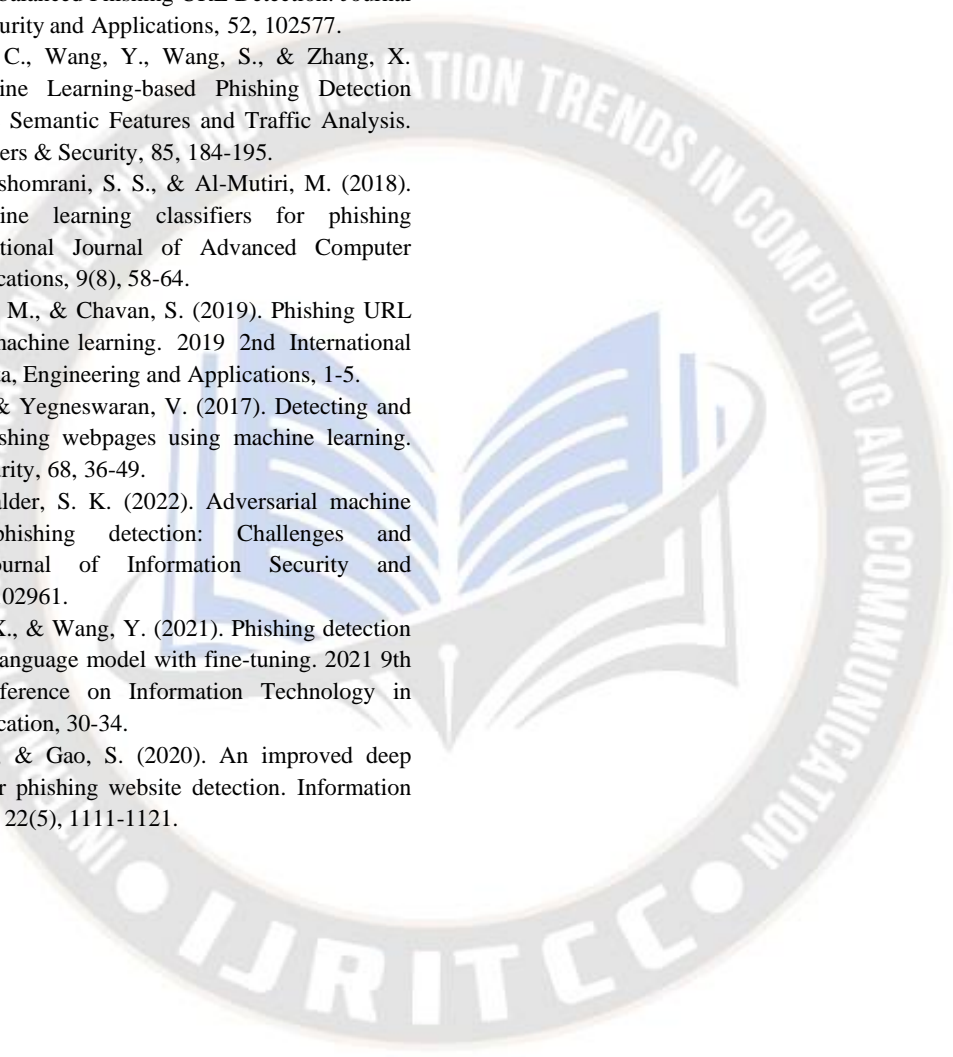
To Secure the Cloud Application Using a Novel Efficient Deep Learning-Based Forensic Framework

Sheena Mohammed and Sridevi Rangu

Abstract

Privacy and security are the most concerning topics while using cloud-based applications. Malware detection in cloud applications is important in identifying application malware activity. So, a novel Goat-based Recurrent Forensic Mechanism (GbRFM) is used to detect the attack and provide the attack type in cloud-based applications. At first, the dataset is pre-processed in the hidden phase, and the errorless features are extracted. The proposed model also trains the output of the hidden layer to identify and classify the malware. The wild goat algorithm enhances the identification rate by accurately detecting the attack. Using the NSL-KDD data, the preset research was verified, and the outcomes were evaluated. The performance assessment indicates that the developed model gained a 99.26% accuracy rate for the NSL-KDD dataset. Moreover, to validate the efficiency of the proposed model, the outcomes are compared with other techniques. The comparison analysis proved that the proposed model attained better results.

Keywords: Forensic architecture ▪ cloud application ▪ recurrent neural network ▪ wild goat optimization ▪ classification accuracy ▪ error rate

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Behavioral Cloning-Enabled Autonomous Vehicle Lane Line Detection Using Nvidia Convolution Neural Network Model

Satya Kiranmai Tadepalli, Kratika Sharma, U. Sairam, and V. Santosh

Abstract The fast improvement in artificial intelligence has revolutionized the location of self-sustaining motors by using incorporating complicated models and algorithms. Self-driving motors are constantly certainly the biggest inventions in computer technology to know-how and robot intelligence and quite sturdy algorithms that facilitate the functioning of those automobiles probably decreases many existence-threatening accidents which arise due to human negligence and facilitate the benefit of visiting over long distances. In this paper, our aim is to create a deep mastering model with a view to force the car autonomously and can adapt nicely to the actual time tracks and doesn't require any manual function extraction. This research provides the laptop vision techniques using OpenCV for lane lines detection, development of convolutional neural networks to perceive between diverse traffic symptoms and Keras library implementation and behavioral cloning.

Keywords Autonomous · Lane lines detection · Nvidia convolutional neural networks · Udacity simulator · Deep learning · Behavioral cloning

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1   Introduction

Automation has made significant strides in the modern era, and artificial intelligence has aided in our transition to newer technology. Numerous difficulties in the real world have been solved by artificial intelligence. Autonomous vehicle operation is one of the hottest issues right now. Autonomous vehicles can help users save valuable time and reduce accidents. There are several brand-new approaches to autonomous driving, but in this paper, we'll concentrate on one approach, which is based on machine learning. We are utilizing the capabilities of convolutional neural networks to extract characteristics from the images produced by the simulator to address this issue [1]. We have access to a simulator through the e-learning platform Udacity that allows us to gather data and test deep learning models on several tracks. The simulator offers image-based data collecting. The information is carefully gathered from the left, center, and right angles. Using these photographs as training data, the model predicts an angle between − 1 and 1. An angle with a negative value indicates a left turn, one with a positive value larger than zero indicates no steering, and one with a zero angle indicates a right turn. An open-source software created with unity and offered by Udacity is called Udacity simulator. Unity is a robust cross-platform IDE for developers and a 3D/2D game engine. Unity offers all the built-in elements as it is a game engine. It has physics, detection of collision and rendering. There is no need to create it from the standpoint of a developer. With the aid of various environments to test various models in accordance with requirements. Unity is both an IDE and a game engine. "Integrated development" is what "IDE" stands for. Environment refers to a user interface that provides access to all the development tools you require in one location. Creators may easily drag and drop items into scenes with the Unity software's visual editor and then adjust their settings.

The simulator's home screen is depicted in Fig. 1. Udacity offers training mode and autonomous mode, as depicted in the figure. Use of training mode autonomous mode is employed to test the model and record data. A flask server is used to connect to the simulator. The simulator communicates the photographs and other data to the flask server while operating in autonomous mode. The incoming photographs are then preprocessed before being given to the model for prediction. The steering angles are predicted by the model and sent to the simulator. The car steers in the desired direction in accordance with the obtained value.

2   Literature Survey

From [1], with no manual feature extraction needed, the goal of this research is to create a deep learning model that can drive the automobile automatically and adapt well to real-time tracks. This study suggests the model that gains knowledge from video data. Convolutional neural network modeling, behavioral cloning, image processing and picture augmentation are all included. The model learns from human

Fig. 1 Udacity simulator main screen

activities in the video through behavioral cloning, and the neural network architecture is utilized to determine paths, the edges of roads and the positions of obstacles. The idea behind this strategy is to use deep learning in conjunction with supervised learning to reach our final goal. The observations made from this study are: the model is tested by self-driving on a second track that has not yet been seen after being educated on the frames from the first track. There were about 1500 photographs sent to the generating function (for performing image augmentation during the training). Mean Square Error. The validation set had a minimum MSE loss of 0.029. For the most part, the automobile drove perfectly and remained stable. This strategy is effective, no doubt about it is used to train the deep learning model as the loss function, and Adam optimizer was chosen as the optimizer for (on Kaggle's potent k80 GPU, the entire procedure took about 3240.2 s) loss of instruction and approval. The Validation loss continues to decline, and both the a positive sign that the model has learned the correlations adequately and has not over-fit on the training data is that the training loss appears to decrease as the epoch count rises and converges at about 17 epoch.

With the results from [2], through auto-driving, computers could operate vehicles autonomously. One of the essential components of autonomous vehicle systems, which enable the car to maneuver the parking lot without human control, is automated parking. The smart parking lot and the smart car are two systems that are necessary. The smart parking structure can aid in directing the route from the entry to the parking space [3]. Due to the lack of access to GTA 5's inner coding, situational identification must be used to extract visual data from GTA 5. Real-time game picture capturing and array data storage are done using OpenCV and NumPy routines. We may examine the images we've taken using YOLO v4 and TensorFlow. After analysis, we can collect data and categorize the outcomes.

As per [4], self-driving cars are being developed to increase vehicle efficiency and safety, minimize traffic accidents, free up people's time, reduce carbon emissions, lessen the death rate and conserve money and fuel. It falls within the categories of

computer vision and IoT. Lane detection, obstacle identification, traffic signal detection, signboard detection, self-parking, humps, pothole detection, accident detection, four-lane driving, etc. should all be included in the self-driving car's feature set. This study has explored many functionalities, including object detection, lane detection, traffic signal detection and signboard detection.

In this article [5], a summary of the research's current state developed roundabout traffic, the decision's complexity and the preliminary test findings for artificial intelligence-aided autonomous car decision before entering the roundabout. The complexity of the decision, which is the justification for involving artificial intelligence, is addressed in this paper, and a solution is offered. Since we cannot eliminate all errors, we must be very specific about what we want to obtain. In this study, two distinct neural network topologies were put to the test, but neither one outperformed the other. This study created 14 large networks and 39 tiny networks without colliding.

3 Methodology

The goal is to create a virtual autonomous car with a deep learning model that can successfully drive, avoid obstacles and maneuver in a certain environment.

3.1 Data Collection

Recorded operating the vehicle on the predetermined tracks by using the simulator's training mode. Because for recording the user's actual behavior while operating the vehicle, this technique is known as behavioral cloning. To obtain the training data, track 2 has been used. Images from three various viewpoints, primarily the center, left and right, build up the data. The photographs are saved in RGB format and have 320 X 160-pixel width and height, respectively. We were able to effectively collect 3857 photographs with various steering angles in the end. Here RGB photographs to YUV conversion is done using the CV2 library. The benefit of picture conversion is that YUV images consume less bandwidth than RGB ones. After converting the pictures, we use the Gaussian blur method from the CV2 library to smooth the image. The image is being cropped to fit our area of interest. A crucial part of both computer vision generally and self-driving cars is lane line prediction. To reduce the risk of entering another lane and to specify the route for self-driving automobiles, this idea is employed.

Below is the process for lane line detection:

a. Gaussian blur
b. Canny edge detection
c. Hough transformation.

Fig. 2 Before Gaussian blur
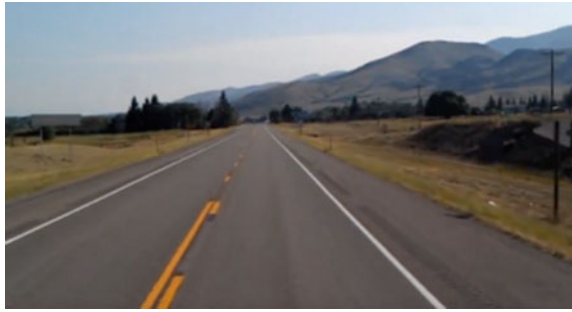
Fig. 3 After Gaussian blur

3.1.1 Gaussian Blur

In a Gaussian blur operation, a Gaussian filter is convolved with the image instead of using a box filter. A low-pass filter known as a Gaussian excludes high-frequency components (Figs. 2 and 3).

3.1.2 Canny Edge Detection

A multi-stage technique is used by the Canny edge detection operator to find a variety of edges in images. It can drastically minimize the amount of data that needs to be processed by extracting structurally valuable information from various vision objects (Fig. 4).

3.1.3 Hough Transformation

In Hough space's parametric space, the intersection of two lines provides us the precise coordinates of the line that connects the two points $y = mx + b$ [6]. This technique is used in analyzing the images and to know about instances of objects (Fig. 5).

Fig. 4 Inverted result of Canny edge detection

Fig. 5 Inverted Hough road
edges

3.2 Preprocessing Data Using Augmentation Techniques

Augmentation techniques have been applied on different ways for the clear view of lines [7]. The following are the different techniques that have been applied:

a. Zoom augmentation
b. View augmentation
c. Flip image augmentation
d. Brightness augmentation (Figs. 6, 7, 8 and 9).

4   NVIDIA CNN Model

CNN is a very common application used in many fields, such as medical image analysis, object detection, automatic speech recognition, classification and wind speed forecasting. One can create a neural network by employing this model and its design. The findings are listed below (Figs. 10 and 11).
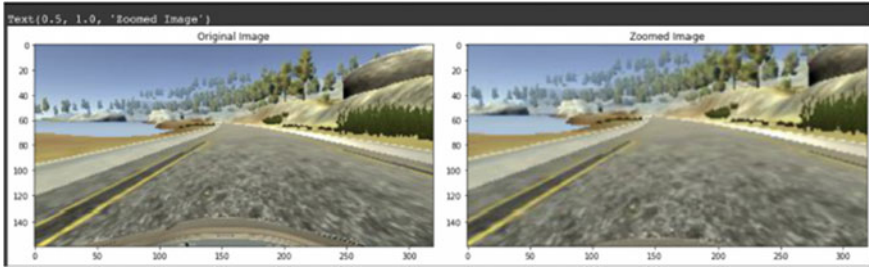
Fig. 6 Zoom augmentation output
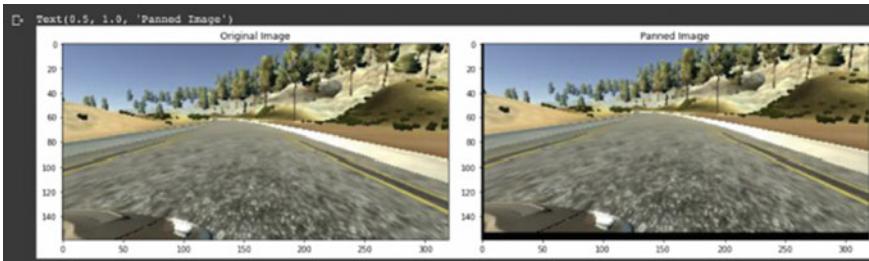
Fig. 7 Panoramic view augmentation output
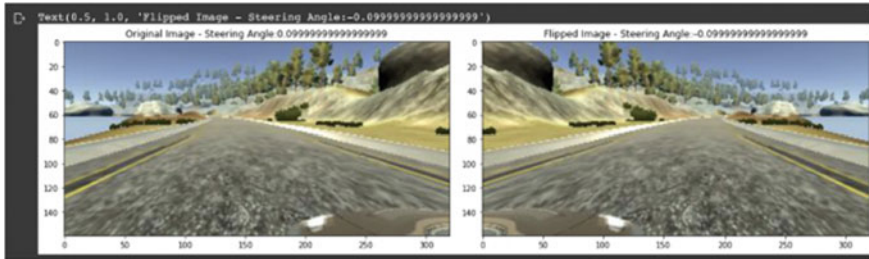
Fig. 8 Flip image augmentation output
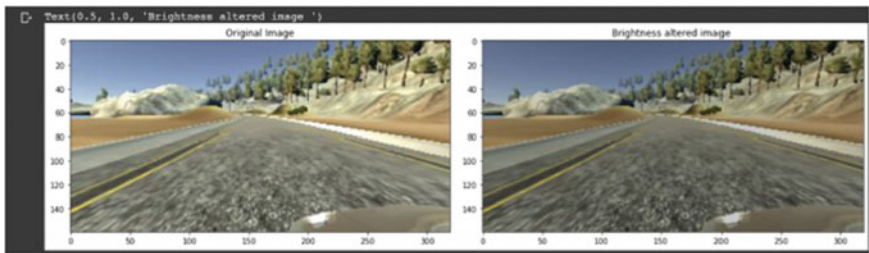
Fig. 9 Brightness augmentation output
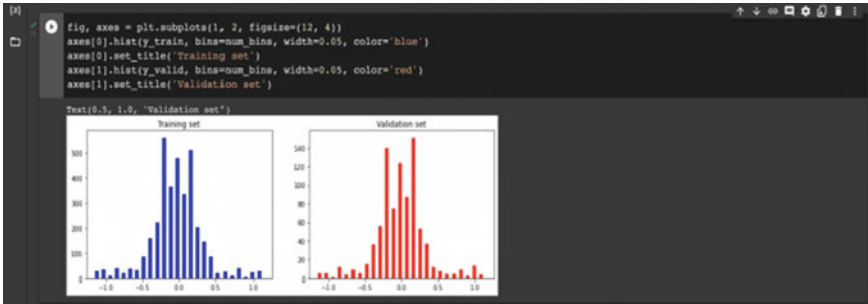
Fig. 10 Training and validation
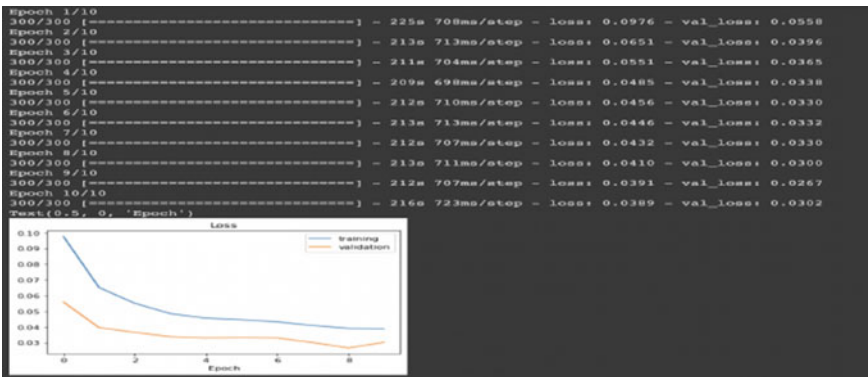
Fig. 11 Epoch losses and validation sets

5 Conclusion and Future Scope

Quasi- and fully autonomous vehicle technology is complete and is ready for commercial implementation. Street mapping, accident avoidance and navigation have all advanced significantly thanks to major automobile manufacturers and software providers.

AVs have the potential to minimize the majority of traffic accidents if technology can live up to its promise, but first it will be depending on a self-driving system that can perceive the road better than the best human driver. It is obvious that data will be necessary to boost the potential of an automated vehicles. Up to 25 GB of data can be produced every hour by connected cars of today. The groundwork for building smart software-defined autonomous systems that can navigate highways with no human interaction is being laid by the ongoing advancement of safety technology. Advanced driver-assistance systems (ADAS), which use sensor technologies to detect objects in many modern vehicles today [8], are becoming more complex with each generation.

The success of AV will depend on the progress of 5G technologies, which will enable artificial intelligence (AI) and analytical skills in self-driving automobiles.

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A Survey on Collaborative and Effective Implementation of Augmented Reality (AR) Interactive Learning Application

Satya Kiranmai Tadepalli, Fariyal Ajrad, Nimisha Malreddy, and B. Medha Reddy

Abstract As schools seek interactive learning methods to make complex concepts easily graspable, it is observed that technology can be leveraged toward the same. In particular, augmented reality has the potential to make demanding topics not seem like rocket science. With real-time visualization from day-to-day devices like smartphones and tablets, regular pedagogical strategies can be modified for the betterment of both students and teachers. This AR interactive learning application is specially designed for the NCERT science textbook of X standard CBSE board. Diagrams from the book can be scanned and visualized in 3D. The Unity game engine and Vuforia AR SDK are used for the development of the app. These models can be zoomed in and out, rotated, and rigged for an immersive experience. Along with the 3D model, a dialog box consisting of a brief description, additional resources, and aided text-to-speech audio functionality is available. The models and other assets are downloaded from TurboSquid. Additionally, to test their knowledge, students can participate in timed quizzes which have questions from the NCERT textbook for the particular topic.

Keywords Augmented reality · NCERT biology

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1 Introduction

Augmented reality (AR), in simple words, can be described as integration of the users' real-world environment with computer-generated or digital content. Virtual reality (VR) on the other hand gives an opportunity for a more immersive experience by creating a full-fledged artificial environment that replaces the users' reality, unlike augmented reality [1]. In order to view digital content in a real-time environment, AR requires a device (smartphone, tablet, data glasses, etc.) with a camera and AR software. Computer vision permits AR systems to extrapolate virtual content to appropriate locations or targets. It then realistically presents the digital content in a real-world environment through display devices. AR can be categorized into two types as: Marker-based (Augmented reality applications are set off by using a set of predetermined physical images known as markers that are captured by the cameras to place digital media on them [2]) and Markerless AR (Independent of markers and gives us the freedom to decide where to display the digital elements [2]).

2 Augmented Reality in Education

It has a variety of applications across different sectors of society. However, it has shown its true potential in the field of education. Technology in education influences and motivates students to learn actively, leading to effective learning processes [3]. AR has proven to be of great potential in making the educational experiences more agile, effective, and purposeful. Not to mention, the integration of AR and education has been in the radar of extensive research as it allows students to get lost in realistic experiences [3]. Applications of AR in education are found in many fields, including biology, astronomy, chemistry, mathematics, history, geography, and physics.

3 Literature Survey

AR is currently a technology medium that offers a unique opportunity to combine the physical and virtual worlds. AR (as a learning aid) was used in a study to compare and evaluate students studying about microorganisms and found that the method actually improves biology learning [4]. In addition, the AR Marine Scientific program aims to raise awareness of their marine environment among students. The application was found to help improve the learning of their underperforming students. A recent study on virtual and augmented reality effects on K-12, higher and tertiary education students' twenty-first century skills found that the use of AR in the classroom improved levels of concept comprehension, creativity, motivation, retention, and collaboration [5]. Many AR applications also include game elements (gamification) to grab the learner's attention (Table 1).

Table 1 Literature survey table

Paper title	Author	Methodology	Limitations/Conclusion
AR learning platform for mentally differently abled children (2021)	Geetha et al. [6]	– Primary playbook with alphabets and rhymes-Unity 3D, Vuforia AR SDK, Paint 3D	– Audio-assisted contents can be helpful for differently abled children
Microorganisms: integrating augmented reality and gamification in a learning tool (2021)	Ramli et al. [4]	– Includes AR and gaming features – Unity 3D and Adobe Photoshop, AutoDesk 3D Max	– Limited to only microorganisms – Available only on Android platform
The integration of augmented reality (AR) in learning environment (2020)	Zambri and Kamaruzaman [7]	– AR-based learning app based on ARCS and CTML theories for Malaysian education system	– No use of 3D assets. Only AR multimedia such as videos are used. This is available on video streaming apps too
Creating an augmented book from a geography textbook (2019)	Vahldick and Bittencourt [8]	– App to study geography of Africa for IX class students	– Lack of information for the models used, i.e., no text/audio descriptions
Real time 3D magnetic field visualization based on augmented reality (2019)	Liu et al. [9]	– Provides real-time visualization of 3D magnetic field using AR	– When the number of magnetic lines calculated increases, the model is not rendered as expected
Innovations in tourism industry and development using AR and VR reality	Katkuri et al. [10]	– Tourist guide that gives information like history and explorations about a few tourist attractions via means of multimedia	– Does not use GPS to track the users' location, so that it can send relevant notifications automatically
Extending a user involvement tool with virtual and augmented reality. (2019)	Florea et al. [11]	A survey that studies the effect in user engagement in a living laboratory by augmented and virtual reality tools	– VR clients were experienced as innovative, easy to use, interesting, and fun, whereas AR client to be playful and empowering
Integration of augmented reality in the teaching of English as a foreign language in early childhood education	Redondo et al. [12]	This study presents the development and evaluation of an educational experiment related to early childhood education, with a special focus on the learning of EFL	– The interaction with AR in the early childhood education classroom creates a distinct atmosphere in which pupils improve their socio-affective relationships

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Table 2 Tools and technologies used

Tool	Platform	Supported features
Vuforia	Android, iOS, UPW, and Unity Editor	Unity, 3D recognition, geolocation, cloud storage, and smart glass
Unity	Windows, Linux, and Mac	3D world building, AR, VR, gameplay, cinematic studio, and engineering feature set

4 Tools and Technologies

The software tools needed to build this AR application are Unity and Vuforia SDK. Unity is a game engine that uses the 3D models designed to create the application with real-time rendering [8]. Vuforia is a software development kit (SDK) that supports different operating systems [8]. 3D models can be designed using Adobe Photoshop or external digital media software like TurboSquid. This is given in Table 2.

5 Methodology

The application logic mainly resides in a database of many AR markers, each acting as a distinctive label for a set of input images. The main framework will be implemented using Unity 3D, and also SDK of Vuforia would be incorporated. 3D models are acquired from various open-source websites and Photoshop for designing AR markers. The procedure is primarily divided into three main steps.

5.1 Set up the Required Software

In this project, the first step is to set up the Unity game engine. This step involves creating a Unity project and selecting the platform to work on—Android, IOS, etc. The Android 6.0 'Marshmallow' (API Level 23) is highly preferred since most of the Android mobile phones manufactured from 2017 and above work on that level of software. This step also involves setting up the Vuforia engine.

5.2 Create User Interfaces

Next step is to create the user interfaces (UI) for the application. These UIs can be made on designing tools like Figma, AdobeXD, Adobe Illustrator, etc. The main features in the interface include a home page, a dialog box containing a description

of the biology textbook diagrams, an audio button which will be used to describe the text content in the dialog box, the quiz section interface, and other basic buttons. The buttons are coded using C# script to perform their functionality.

5.3 Importing Assets

The third main step is to create marker images. Marker images, in this case, will be the diagram pictures in the biology textbook. The images are added into a database in Vuforia engine, and each image is given a rating. A rating of 4 and above out of 5 is required for the image to qualify and be used. The database is created and downloaded to be imported into the Unity game engine. Three-dimensional model assets are then imported into the asset library in Unity engine and then placed accordingly on marker images to preview how they will look when it appears on the mobile screen.

6 System Architecture

The capturing module captures the image from the camera. It takes the video from the live video feed which is divided by frames. Those frames are going to the image processing module where the marker is detected and tracked. Create a binary image, a digital image with two possible values for each pixel. The two colors commonly used in binary images are black and white. These binary images are provided as inputs to the image processing engine. Then, the tracking module calculates the pose (six degrees of freedom), i.e., the 3D location and orientation of an object in real time.

Next, it is passed to the rendering module which combines the digital object with the real-world visual to generate the augmented image. Finally, it renders the augmented digital object on the image (Fig. 1).

7 Conclusion

Making conventional pedagogy fun proves more effective in students grasping concepts. As young minds are very fickle, they are resilient toward focus. So, we made a platform where they can both interact and learn. Practical constraints such as a lack of microscope or feasibility of procuring certain elements in biology lessons hinder students' curiosity in visualizing the concepts. Traditional textbooks make it difficult to comprehend by comparing and contrasting. Our app solves this problem by providing a crisp 3D model of the object that can be panned, rotated, and viewed from any angle. Teachers and parents have a hard time teaching their children. This
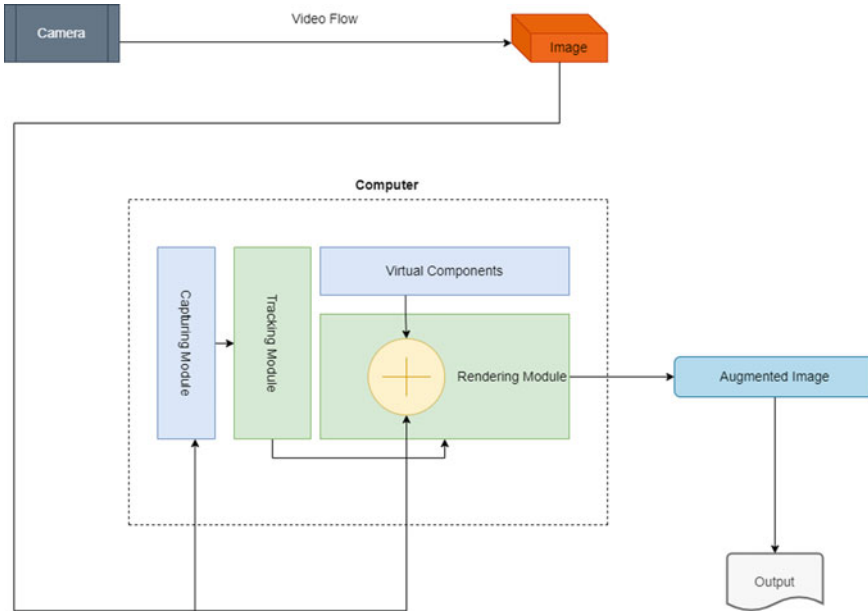
Fig. 1 System architecture

easy-to-use app for parents, teachers, and students, with simple but effective UI-UX, solves the hassle of aforementioned struggles.

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An Entropy enabled Random Forest Neural Network Algorithm to Grade the Reproductive System for Efficient Early Detection of Infertility

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Abstract--**The membrane that borders the uterus is called endometrium. When the liner leaves the uterus, a problem is evident. The main risks of infertility and other health issues can be substantially reduced if the primary cause of endometriosis is understood. As a result, the affected people can receive the right medical care and therapy. The suggested ensemble model performs better than traditional machine learning techniques. For effective implantation, there must be a dependency between the endometrium and the embryo at the blastocyst stage. Data mining method where information gathered from the endometrium/sub endometrium and their ability is assessed uses the endometrium as a site for embryo implantation. Using a typical rating system has certain drawbacks because there are so many irrelevant and unclear criteria. The usability and precision of scoring systems can also be increased using a number of artificial intelligence methods, including random forests and neural networks. This study coupled an advanced reproductive grading system with an entropy and random forest approach to define individuals with infertility according to their health conditions and choose more effective therapies.**

Keywords: Endometriosis, Blastocysts, Neural network, Random Forest, Entropy

I. INTRODUCTION

40 years of age or younger make up to 3-16% of endometrial cancer patients. Although endometrial cancer is uncommon in women of childbearing age, it has a significant impact on the success of conception. Endometrium is less receptive to implantation stage embryos, which makes pregnancy challenging and raises the risk of spontaneous abortion. The risk factors for infertility can be divided into genital, endocrine, developmental, and general categories[14]. The percentage of cases of infertility attributable to specific factors in men or women in underdeveloped nations was calculated by the WHO in the 1985s: Infertility is caused by male factors in 8% of instances, female factors in 37%, females in 35% of cases, and an unexplained reason in 35% of cases (the remaining 15% are pregnant). With so much inconsistent data and unknown criteria, using a traditional ranking scheme has specific drawbacks[9]. However, incorporating innovative technologies will enhance the qualities and offer an alternative method of resolving numerous metrics from the first findings. Computers can find patterns in datasets that are readily available and draw conclusions, implementing the data by employing a suitable AI system, all without the need for explicit instructions. Currently, AI is primarily used in the healthcare industry for picture identification tasks[2]. The great accuracy of AI in diagnosing cancers, and diabetic retinopathy has been noted in several papers. All the cancer and various health domains have all been successfully treated using ML algorithms [3]. The ability to "systematically evaluate every variable, present, and future, to locate groupings of related cases with similar outcomes" is provided by machine learning (ML), as cancer prognostication and prediction systems become more complex due to an increase in factors. Further discrimination can be achieved by using an entropy-based approach, which is frequently employed. An entropy-based technique to loan credit combination has recently been proposed by a study. A number of researchers suggested an auto graded system for use in clinical settings by fusing multi-scale entropy with understanding of sleep architecture. Additionally, a variety of artificial intelligence techniques, such as integrating random forests and neural networks, can further improve the accessibility and accuracy of scoring systems [4]. In order to define individuals with infertility in their physical state and select more effective treatments, this

study used an entropy and random forest algorithm with a complicated reproductive grading scheme[6].

A. Data Collection and Pre-Processing

The patient health claims database for the time period of September 1, 2021, to February 14, 2022, serves as the project's data source. A group of patients ICD 10 endometriosis diagnostic codes were used to identify the study's objective and control groups. Female patients 18 years of age and older made up the study group because endometriosis is a condition that only affects women. In order to create a patient sample that can be compared to the study's target cohort, a control cohort is frequently used. Case control studies and cohort studies are the two forms of exploratory research that can be conducted using randomized control trials. These studies may use prospective or retrospective data. Analysis that is retroactive is based on prior or past occurrences. Future specifics are dealt with in prospective. Case-control research is done in the past. Both prospective and retrospective cohort studies are possible. Therefore, the focus of this research is on cohort studies.

In order to create a patient sample that can be compared to the study's target cohort, a control cohort is frequently used. Before the 2021 death toxicity event, 36 months of patient medical history for the research target and control groups were gathered. To determine the chance of endometriosis, a variety of analytical techniques, including machine learning and rules-based frameworks, were used [7].

TABLE I.   ICD10 CODES FOR ENDOMETRIOSIS

Diagnosis Codes	Diagnosis Long Description
N80.0	Endometriosis of uterus
N80.1	Endometriosis of ovary
N80.2	Endometriosis of fallopian tube
N80.3	Endometriosis of pelvic peritoneum
N80.4	Endometriosis of rectovaginal septum and vagina
N80.5	Endometriosis of intestine
N80.6	Endometriosis in cutaneous scar
N80.8	Other endometriosis
N80.9	Endometriosis, unspecified

There were 3,89,823 patients identified with endometriosis in 2021 using pre-defined ICD 10 diagnostic codes. The propensity score match algorithm is used to obtain comparable traits based on target research cohort . A statistical method

termed the propensity matching algorithm chooses the control cohort based on identical characteristics or variables seen in the study target cohort[1]. The victim's age and medical conditions were covariates that were taken into consideration[12]. The overall comparison between the target and control cohorts of the study is shown in Table 2 by age and Census regions. The ages of patients and locations were divided into regions toform the patient age variable.

Algorithm: Propensity Score Match

$Step-1. Calculate\ propensity\ ratings, for\ instance\ using\ logistic\ regression$

$Z = 1\ if\ t⊡e\ unit\ took\ part\ (\ treatment\ group);\ Z$
$= if\ t⊡e\ unit\ did\ not\ take\ part$
$(i.e., is\ a\ member\ of\ t⊡e\ control\ group).$

Select the proper confounders (variables likely to be related to both the treatment and the outcome)

Obtain a propensity score estimate, such as expected probability p or $\log[p/(1\ p)]$.

Step-2: compare each participant to one or more non-participants based on propensity score:

Mahalanobis Metric matching

Nearest Neighbor Matching

Exact Matching

Step-3:Verify that the parameters are distributed equally among treatment and control groups

To examine distributions, use graphs or standardized differences.

Modify the process by going back to steps 1 or 2 if the covariates are not balanced.

Step-4: Analyse effects using a newly collected sample.

Use analyses suited for non
− independent matched samples if more than one non
− participant is matched to each participant.

TABLE II. COMPARISON OF TARGET AND CONTROL COHORT BY LOCATION AND AGE

Age Group	Target	Control	Location
18–20	6.42%	6.57%	South
21–30	27.11%	26.24%	East
31–40	35.78%	35.08%	Southwest
41–50	28.18%	29.28%	West
51–60	4.23%	4.31%	Northeast
60+	1.52%	1.64%	Midwest

II.   PROPOSED IMPLEMENTATION

A. Cascade Antistrophic CNN

The CAN architecture comprises of several stages or cascades of anisotropic convolutions, where each stage is made up of numerous convolutional layers that capture various degrees of information at various sizes. The main advancement of CAN is the handling of the anisotropic character of 3D medical pictures, where the resolution is not constant across all dimensions[8]. Anisotropic convolutions are convolutions with variable filter sizes in different directions. As a result, the segmentation findings are more accurate since the network is able to collect both geographical and contextual information in the data. A dataset of endometrial pictures generated via ultrasound or other imaging modalities can be used to train a CA-CNN model for endometriosis [16]. After that, the CA-CNN can be trained to recognize patterns and characteristics in the images that are suggestive of endometriosis, such as the presence of cysts [5]. Given that the neural network is based on objective criteria acquired from a sizable collection of photos, it can aid in reducing subjectivity and unpredictability in the diagnosis of endometriosis. This may result in diagnoses that are more precise and reliable as well as more individualized treatment strategies[11]. This architecture uses three networks embedded procedure to identify the endometrium cyst. In this analysis, image sectionalization plays a significant

influence. It is a technique for cutting an image into several parts or fractions. This can make it simpler for medical experts to spot anomalies and develop treatment strategies by highlighting and isolating particular tissues inside an image. Additionally, CNNs can be utilized for image analysis, and entails aligning images obtained from many sources and at various times in order to detect changes in a victim's status over time.
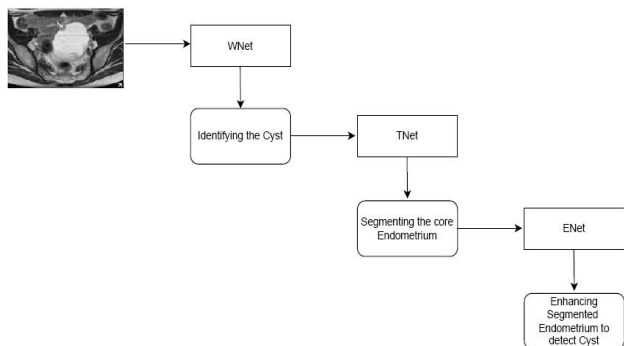
Fig.1 Layers of CA-CNN Architecture

B. DFKZ NET

A deep learning framework for image classification tasks created especially for histopathology image analysis is called DFKZ Net. The German Cancer Research Centre (Deutsches Krebsforschungszentrum), where the architecture was created, is known by the initials "DFKZ". The VGG Net design, a well-liked convolutional neural network (CNN) architecture for image classification applications, serves as the foundation for the DFKZ Net architecture. The DFKZ Net changes were made to better suit the architecture to the demands of histopathology image analysis[13].

The DFKZ Net architecture consists of fully connected layers at the network's end as well as a number of convolutional layers with various filter sizes and pooling layers. To increase the robustness of the model, DFKZ Net also employs an increasingly aggressive data augmentation strategy [15]. A context encoding route, three content modules, having 3x3x3 convolutional layers, and a dropout layer with residual connection make up the DFKZ Net, which was inspired by U-Net. Sampling, localization modules, and the SoftMax function are all used. We used the multi-class Dice loss function to address the issue of class imbalance.

$$L = -\frac{2}{|K|}\sum_{k \in K}\frac{\sum_i ui(k)vi(k)}{\sum_i ui(k)+\sum_i vi(k)} \quad (1)$$

Where, u is Output possibility having encoded ground truth (v) having K as total no. of classes and assessing for a particular class (k)
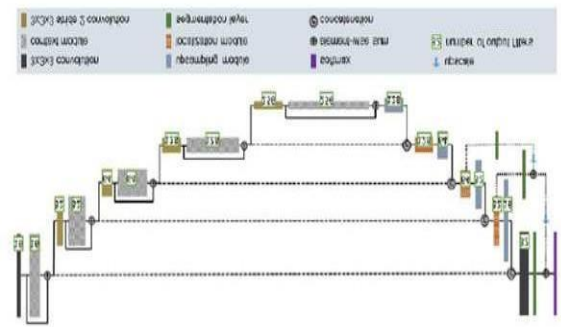

Fig.2 DFKZ NET Architecture

C. 3D U-Net

It is a traditional network for segmenting biological images. Three convolutional layers with dropout and pooling are present in each route. 3X3X3 convolutional kernels are present in each layer of the LSTM. 32 filters

make up the first convolutional layer, while deeper layers have twice as many filters as the preceding shallower layer. The Adam optimizer was utilized for implementation.
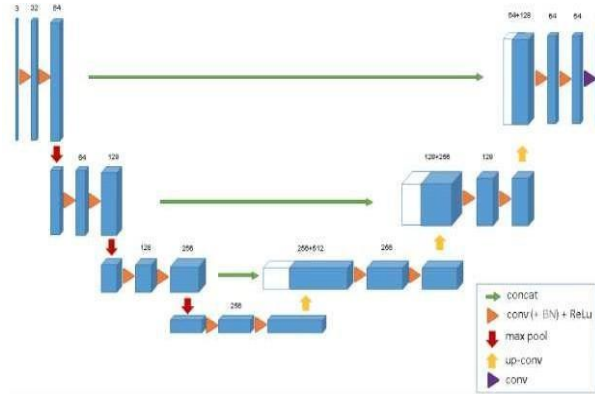

Fig 3. 3D U-NET

D. Ensemble model (Entropy with Random Forest)

The information gain algorithm, also known as the entropy-based algorithm, calculates how much information is present in a batch of data. It computes the entropy difference between the decision tree preceding and following a split. The best split is the one that produces the greatest information gain [10]. The approach is used to identify the best split at each decision tree node in the setting of a random forest. The random forest can produce decision trees that are more effective in categorizing the information, thereby leading to more precise predictions, by choosing the most effective split at each node.

Algorithm: Propensity Score Match

$Step -$

1: $Gat\square ering\ data\ and\ weed\ out\ anomalies\ or\ missing\ numbers$

Step-2 : Distinguishing training and test sets from the dataset.

Step-3 : Constructing a random forest model with numerous decision trees, each of which determine the ideal split at each node using an entropy-based technique.

$$E(D) = -sum(p(c) * \log(p(c)))$$

Where, p is the probability of having a datapoint c in D

Step-4: Using the training set to train the random forest model and the testing set to assess its performance.

$$Acc = \frac{No.\ of\ Correct\ predictions}{Total\ no.\ of\ predictions}$$

Step-5 : Adjusting the model's hyperparameters to enhance performance, such as the total number of trees and the optimum depth of each tree.

III.   PERFORMANCE EVALUATION

On the basis of the test and validation data, a model has been built. Following completion of the validation set, the ensemble model segmentation of the data was calculated. The outcomes are shown in below Table 3. As a result, ensemble model outperforms single models in terms of enhancing the tumor as a whole, whereas CA-CNN performs comparably poorly on the surface of endometrial cysts. The applied algorithm's top attributes that catered to the target group were determined. These characteristics were chosen as patient scourged criteria since they were shown to be critical in the diagnosis of the endometriosis condition. Results show that the Entropy and Random Forest models both did fairly well to predict the condition. These results have been published based on the two approaches.

A. Dice Coefficient

It is a scoring method used to evaluate predicted and true values of binary segmentation and then computes intersection of these two values and then computes the result using the below formula.

$$Dice = \frac{2|S \cap G|}{|S| + |G|} \qquad (2)$$

B. Hausdorff distance

This is a metric evaluation method for calculating dissimilarity between two set of points in medical image segmentation. This mainly calculates the distance between predicted point and the ground truth value.

$$d_H(X, Y) = \max\{sup_{x \in X, y \in Y} \inf d(x, y), sup_{x \in X, y \in Y} \inf d(x, y)\} \quad (3)$$

Where it calculates supremum and infimum values of the intervals.

TABLE III. METRIC CLASSIFICATION FOR TRAINING AND TESTING

Algorithms	Measurement	Train Set	Test Set
Entropy	Mean Dice	92%	93%
	Sensitivity	93%	95%
	Specificity	96%	97%
	Mean Hausdroff	1.22mm	1.30mm
Random Forest	Mean Dice	90%	88%
	Sensitivity	86%	84%
	Specificity	95%	93%
	Mean Hausdroff	1.28mm	1.29mm

The results are shown below for different model approaches that have been used for measuring endometrium cyst.

TABLE IV. RESULTS EVALUATION

Stage	Measurement	Whole Endometrium cyst	Enhancing Endometrium cyst	Endometrium cyst core
CA-CNN	Mean dice	0.09028	0.76682	0.86382
	Mean Hausdorff(mm)	5.4137	3.3203	6.55693
	Sensitivity	0.93145	0.81158	0.84315
	Specificity	0.99236	0.98707	0.98785
DFKZ Net	Mean dice	0.88305	0.75659	0.82359
	Mean Hausdorff(mm)	5.60114	5.90681	6.92303
	Sensitivity	0.89018	0.80319	0.82196
	Specificity	0.98588	0.99533	0.99749
3D U-Net	Mean dice	0.88662	0.77088	0.82667
	Mean Hausdorff(mm)	12.6228	7.73456	13.34535
	Sensitivity	0.90088	0.84272	0.81813
	Specificity	0.99316	0.99634	0.9881

The validation and test results are shown below in Fig. 4 and 5.
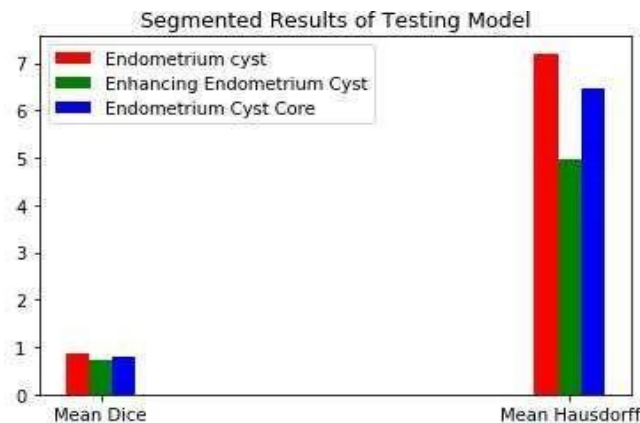
Fig 4. Segmented Results of Validation
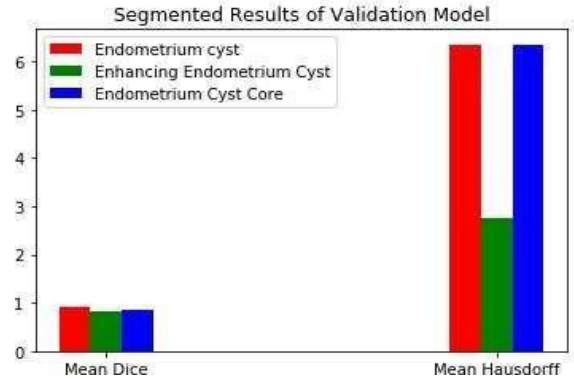
Fig 5. Segmented Results of Testing

IV. CONCLUSION

In this research, it has established the critical importance of AI and ML in the diagnosis, prognosis, and forecasting of diseases. In order to forecast the chance of endometriosis occurring in female, usage of machine learning algorithms to analyze the medical histories of those diagnosed with endometriosis and retrain the ensemble model on a few key variables. The chance to get necessary medical care initially in the journey of the individual can be provided via early disease prediction. Making a typing tool that can be easily accessed by healthcare providers and integrated into Electronic Records could help the goal of improving diagnosis activities and inform diagnostic processes that would lead to timely and accurate diagnoses, ultimately improving patient care and quality of life. As part of our ongoing research, we intend to investigate cutting-edge deep learning techniques to improve model performance and boost the predictive power of machine learning models.

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| Abstract | | In recent decades, consumers, manufacturers, and researchers have been more interested in functional foods, which include probiotics, prebiotics, and postbiotics. Probiotics are live microbes that, when regulated in enough quantities, provide health benefits on the host, while the prebiotics are substrates that host microorganisms selectively use. Postbiotics are metabolites and cell-wall components that are beneficial to the host and are released by living bacteria or after lysis. Postbiotic dietary supplements are more stable than probiotics and prebiotics. Many bioactivities of postbiotics are unknown or poorly understood. Hence, this study aims to present a synopsis of the regular elements and new developments of the postbiotics including health-promoting effects, production, conceptualization of terms, |

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Graphical Abstract:
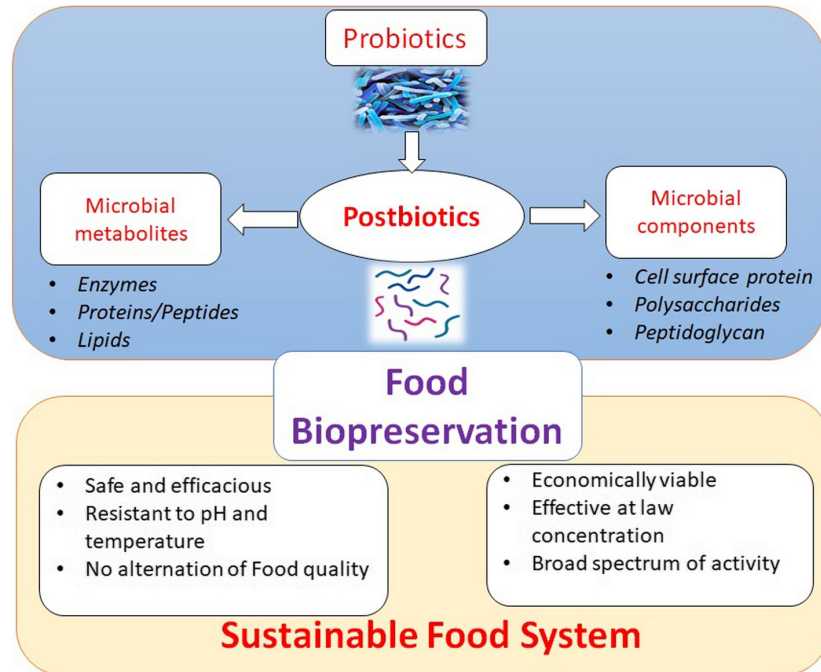
Keywords (separated by '-')	Food and health - Food safety - Probiotics - Postbiotics - Bio preservation
Footnote Information	Bishwambhar Mishra, Awdhesh Kumar Mishra and Yugal Kishore Mohanta contributed equally and treated as joint first authors.

Food Production, Processing and Nutrition

Postbiotics: the new horizons of microbial functional bioactive compounds in food preservation and security

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Abstract

In recent decades, consumers, manufacturers, and researchers have been more interested in functional foods, which include probiotics, prebiotics, and postbiotics. Probiotics are live microbes that, when regulated in enough quantities, provide health benefits on the host, while the prebiotics are substrates that host microorganisms selectively use. Postbiotics are metabolites and cell-wall components that are beneficial to the host and are released by living bacteria or after lysis. Postbiotic dietary supplements are more stable than probiotics and prebiotics. Many bioactivities of postbiotics are unknown or poorly understood. Hence, this study aims to present a synopsis of the regular elements and new developments of the postbiotics including health-promoting effects, production, conceptualization of terms, bioactivities, and applications in the field of food safety and preservation. Postbiotics aid in bio preservation and the reduction of biofilm development in food due to their organic acids, bacteriocins, and other antibacterial activities. The present study examines the production of postbiotic metabolites in situ in food and the effects of external and internal food components. The antimicrobial roles, removal of biofilms, and its applications in preservation and food safety have also been discussed. This paper also explored the various aspects like manipulation of postbiotic composition in the food system and its safety measures.

Keywords Food and health, Food safety, Probiotics, Postbiotics, Bio preservation

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Graphical Abstract

Introduction

Numerous elements, such as physical, chemical, and biological threats, compromise food safety. Biological hazards are of the utmost relevance in this regard. Bacteria, for example, play key roles in food decomposition and food-borne disease transmission. Probiotics and their byproducts are examples of bioactive compounds that can be used to suppress harmful microorganisms growth and thus lengthen the lifespan of food products (Singh et al. 2019). Due to their substantial antibacterial effects, probiotics and postbiotics have been used to prevent the proliferation of pathogenic microorganisms and their mediated corruption. Recent research suggests that postbiotics may be suitable replacement ingredients for the probiotic cells and also can be used as innovative antibacterial agents (Nataraj et al. 2020). Healthy effect and adverse effect of probiotic for host health has been illustrated in Fig. 1.

As per the statement defined by expert group of FAO-WHO 2001, probiotics are "live bacteria, which when provided in suitable proportions, impart a health benefit on the host" (https://www.fao.org/3/a0512e/a0512e.pdf). Moat probiotic supplements contain a finite list of microbial taxa, principally lactic acid bacteria (*Bifidobacterium* spp., *Lactobacillus* spp.), which are considered safe (GRAS). On the other hand prebiotic is defined as "a substrate that is selectively used by host bacteria giving a health advantage" (Binda et al. 2020). Prebiotics can modulate the microbiota framework by boosting species growth, which benefits the host. Synbiotics are frequently characterised as "synergistic mixes of probiotics and prebiotics that benefit the host by enhancing the survival and colonisation of live beneficial bacteria in the host's gastrointestinal tract" (Roberfroid et al. 2010). Synbiotics can modify the configuration of the microbes present in digestive system and the synthesis of microbial metabolites. Postbiotics are any substances that are released by a microorganism or made by it as part of its metabolic process and have a beneficial upshot on the host, directly or the other way. Since postbiotics don't have live microbes, the risks that come with them are lower (Binda et al. 2020; Salminen et al. 2021b). However, one concern that arises in connection with the use of the probiotics is the presence of the antibiotic-resistant genes in certain strains of probiotics (Thorakkattu et al. 2022; Vinderola et al. 2022). This is because these strains can implicit to transport antibiotic-resistant genes to infectious microbes through the process of horizontal
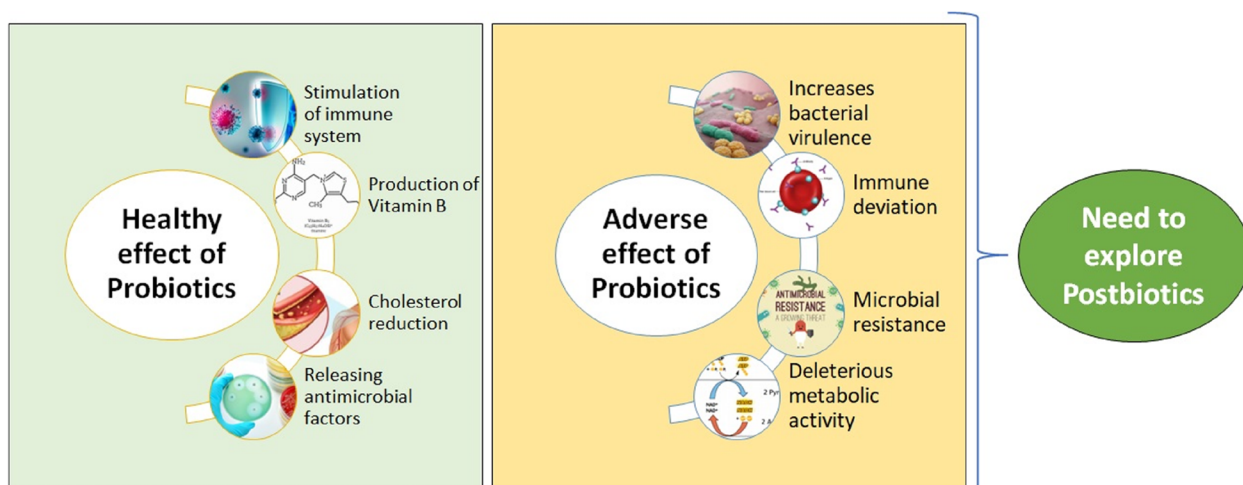
Fig. 1 Healthy effect and adverse effect of probiotic for host health

gene transfer (Puccetti et al. 2020). Because of this lack of stability in the probiotics, the health advantages that are supposed to be offered by probiotic supplements may not be achieved. A significant percentage of postbiotic research is presently devoted to the growth of innovative functional foods and preventive medication formulations for improving host health, also the exact identification of their mechanisms of action. A broad range of bioactive food items, such as probiotics, dairy/ non-dairy products, are currently in the market to meet the needs of clients' nutrition with different dietary choices, especially those who are hypersensitive to milk peptides, lactose intolerance, and vegetarians (Moradi et al. 2020; Ozma et al. 2022; Wegh et al. 2019). Correlation with definition of probiotics, prebiotics, symbiotics, and postbiotics has been illustrated in Fig. 2.

The idea emerged that postbiotics obviate the requirement for conventional intake of substantial quantities of microorganisms (Rad et al. 2021). Also, the use of postbiotics can be done in a controlled and standardized way. However, when living bacteria are used, the level of toxicity is much lower because the size and function of the active structure in the digestive system are directly related to the number of strains and the level of metabolic activity, they show (Aguilar-Toalá et al. 2021; Nataraj et al. 2020; Tsilingiri & Rescigno 2013). Postbiotics have a number of advantages, including greater immunological and digestive health. In addition to having anti-inflammatory, immune-modulating, antioxidant, anti-hypertensive, and anti-obesity, postbiotics also have beneficial qualities. A significant amount of research, encompassing both animal and human trials, has yielded encouraging findings about the efficacy of postbiotics in addressing obesity. For example, studies utilizing kefir products enriched with postbiotics have shown positive effects on body weight, fat mass, and metabolic indicators in both animal models and human subjects. Furthermore, empirical research has demonstrated that certain

Fig. 2 Differentiating and defining probiotics, prebiotics, symbiotics and postbiotics

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postbiotics possess the ability to regulate the composition of the gut microbiota, hence promoting the proliferation of advantageous bacteria that are linked to the regulation of body weight (Dini & Mancusi 2023; Park et al. 2023).

Postbiotics are appealing for commercial uses due to their non-toxic, easy-to-transport, less expensive-to-store, and up to five-year shelf-lives as well as their cholesterol-lowering and antiproliferative capabilities. Postbiotics such as bacteriocins, organic acids, fatty acids, peptides and H_2O_2 molecules are what give them their antibacterial capabilities. Vitamins produced by probiotic mother strains, especially vitamin C, are helpful in suppressing pathogenic ones. It has a substantial influence on the microbiota structure, the gut ecosystem, barrier function, immune system development, and all of these things. Thus, postbiotics may be useful in management or prevention of a variety of disease entities, including those for which no curative therapy for the underlying cause has yet been identified, such as multiple sclerosis, inflammatory bowel disease or Alzheimer's disease. Clinical studies are being conducted, and the preliminary findings are encouraging. These studies are looking at how to alter the microbiome of people who have the aforementioned diseases (Aguilar-Toalá et al. 2018; Collado et al. 2019; Salminen et al. 2021a). Given the importance of the initial few months of life for the development of the proper microbiota structure, postbiotics can be especially helpful for infants. For the appropriate growth and safeguarding the child's ultimate welfare, the right postbiotic settings for the generation of the right microbiota appear to be required (Ashraf & Shah 2014; Johnson et al. 2019). Postbiotics may be beneficial for the avoidance and treating of SARS-CoV-2 infections because the morphology and metabolic functions of the gut microbiome can be connected with the emergence of the biomarkers that anticipate the course of extreme coronavirus disease- 2019 (COVID-19) (Rather et al. 2021).

The food industry has always been focused on using preservatives to enhance quality and prolong its shelf life. However, most people today dislike food additives because they think they are unhealthy, despite the fact that they don't know how the additives have on health. Because of this, modern research has been trying to come up with products which uses lesser additives or natural ingredients to make sure food is safe and of good quality while still meeting consumer needs. In this way, researchers have paid a lot of attention to natural antimicrobial agents, which have made it possible for manufacturers to switch from using artificial additives and make safer and healthier foods. Several Lactic acid bacterial strains can be thought of as probiotics, and their postbiotic substances often have the same or similar health benefits for consumers. Postbiotics can be used to maintain and eradicate bacterial biofilm formation in foods as well as for food bio-preservation (Motalebi Moghanjougi et al. 2020; Silva et al. 2018). The idea behind the postbiotics covers the microbial fragments and their metabolites that have a positive impact on the host. Due to different architectural and heterogeneity, a variety of possible acquisition methods is implied by the postbiotics. Bacterial cells can be lysed by mechanical or chemical means. These techniques include heat, sonication, solvent extraction, and enzyme extraction. To seggregate and recognize desired compounds, chromatography, dialysis, and extraction are employed (Fiore et al. 2020; Wegh et al. 2019). The current research investigates the formation of postbiotic metabolites in food, in situ, as well as the effects of both the external and the internal components of food. In addition to this, the antibacterial roles, the elimination of biofilms, and all of its uses in food standards and storage have been considered. This review, however, was meant to focus on the very recent uses of postbiotics to ensure food safety. The possible usage of postbiotics in food packaging, food bio-preservation and preventing and getting rid of biofilm that comes from food were looked at. This study also investigated a variety of other topics, such as the combination of postbiotic composition in the food system and the precautions that should be taken with regard to it.

Production of postbiotics

The food that is most frequently used to provide probiotics is yoghurt. Numerous products, both fermented (like yoghurt and cheese) and non-fermented (such as cereal and chocolate bars), have probiotics added to them. Certain food characteristics, such as acidity, water activity, specific chemical components, moisture, temperature, package permeability to oxygen, and duration, can pose challenges for probiotics in terms of survival during both production and storage. Most of the stated health advantages of fermented milk have been verified. Another example of a food that provides probiotics, prebiotics, symbiotics, and postbiotics is infant formula (Aguilar-Toalá et al. 2018; Damián et al. 2022). Fermented infant formula has been made specifically using *Bifidobacterium breve* and *Streptococcus thermophilus*. The bacteria are then killed by spray drying following the fermentation process. Inanimate bacteria and fermentation byproducts are present in the newborn formula. A number of pediatric clinical studies showed its safety and postbiotic properties, including modulating the gut microbes to be more similar to that of infants under breastfeeding, reducing the grievousness of severe diarrhea, improving immune markers and inflammatory, which may be connected to few attributes of the gastrointestinal tolerance,

and reducing digestive symptoms. Apart from the above, it reduces allergic reactions in babies, as well as the prevention of thymus enlargement and alkaline stools in healthy-term infants (Chaluvadi et al. 2015; Cristofori et al. 2021; Maguire & Maguire 2019). Food supplements are a viable sector for the creation of new postbiotic products since they may have longer shelf lives than probiotic food supplements due to their lack of viability. The range of microorganisms used for functional purposes will probably expand as a result of the idea of postbiotics. Species beyond those from the usually benign genus Bifidobacterium or the family Lactobacillaceae, that were unable to be managed live due to safety and health issues, have been examined as potential postbiotics (Chang et al. 2021; Foo et al. 2019; Liu et al. 2020). Postbiotics can be included in foods and ingredients prior to heat processing without impairing their functions because they are stable throughout a wide range of temperatures. Producers might benefit from this in terms of technology and finances. Postbiotics can be employed in drug carriers such as food supplements and/or pharmacological items since their correct dose can be managed during manufacturing and storing parameters when survivability is not the key deciding factor (Wegh et al. 2019). The production of postbiotics involves several techniques, including sonication, enzymatic treatments, and chemical processes. These methods play a crucial role in extracting bioactive components, modifying microbial structures, and ensuring the viability and effectiveness of postbiotics for various health-promoting applications.

The choice of method for postbiotic production depends on various factors, including the desired postbiotic compound, the microbial strain used, the intended application, and scalability considerations. Researchers and manufacturers carefully select the most suitable method to maximize the yield, quality, and safety of postbiotic products. Production of postbiotics through various techniques has been illustrated in Fig. 3.

The most common postbiotic source in the food sector is fermentation. Many milk-based products, as well as other items including kefir, kombucha, yoghurt, and pickled vegetables, naturally contain postbiotics. The producer strains, which can be utilized to extract the postbiotics in situ, primarily consist of *Lactobacillus* and *Bifidobacterium* strains, but they may also contain *Streptococcus*, *Akkermansiamuciniphila*, *Eubacateriumhallii*, *Faecalibacterium*, and *Saccharomyces boulardii* (Gezginç Et Al. 2022; Hernández-Granados & Franco-Robles 2020; Żółkiewicz et al. 2020). A variety of bacteriocins have also been discovered, described, and may have future industrial applications. The microbiological strains and growth parameters will influence their extraction and characterisation. Nisin, also used as a preservative substance in numerous food products (canned soups, dairy products, infant formula), can be made by *Lactococcus lactis*, however they must first be physiologically inert before being transformed to become active (Basavanna & Prapulla 2013). A number of research have also concentrated on using enzymes rather than probiotic bacteria to produce particular results. *Bifidobacterium*

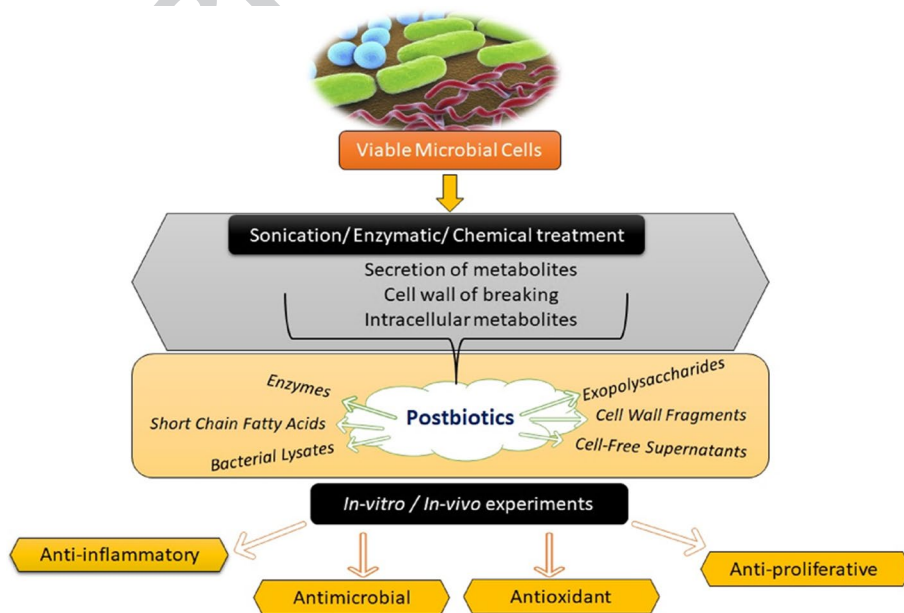**Fig. 3** Schematic representation for production of postbiotics through various techniques and its bioactivities

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pseudocatenulatum and *Bifidobacterium longum* producing postbiotic enzymes like purified phytases, for instance, increased myoinositol triphosphate levels while reducing the amount of phytates in cereal combinations. Numerous writers have also reported vitamin enrichment in food products. It's a very frequent practice to use fermentation to increase vitamin B content in cereal grains. Vitamin B is abundant in cereal grains. These vitamins, however, are lost during grinding or heat processing. The number of bacteria which can create the vitamins B1, B2, B3, B9, B11, and B12 is increased by cereal fermentation and LAB (Lactic Acid Bacteria) pre-treatment. The LAB fermentation of cereals consequentially enhanced the amounts of protein fractions, total lysine, soluble dietary fiber, sugars and Fe, Ca, and Zn bioavailability in vitro. Additionally, wheat could yield antioxidant peptides, -aminobutyric acid, and angiotensin I-converting enzyme-inhibitory peptides through LAB fermentation (Khalil et al. 2018; Kumar et al. 2017; Masuda et al. 2012).

Postbiotic and food additive interactions

Impact of nutritional factors on postbiotic

The performance of postbiotics is influenced by both internal (matrix substances: food composition, pH levels, moisture content) and external (all elements affecting the storage of food: temperature, oxygen exposure, light exposure, time and duration, packaging materials) factors of food (Patil et al. 2019). The findings of the studies have demonstrated that these variables have a major impact on the structure, nature, and functions of postbiotics, that is important when evaluating the ideal circumstances for their manufacture and use in pharmaceutical or food products (Rad et al. 2021).

Internal factors

The function of postbiotics can be impacted by a variety of food additives like preservatives, emulsifiers and stabilizers, sweeteners, colorants and flavors, and antioxidant etc. The function of metabolites can be inhibited by interactions between active postbiotic metabolites and specific food components such enzymes, proteins, carbs, endogenous microflora, and lipids (Rad et al. 2021). As an illustration, food-borne proteolytic enzymes may influence the activity of postbiotic substances (Peluzio et al. 2021). In order to prevent postbiotic protein molecules from functioning, proteolytic enzymes can degrade them. Either the feed itself contains these enzymes or the proteolytic bacteria in the diet produce them. Trypsin, chymotrypsin, pepsin, papain, and proteinase K are the most crucial enzymes (Abdulhussain Kareem & Razavi 2020). The protease enzyme, for instance, breaks down the protein when proteinaceous postbiotics are used, preventing the postbiotic action. Proteolytic enzymes should therefore be taken into account when talking about postbiotic dysfunctions. Fermented dairy products (e.g., Yogurt and Kefir), fermented vegetables (e.g., Sauerkraut and Kimchi), fermented soy products (e.g., Miso and Tempeh), fermented grain products (e.g., Sourdough Bread) are the examples of foods where enzymatic activity can indirectly promote a favorable environment for postbiotic production. However, there are no examples of postbiotic combinations with dietary components having synergistic or antagonistic effect (Nataraj et al. 2020).

External factors

The antibacterial action of postbiotics can be impacted **AQ3** by food pH. Foods that are acidic or alkaline can make postbiotics less effective (Ebrahimi et al. 2021). Postbiotic activity has a specific range of application. The ideal pH range for postbiotic action is between 4 and 9 (Prabhurajeshwar & Chandrakanth 2017). Pasteurized milk and ground beef were few of the food components which used postbiotics to manage microorganisms because they had good pH levels and no postbiotic function disturbances. Another external element that may have an impact on postbiotic performance is heat. Postbiotics' ability to fight against microbes can be hampered by heat. Postbiotic chemicals' antibacterial action is diminished for 30 min at 30 °C and then for 15 min at 121 °C (Chelliah et al. 2016). As a result, food heating can also have a big impact on the activity of postbiotics. In this instance, maintaining the temperature parameter at an ideal level, is very crucial (Pavli et al. 2018).

Different classes of postbiotics and its bioactivities

The postbiotics can be classified based upon its chemical nature and its bioactivities. Various types of postbiotics **AQ4** and its role in food preservation have been discussed in this section. A synopsis of the few studies that have been reported on postbiotics and their use in a variety of food products has been describes in Table 1.

Organic acids

Inhibiting food spoilage bacteria is one among the most significant effects induced of postbiotics in the food sector. Compounds suitable for use as antibacterial agents include organic acids. One of the important postbiotics is recognized to be organic acids. Two isomers of lactic acid, L and D, which are formed by bacterial fermentation processes, efficiently limit pathogenicity. Additionally, by generating an acidic environment, acids like acetic acid and citric acid prevent the formation of infections. Acetic acids (pka = 4.76) and Lactic acids (pka = 3.86) among organic acids prevent the growth of infections by lowering pH levels in in vivo or/and in vitro condition. Organic

Table 1 Summary of few reported studies in postbiotics and their applications in different food products

S.L No	Name of the food	Postbiotic element	Source organism	Key finding	References
1	Yoghurts	Polysaccharide	*Lactariusvolemus*	Increased water absorption and pH reduction	(Huang et al. 2020)
2	Soybeans	Extracellular products	*Lactobacillus plantarum* YML 007	Shelf life has been extended to two months	(Rather et al. 2014)
3	Cheddar cheese	Exopolysaccharide	*Lactobacillus rhamnosus*	enhanced product functionality	(Torino et al. 2015)
4	Cereal mixtures	Purified physates	*Bifidobacterium longum*, *Bifidobacterium pseudocatenulatum*	Decreased physate concentration and raised myo-inositol triphosphate levels	(Tamayo-Ramos et al. 2012)
5	Cheddar cheese	Unknown enzyme	*Lactobacillus rhamnosus* S93	Increased levels of soluble nitrogen in phosphotungstatic acid and free amino acids	(Azarnia et al. 2010)
6	Grilled beef	Extracellular products	*Lactobacillus sakei* NRRL B-1917	Decreased number of *Listeria monocytogenes* and *E. coli*	(Beristain-Bauza et al. 2017)
7	Custard cream	Bacteriocin	*Lactobacillus gasseri* LA39	Four decomposition strains are completely inhibited	(Nakamura et al. 2013)
8	Food in general	Bacteriocin	*Lactobacillus coryniformis* MXJ 32	Bactericide for *Staphylococcus aureus* and *Escherichia coli*	(Lü et al. 2014)
9	Chicken breast	inhibitor Substance like- Bacteriocin	*Lactobacillus plantarum* ST16Pa	Bioconservative against *Enterococcus faecium* for 7 days	(Da Silva Sabo et al. 2017)
10	Ground beef and whole milk	Pirrolo [1,2-a] and pyrazine-1,4-dione	*Lactobacillus salivarius*	Biofilm removal of *Listeria monocytogenes*	(Moradi et al. 2019)
11	Kombucha Tea	Polyphenols	*Acetic acid bacteria and yeast*	Improved antioxidant properties and anti-inflammatory effects	(Jayabalan et al. 2014)
12	Kimchi	Lactic acid Bacteria Metabolites	*Lactobacillus plantarum and Lactobacillus brevis*	Enhanced gut health and immune modulation	(Jung et al. 2011)
13	Miso soup	Peptidoglycans and Teichoic Acids	*Saccharomyces cerevisiae and Lactobacillus sakei*	Regulation of gut microbiota and anti-inflammatory effects	(Fukuda et al. 2011)
14	Fermented pickles	Organic Acids (e.g., Lactic Acid)	*Lactobacillus plantarum and Pediococcus pentosaceus*	Improved digestion and nutrient absorption	(Marco et al. 2017)
15	Tempeh	Oligosaccharides and Peptides	*Rhizopus oligosporus*	Prebiotic effects, promoting the growth of beneficial gut bacteria	(Ahnan-Winarno et al. 2021)
16	Natto	Nattokinase (Fibrinolytic Enzyme)	*Bacillus subtilis* var. *natto*	Cardiovascular health improvement and blood clot prevention	(Chen et al. 2018)
17	Fermented Dairy products	Bacteriocins and Organic Acids	Various Lactic Acid Bacteria Strains	Enhanced shelf life and inhibition of harmful bacteria	(Guillemard et al. 2010)
18	Sourdough Bread	Lactic Acid and Phenolic Compounds	*Lactobacillus sanfranciscensis and Candida milleri*	Reduced gluten content and improved digestibility for gluten-sensitive individuals	(Papadimitriou et al. 2019)
19	Sauerkraut	Glucosinolates and Isothiocyanates	*Lactic Acid Bacteria*	Anticancer properties and immune system support	(Vitali et al. 2012)
20	Fermented Fish Sauce	Amino Acids and Peptides	Various Marine Bacteria and Yeasts	Rich source of umami flavor and potential antimicrobial effects	(Faisal et al. 2015)

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Table 1 (continued)

S.L No	Name of the food	Postbiotic element	Source organism	Key finding	References
21	Kimchi	Bioactive soluble byproducts	*Leuconostoc mesenteroides J.27*	*Leu. mesenteroides* (LAB J.27) and food-grade EO (eugenol or thymol) was highly effective against a variety of pathogenic bacteria	(Toushik et al. 2022)
22	Frankfurters	Bacteriocin	*Pediococcus acidilactici*	Antimicrobial effect against *Escherichia coli*, *Salmonella*, *Typhimurium*, *Listeria monocytogenes* on frankfurters during refrigerated storage	(İncili et al. 2022)
23	Korean kimchi	Biopreservative	*Lb. plantarum YML 007*	Cell free supernatant improved shel life of unshelled soybeans upto 2 months	(Malashree et al. 2019)
24	Baker's yeast	vitamins, polyphenols, sterols, and phospholipids	*Saccharomyces cerevisiae*	EpiCor is an immunogen product	(Bourebaba et al. 2022; Jensen et al. 2007)
25	Traditional koumiss	Whole peptidoglycan (WPG)	*Lactobacillus paracasei* sub sp. *paracasei* M5 strain	Potential anticancer activity	(Bourebaba et al. 2022; S. Wang et al. 2018a, b)
26	Breast-milk feeding	Lipoteichoic acid (LTA)	*B. animalis* subsp. *lactis* CECT 8145	Reduces fat deposition	(Balaguer et al. 2022)
27	Yogurt	D-alanyl-lipoteichoic acid	*Lactobacillus plantarum* CRL1506	Modulate the Intestinal Antiviral Innate Immunity	(Mizuno et al. 2020)
28	Tomato processing waste	Exopolysaccharides	*Lactobacillus buchneri* TCP016	Induced liver injury and improves the modification of the gut microbiota	(Xu et al. 2019)
29	Fermented Fuyuan pickle	Exopolysaccharides	*L. fermentum* S1	Promising functional adjunct for application in foods	(Wang et al. 2020)

acids' impact on bacterial cell membranes is connected to their inhibitory action. Decreasing the pH inside the cell and maintaining membrane integrity are the key mechanisms at play here (Chang et al. 2021). There are two connections between organic acids' antibacterial properties preventing or regulating acidification of cellular cytoplasm and energy production. Organic acids (tartaric acid, acetic acid, lactic acid, citric acid, and malic acid) produced by three strains of *Lactobacillus plantarum* (P1, S11, and M7) and looked into how effective these acids were at killing pathogenic bacteria (*Escherichia coli* and *Salmonella*) (Hu et al. 2019). They discovered that *L. plantarum* strains reduce the growth of harmful bacteria by secreting organic acids. Organic acids work to kill bacteria by bringing down their pH and acidifying their cell membranes. Lactic acid and acetic acid are two organic acids that have particularly potent antibacterial properties. These findings suggest that a strategy involving the mixing of various organic acids could be used to generate new antibacterial agents for widespread usage in the food industry (Chelliah et al. 2016; Ebrahimi et al. 2021; Moradi et al. 2021; Patil et al. 2019; Pavli et al. 2018; Peluzio et al. 2021; Prabhurajeshwar & Chandrakanth 2017).

Bacteriocin

Antimicrobial peptides or proteins known as bacteriocins are produced by a variety of bacteria, including *Archaebacteria* and *Eubacteria*. Because of their potent antibacterial properties, bacteriocins have been utilized by humans in fermented meals for countless years. Bacteriocins are classified according to their size, mode of action, and spectrum of inhibitory activity. Bacteriocins offer a variety of advantageous properties, such as the ability to withstand heat and pH changes and to inhibit the development and growth of gastrointestinal infections. The inhibition of spore formation, pore development on pathogenic cell membranes, and impacts on the morphological and functional properties of bacterial peptides are all key components of bacteriocins' antibacterial mechanism (Abdulhussain Kareem and Razavi 2020; Kim et al. 2020). Wang et al. (2018a, b) employed fish-isolated *Lactobacillus plantarum* LPL-1 bacteriocins against *Listeria monocytogenes* in a study (Wang et al. 2018a, b). It

was discovered as a result that the bacteriocins might stop *L. monocytogenes* from growing by acidifying its cell membrane and producing pores in the bacterial membrane. Kim et al. (2020) and his colleagues examined the effectiveness of *Lactobacillus taiwanensis* produced bacteriocins against *Escherichia coli* and *Salmonella gallinarum* in a different investigation. As a result, it was discovered that *L. taiwanensis* bacteriocin may destroy pathogenic bacteria's protein structures and impede bacterial development by lysing their membranes. Bacteriocins can be utilized as a technique to reduce the bacteria that can cause food spoiling, according to the findings of the studies listed above (Kim et al. 2020).

Fatty acids

Antibiotics can be replaced with fatty acids and their derivatives. For over a century, it has been recognized that fatty acids possess antibacterial properties. Fatty acids are generated by joining a hydrophilic carboxylic group to a saturated or unsaturated carbon chain. Additionally acknowledged as possible postbiotics with significant antibacterial effects are fatty acids (Patil et al. 2019). Eicosapentaenoic acid (EPA), a long-chain fatty acid, inhibits the growth of Gram-positive bacteria. Lauric and meristic acids, among other fatty acids, have a strong inhibitory effect on the growth and development of microorganisms. Fatty acids have antimicrobial effects on bacteria by causing cell lysis, increased membrane permeability, disruption of the electron transport chain, disruption of enzyme activity and structure, and induction of functional/ morphological alterations in sensible components like proteins. The impact generated by fatty acids induced by *L. fermentum, Lactobacillus acidophilus* and *L. paracasei* against *Klebsiella oxytoca* was investigated by Higashi and colleagues in 2020. They discovered that the probiotic bacteria's fatty acids lyse *Klebsiella oxytoca*'s cell wall, preventing *Klebsiella oxytoca* from growing (Higashi et al. 2020).

Peptides

Antimicrobial peptides are produced by microorganisms. Peptides kill microorganisms by inhibiting the synthesis of macromolecules and degrading microbial membranes, which is known as pleiotropic processes. There are two categories of antimicrobial peptides: ribosomal and non-ribosomal. The bacteria's ribosomal proteins exhibit potent antibacterial action in vitro by rupturing microbial membranes. Nearly all bacteria have peptides. As was already noted, some peptides primarily target cell membrane, whereas others target cytoplasm and delicate bacterial structures. The peptides' antimicrobial effects include (a) causing the bacterial cell membrane to become acidic, (b) producing

physical holes that allow cells to leak out, (c) generating hydrolases that harm the cell wall, and (d) harming the microorganisms' sensitive internal components. *E. coli* Nissle 1917 peptides were used by Forkus et al. (2017) to combat *Salmonella enterica* that was isolated from digestive system of the turkey. In this work, it was discovered that *Salmonella enterica* growth is inhibited by *E. coli* Nissle 1917 antmicrobial peptides that damage the cell wall. *Bacillus subtilis* produces antibacterial peptides that have been tested for effectiveness against *E. coli* and *L. monocytogenes.* According to the study, *Bacillus subtilis* peptides harm sensitive structures in order to prevent germs from growing. These findings raise the possibility of employing probiotic-produced antimicrobial peptides for food preservation (Forkus et al. 2017; Osés et al. 2015).

Unlike ribosomal peptides, non-ribosomal peptides are produced through non-ribosomal peptide synthetases (NRPS) or polyketide synthases (PKS), complex enzyme systems that are capable of assembling peptides from individual amino acid building blocks. These non-ribosomal peptides can have diverse structures and functions (Enzyme inhibition, immune modulation, and biofilm disruption etc.) including antimicrobial activity (Hernández-Granados and Franco-Robles 2020; Li et al. 2021). **AQ7**

Hydroxyl radicals

H_2O_2 can be converted into hydroxyl radicals, which have potent oxidative properties. All bacteria primarily create hydrogen peroxide, which is the principal metabolite of lactic acid bacteria and is typically found in catalase-negative bacteria under aerobic culture. The inhibitory and antibacterial effects are primarily determined by the concentration of hydrogen peroxide (H_2O_2), which can have variable effects depending on a number of factors. Bacterial concentration can also be influenced by a number of variables, including particular bacterial strains and ambient conditions (temperature and pH). H_2O_2 has powerful oxidizing properties that cause damage to cytoplasmic protein structures in bacteria, which contributes to its antibacterial activities (Li et al. 2021; Markowiak & Ślizewska 2017). The effectiveness of *Bifidobacterium longum, B. infantis, Lactobacillus acidophilus*, and *L. rhamnosus* breve against methicillin-resistant *Staphylococcus aureus* (MRSA*)* in vitro was examined. The research found that hydrogen peroxide produced by probiotic bacteria can reduce the growth of Staphylococcus aureus. According to these findings, postbiotic substances like hydrogen peroxide can be utilized as an effective substitute for antibiotics in the fight against pathogens and spoilage of food (Żółkiewicz et al. 2020).

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Vitamins

Large amounts of vitamins are produced by probiotic bacteria in the food matrix and the stomach of the host. Although probiotic bacteria in the colon produce very little vitamin material, food matrix production of vitamins, particularly in dairy products, greatly rises. It was discovered through researching the probiotic bacteria's antibacterial function that the vitamins these bacteria produce are crucial in blocking dangerous germs. Vitamin compounds are created in lab models by breaking down probiotic microorganisms (*Lactobacillus plantarum*). Comparatively, vitamin C plays a stronger antibacterial role. Vitamin C raises the acidity of the lipids in bacterial cell membranes, causing the membrane and cell wall of the bacteria to be lysed. Postbiotic chemicals have valuable antibacterial capabilities, and the food industry can utilize these compounds in a variety of ways to preserve food and lengthen food shelf (Cueva et al. 2010; Górska et al. 2019).

Applications of postbiotics in food biotechnology

Because microbiological deterioration, notably mould growth, starts on the food's surface, it is not practical to cheaply embed a significant amount of the preservative in the matrix of the food because this would result in the food becoming contaminated (Vilela et al. 2018). Use of food packaging to increase food's shelf life has been suggested as a potential solution to these issues.

Bio preservation of food

Dairy products have been used in the past to help the good bacteria in the stomach (probiotics). Probiotic strains might not survive during processing and storage, nevertheless, if extrinsic elements that cause dairy components to degrade have an adverse effect. Including postbiotics in dairy products is a cutting-edge method of enhancing their safety. The preservation of food naturally depends on postbiotic performance characteristics. From a safety standpoint, producing postbiotic compounds in a Mannitol Salt Agar Culture medium is less thrilling than manufacturing postbiotics. For instance, Mehran Moradi et al. researches demonstrated that postbiotics prepared by MRS may show considerable detriment on the product's sensory qualities and affect total customer acceptability. Milk is a substance that can absorb substances that change its colour and consistency because of its whiteness, fluidity, and opacity. In a recent study, postbiotics generated from three probiotic milk strains were assessed as antifungal drugs to inhibit the development of mould in semi-hard cheese and sour cream. Postbiotics were discovered to drastically lower the number of fungi in cheese while possibly having no negative effects on sensory perception. As a spray-form antibacterial agent to prevent dangerous germs, postbiotics have recently been proposed (Moradi et al. 2019).

Multiple studies have shown that postbiotic components are effective in improving the preservation of refrigerated meat. For instance, in a recent study, *Bifidobacterium lactis* Bb-12 is directly added to minced meat, which extended its preservation for up to three months at 4 °C (68). Similarly, *Lactobacillus rhamnosus* EMCC 1105 postbiotics at a concentration of 100 mg/g eliminated *Clostridium perfringens* in minced chicken after four days of storage at 6 °C. The antibacterial action of postbiotic molecules is determined by their type, with bacteriocins being potent antibacterial agents (69). In one study, postbiotics from three probiotics (*Lactobacillus casei* 431, *Lactobacillus acidophilus* LA5, and *Lactobacillus salivarius*) were evaluated for their antibacterial effects on *Listeria monocytogenes* in minced beef and Luria Bertani broth. The postbiotic substance inhibited *L. monocytogenes* and prevented the deterioration of Luria Bertani broth and minced meat (70).

Removal of biofilm

There are a variety of microorganisms with varying rates of growth that may include one or more different types. In a protein or carbohydrate matrix, a complex microbial population is called a biofilm. Microorganisms like bacteria and fungi can generate biofilms (Urish et al. 2016). These abilities are shared by gram-negative and gram-positive bacteria. One of the major problems facing the world today is the bacterial resistance to antimicrobials during the biofilm phase. Reversible and irreversible surface adhesion, microclone forms with exopolysaccharide synthesis, and other production steps are among them. For the food product industry to make ensure food safety, controlling colony components and irreversible biofilms is crucial. The removal of biofilms created by the food industry is less effective when cleaning and disinfecting surfaces (Andrade et al. 2020; Przekwas et al. 2020). Some major bacteria that create biofilms are *Campylobacter jejuni*, *Yersinia enterocolitica Listeria monocytogenes* and *Staphylococcus aureus*. To manage and eliminate bacterial biofilms, a variety of techniques have been employed. An innovative method for removing biofilms is to use postbiotics. It has been found in recent studies that postbiotics can successfully remove bacterial biofilms (Andrade et al. 2020; Przekwas et al. 2020. In a study, probiotic bacteria *Lactobacillus casei* 431, *Lactobacillus acidophilus* LA5, and *Lactobacillus salivarius* were used to cure a biofilm created on polystyrene surfaces by *L. monocytogenes*. It has been discovered that postbiotics inhibit the growth of biofilm. The authors illustrated that the lack of postbiotics containing bacteriocin and organic acids was the primary factor in reducing the biofilm of

L. monocytogenes. Postbiotics are a viable strategy in the food product industry to prevent the development of bacterial biofilm (Sharma et al. 2018; Shi & Zhu 2009).

Development of active food packaging

As consumer preferences and market trends change, one of the most inventive methods of food packaging is called "active packaging" (Ahmed et al. 2017). The primary active packaging strategies target flavours, odours, antimicrobials, antioxidants, moisture, ethylene, carbon dioxide, and those that release CO_2. The shelf life of food is affected by a combination of parameters, includes the food product itself, the packaging material used, and various environmental conditions. An active packaging system known as "antimicrobial active packaging" protects food from microbial decomposition during transportation and storage by adding antimicrobial agents (AAs) of plant, animal, and microbial origin or their metabolites, antimicrobial nanoparticles, etc., in the packaging (Yildirim et al. 2018). Due to various environmental factors that can affect the survival of probiotics in bioactive packaging and the production of antimicrobial substances, such as temperature, relative humidity, light intensity, and amount of moisture in food, the antimicrobial efficacy cannot be accurately predicted. Moreover, the consumption of bacterial cells can alter the thermal, barrier and mechanical characteristics of the packaging material. Because of these aspects, antimicrobial packaging methods (use live bacteria) can use postbiotics.

Application of individual postbiotics

The use of postbiotics produced by various probiotic strains is also possible for food-active packaging. Bacteriocins, bioactive peptides have antibacterial properties, are the most often employed postbiotic metabolites in the food sector (Mohammadi et al. 2022). The development and assessment of bacteriocin-loaded active packaging devices is of great interest to many researchers for the aforementioned reasons. Despite the fact that there are a multitude of bacteriocins, nisin is the one that is very well-known and regularly utilized in the production of antimicrobial drug films. Several different strains of the bacterium *L. lactis* produce it (Silva et al. 2018). The effectiveness of starch halloysite nanocomposite films loaded with pediocin and nisin in inhibiting *Clostridium perfringens* and *Listeria monocytogenes* was assessed for their antimicrobial activity. The findings revealed that while pediocin and nisin had varying degrees of antilisterial activity, nisin had higher levels of antagonistic activity against *Clostridium perfringens*. Furthermore, the presence of halloysite aided in reducing bacteriocin diffusion and improved antimicrobial agent retention in the polymer matrix (Meira et al. 2017).

Another type of isolated individual postbiotic used in the production of antimicrobial films is enterocin, which is produced by various *Enterococcus* species. To create the films mentioned in (Ibarguren et al. 2015), enterocin A, B, and P were combined with gelatin. This demonstrates that. The film loaded with enterocin was effective in inhibiting Listeria monocytogenes, *Staphylococcus aureus,* and *Bacillus cereus*. Furthermore, when both prunin laurate and enterocines were incorporated into the film simultaneously, a synergistic inhibitory effect was observed against these microorganisms. They further noted that the addition of active compounds had no impact on the gelatin films' mechanical, thermal, or barrier properties. Bacteriocins are popular and widely used, but they have a significant drawback that prevents them from being used in all situations: they are expensive to produce and have a low yield.

Application of postbiotics mixture

The solution of postbiotics comprises several physiologically active metabolites that exhibit synergistic antibacterial properties towards both the food products and films (Bali et al. 2016). A suitable antimicrobial agent is postbiotics, and interest in creating antimicrobial agent-infused movies has grown recently. *Lacticaseibacillus rhamnosus* NRRL B-442 (6, 12 or 18 mg/ml) and calcium caseinate films were used in an experiment. The results of their investigation suggested that postbiotics applied at a conc. of 18 mg/mL had antimicrobial activity (Beristain-Bauza et al. 2016). *Staphylococcus aureus*, *E. coli*, *Listeria monocytogenes*, and *Salmonella typhimurium* have all been successfully tested in both movies without having their physical characteristics changed. Postbiotics were added to brown ink coatings, which resulted in coatings with lessened puncture resistance and moisture vapor transport (Beristain-Bauza et al. 2016). Whey protein isolate alginate films were created by and coated with postbiotics from *Lactobacillus Sakei* NRRL B-1917 for the purpose of packaging beef cubes contaminated with *Listeria monocytogenes* or *E. coli*. Following 120 and 36 h of cooling, *Listeria monocytogenes* and *E. coli* displayed corresponding decreases in CFU/g of 1.4 and 2.3 log_{10}. The findings indicated that there were no notable distinctions between the grilled beef samples that underwent packaging and those that did not undergo any packaging at all (Beristain-Bauza et al. 2017).

Through the use of bacterial nanocellulose and postbiotics from *Lactiplantibacillus plantarum*, an antibacterial meat wrap nanopape was created in an experiment (Shafipour Yordshahi et al. 2020). A network with less porosity was produced as a result of the immobilisation of postbiotics on the nanocellulose matrix. It was possible to produce films with strong antimicrobial activity

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using postbiotics, but doing so might compromise the films' physico-chemical characteristics. Postbiotics must therefore be applied at a concentration that maximizes both their thermomechanical and antibacterial propertiesput forth the hypothesis that the improved storage stability of bacteriocins brought about by their immobilisation on cellulose nanocrystals counteracts the negative effects of postbiotics on the barrier and mechanical properties of starch films (Bagde & Nadanathangam 2019).

Manipulation of postbiotic composition in food

The majority of postbiotic sources in the food industry are obtained through the process of fermentation. Postbiotics are naturally occurring microorganisms that can be found in many dairy products, as well as in kefir, kombucha, yoghurt, and pickled vegetables. The extracellular biopolymers, or EPS, that bacteria produce or exude as they develop. The sensory and physiochemical qualities of products made from food can be improved by EPS produced by LAB, including *Lactobacillus rhamnosus*, a crucial component in dairy products (Nguyen et al. 2020). Numerous research have centered the use of enzymes rather than probiotic microorganisms to achieve desired results. For instance, purified phytases derived from Bifidobacterium longum and *Bifidobacterium pseudocatenulatum* have been found to increase myoinositol triphosphate levels and decrease phytate levels in cereal blends. Food items are supposedly vitamin-enriched, according to numerous authors. It's not unusual to use fermentation to increase the vitamin B content of cereal grains. Vitamin B is abundant in grains used for cereal. These vitamins are lost, though, during grinding or heat processing. Fermenting cereal and pre-treating it with LAB (lactic acid bacteria) can result in producing additional bacteria that are capable of synthesizing vitamins B1, B2, B3, B9, B11, and B12. (Nkhata et al. 2018). The LAB fermentation of cereals significantly improved the Ca, Fe, and Zn's *in-vitro* bioavailability as well as sugars, soluble dietary fiber, total lysine, and protein fractions. Through LAB fermentation, wheat may also generate aminobutyric acid, peptides that protect against oxidation, and peptides that block the angiotensin I-converting enzyme. Using probiotic-induced fermentation to eliminate some potentially harmful food components is another creative way to use probiotics in addition to adding postbiotics to food (Bai et al. 2021).

Safety concerns and future prospects

Numerous studies have offered convincing proof of the advantages of bacteria, especially in the gut. In light of the possible risks and safety concerns, the regulatory requirements for postbiotics and other similar functional meals should be anticipated. Despite the risks associated with foodborne bacteria that have already been mentioned, LAB (lactic acid bacteria) and bifidobacteria, which are considered to be beneficial bacteria, can effectively compete against pathogens and release amino acids (AAs) that enhance the lifespan and safety of food products (Nataraj et al. 2020). Additionally, these bacteria have the power to act as potent barriers to the emergence of pathogens and spoilage-causing microbes. The limitations of probiotics led to the development of the postbiotic idea, a novel approach for functional food ingredients. On the other hand, it might be necessary to take into account the probiotic strains, the type of fermentation, and the safety concerns for consuming postbiotics when producing postbiotics (Anderson 2019; Żółkiewicz et al. 2020). Despite the fact that postbiotic eating is still a new strategy, there is no epidemiological or clinical proof of any dangers. The threat of infection is ostensibly gone, though, because there are no active microbes. Studies in vivo and in vitro investigated how postbiotics affected various cell types, blood parameters, metabolic markers, and intestinal mucosa. In vitro research is expected to be advantageous for studying how commensal and pathogenic microbes interact with the host along with its microbial products. In vivo studies are highly encouraged to confirm the effects of postbiotics in *in-vitro* due to the limited transferability of in vitro research and the possibility of species-specific effects. Numerous animal models for postbiotics, short chain fatty acids, peptides, EPS, vitamins, peptidoglycans, lipopolysaccharides, teichoic acids, and peptidoglycans have all been identified as potential alternative treatments for infectious diseases in the aquaculture system (Nataraj et al. 2020).

The role of the intestinal epithelial barrier as the primary defense mechanism against numerous infections is widely recognized. As a result, leaky gut, also known as a disruption in the gut epithelium barrier's regular operation, can allow a variety of harmful substances and organisms to enter the body. Postbiotics are therefore potential options since any drugs that have the ability to improvise the intestinal barrier can be recognized as health-promoters. Not only do living bacteria in the digestive tract benefit from fermented foods, but so do other beneficial organisms. The byproducts of fermentation may also have positive health effects. Postbiotics maintain host health and may act as a mediator for the positive effects via a number of pathways, but the targeted mode of action is still under study. The use of postbiotics in the right amounts and concentrations has been proven to be safe by a number of studies. Food safety is improved by postbiotics' antibacterial properties. Some of the elements that determine the antibacterial effect of postbiotics inside the foodservice industry include the kind and dosage of postbiotics, the type of food modeling, and the

features of the food product. The management of food-infecting bacteria is one of the most significant effects of postbiotics on the food industry (Anderson 2019; Dimidi et al. 2019).

Experts predict that postbiotics will have an effect on how the human body works and offer a fascinating area for future study. New products are being introduced by manufacturers to meet the demands of various customers as the research sector grows. Postbiotics provide an advanced and secure way to supplementally improve gut health because they have fewer storage and shelf-life issues than live probiotics. The potential for meals and beverages based on postbiotics has grown as a result of rising health concerns and the subsequent trend toward functional foods. People understand how important their gut microbiota is and how it affects their overall health. Microbial metabolites have come under scrutiny due to the technological challenges posed by the presence of viable microbial cultures in various foods and beverages, as well as the possibility that they could harm immunocompromised people. The demand for healthier food choices by consumers has caused significant transformations in the food and beverage industries. The market is demonstrating that there is a chance for businesses to include postbiotics in the formulations of their products in order to appeal to more customers (Collado et al. 2019; Salminen et al. 2021b). Not only do postbiotics have many health advantages, but they also serve as emulsifiers, preservatives, and guarantee the stability of the finished product, thereby lowering the need for food additives. Researchers are still attempting to determine how postbiotic production may affect people's health, and there aren't many studies on the advantages of postbiotics. In the majority of recent studies, dietary supplements are compared to pre- and probiotic meal consumption (Aguilar-Toalá et al. 2018; Damián et al. 2022).

Conclusion

In summary, the growing interest with functional foods, including probiotics, prebiotics, and postbiotics, has garnered substantial interest from consumers, manufacturers, and researchers in recent years. Postbiotic dietary supplements are notable for their superior stability in comparison to probiotics and prebiotics, rendering them very promising contenders for diverse applications, particularly in the domains of food safety and preservation across the food chain. The objective of this study, as indicated in the passage, is to offer a thorough examination of postbiotics, encompassing their capacity to enhance health, methods of production, nomenclature, biological activities, and their uses in ensuring food safety and preservation. Postbiotics have been observed to exhibit their efficacy in the field of bio preservation by effectively mitigating the formation of biofilms in food products through the use of organic acids, bacteriocins, and several other antibacterial mechanisms. Moreover, the research investigates the in-situ synthesis of postbiotic metabolites in food and examines the impact of both external and internal food constituents on this phenomenon. This study investigates the antibacterial characteristics of postbiotics and their potential utilization in the preservation of food items, hence leading to an overall improvement in food safety.In general, this study on postbiotics presents a potentially fruitful direction for advancement in the food industry. It presents potential solutions that are in line with consumer preferences for healthier, safer, and more sustainable food products. Additionally, it addresses the intricate challenges associated with food safety and preservation throughout the food supply chain. AQ8 AQ10

Authors' contributions
Conceptualization, B.M., Y.K.M., A.K.M.; Data curation: B.M, H.P., and R.G.; writing—original draft preparation, B.M., A.K.M., Y.K.M., D.C.A., H.P., and R.G.; writing—review and editing, C.N.R., S.K.M., R.Y., M.Z.S.; visualization, Y.K.M., A.K.M. B.M. All authors have read and agreed to the published version of the manuscript.

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Declarations

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Not applicable.

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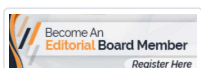**Author(s):** Mahitha Pyla, Sanjana Kankipati, B. Sumithra, Piyush Kumar Mishra, Bishwambhar Mishra, Sanjeeb Kumar Mandal, Jibanjyoti Panda, Hitesh Chopra, Avula Satya Kumar, Mohamed Salah, Yugal Kishore Mohanta and Mohammad Amjad Kamal*

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Abstract

Tumor diseases remain among the world's primary causes of death despite substantial advances in cancer diagnosis and treatment. The adverse chemotherapy problems and sensitivity towards drugs for some cancer types are among the most promising challenges in modern treatment. Finding new anti-cancer agents and drugs is, therefore, essential. A significant class of biologically active substances and prospective medications against cancer is comprised of bacterial proteins and peptides. Among these bacterial peptides, some of them, such as anti-cancer antibiotics and many toxins like diphtheria are widely being used in the treatment of cancer. In contrast, the remaining bacterial peptides are either in clinical trials or under research in vitro studies. This study includes the most recent information on the characteristics and mechanism of action of the bacterial peptides that have anti-cancer activities, some of which are now being employed in cancer therapy while some are still undergoing research.

Keywords: cancer, anti-cancer drugs, bacterial peptides, anti-cancer antibiotics, anti-cancer enzymes, bacteriocins, bacterial toxins, no ribosomal peptides

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