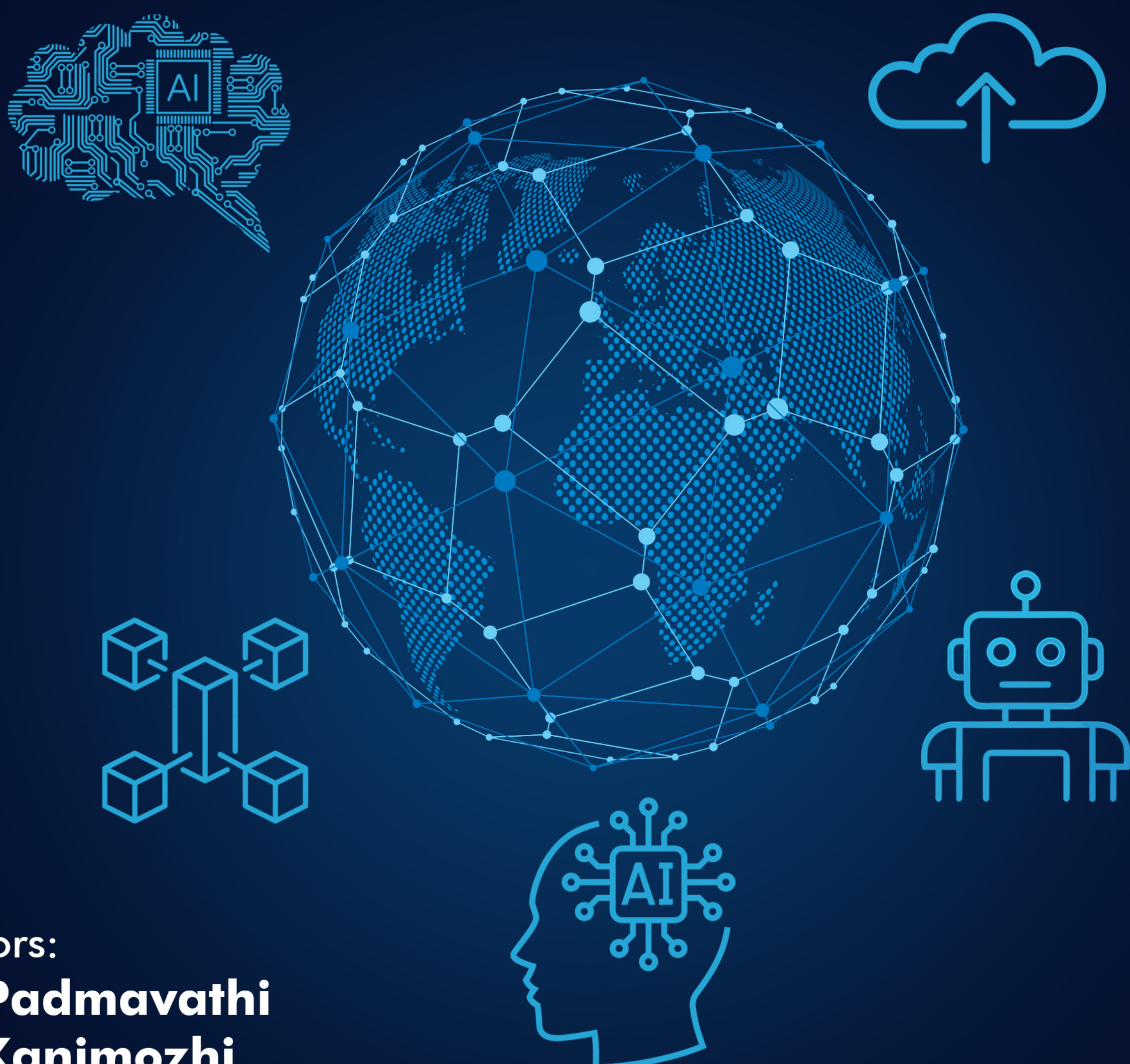
TECHTRENDS

NAVIGATING THE FRONTIER OF EMERGING TECHNOLOGIES



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BENTHAM SCIENCE

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FOREWORD

Today's society is unrecognizable when compared with the one of ten years ago. It is a world where innovation brings changes that affect not only industries but the very foundations of people's lives. This book, "TechTrends: Navigating the Frontier of Emerging Technologies", is a collection of ideas about these transformational technologies that should be useful to anyone interested in learning more about these technologies in order to embrace the future.

Such an environment brings the problem of growing difficulty in gaining relevant information as technology advances exponentially. However, it is critical for practitioners, legislators, scientists, and learners to understand the ways these innovations distort, enhance, or evolve their professions and global society. This book directly addresses that task by offering a brief overview of major technologies, including Artificial Intelligence, Blockchain, Internet of Things, and others.

However, this is not what is evident in TechTrends, which is therefore free from these problems due to its clarity. All in all, the authors have well addressed the requirements for details and, at the same time, avoided excess depth which would have made numbers complex. By the end of this book, the reader is going to get theoretical as well as pragmatic perceptions and examples of how these advancements can be put to use in sectors of healthcare, education, and energy.

That being said, the exposure of expertise in this book is almost unbelievable. Several authors of the articles are from the business fields and academic circles and most of them have provided their valuable insights and ideas to the readers. These are the reasons it is safe to say that TechTrends is an invaluable resource when it comes to understanding today's world, which is filled with emerging technologies and numerous opportunities.

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PREFACE

In the rapidly evolving landscape of today's digital world, staying ahead of technological advancements is no longer an option but a necessity. The emergence of groundbreaking innovations is reshaping industries, redefining possibilities, and fundamentally altering the way we live and work. This book, TechTrends: Navigating the Frontier of Emerging Technologies, is designed to be your compass through this transformative journey.

From Artificial Intelligence to Blockchain and from Quantum Computing to renewable energy, this comprehensive guide examines the key technologies that are driving the future. Each chapter delves deep into the trends that matter most, with a focus on providing clear explanations and practical insights. By blending theoretical understanding with real-world applications, we aim to demystify complex concepts and make them accessible to a broad spectrum of readers.

This book is the result of the combined efforts of industry experts, researchers, and thought leaders who have generously contributed their knowledge and perspectives. Their diverse expertise ensures that the content remains relevant, timely, and rich with practical advice so that readers can immediately apply it to their own contexts.

Whether you are a technologist looking to stay ahead of the curve, a business leader seeking competitive advantages, a student aiming to expand your knowledge, or a policymaker grappling with the implications of emerging technologies, TechTrends offers something valuable. It is not just a reference book but a toolkit for navigating the complexities of tomorrow's innovations.

As you embark on this exploration of the frontier of emerging technologies, I hope you find the insights within inspiring and empowering. It is my sincere belief that with the right knowledge and understanding, we can harness these technologies to create a better, more connected, and more equitable future for all.

Welcome to the Frontier. Let's explore it together.

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CHAPTER 1

Blockchain-enabled Security for Medical Image Transmission: Prescription Data Hiding and Multi-secret Sharing-based Encryption

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Abstract: Medical images bear sensitive patient information, making their transmission a security concern. The privacy and security of such graphical representations and incidental patient information in transit *via* public networks must be preserved. Medical images contain sensitive information, which sets them apart from ordinary images. Medical images are more sensitive and contain crucial information. This leads to a reliance on more secure techniques than conventional methods like cryptography and data hiding, which normally take more time and security. In this chapter, we propose implementing two innovative techniques to enhance the security of medical data sharing: Prescription information concealed in medical images and secure and share-prescription using a multi-secret sharing blockchain. Prescription data hiding, on the other hand, refers to the encryption of prescription details within normal-looking images like X-ray or MRI scans, among others. Incorporating sensitive data into the images makes it difficult for unauthorized persons to access them. Additionally, we build on the potential of using a blockchain, an immovable and distributed database, to share crucial clinical information safely. Medical data is kept through a blockchain database, which spreads the data around a network. It becomes harder for attackers to tamper or alter the data using traditional methods. Smart contracts also add security to data sharing by enabling data to be available only to the relevant parties, which gives security an extra layer. As a novel solution to solve the serious security issues of medical data sharing, the proposed scheme involves prescription data hiding in medical images, multi-secret sharing-based encryption, and the security properties of the blockchain. Our proposed techniques ensure the privacy and integrity of patients' data when transmitting medical images.

Keywords: Blockchain technology, Data security techniques, Data transmission, Electronic health records, Privacy.

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INTRODUCTION

Medical data transmission is an important procedure that involves transferring medical images through public networks and ascribes a massive priority to security measures. Such images bear very sensitive patient details; therefore, there is a need to ensure that their transfer is very secure. Several internal traditional data security approaches, like cryptography and data hiding, possess some drawbacks regarding time consumption and the degree of protection they offer to medical image applications. Thus, this project will provide a solution to increase the security of medical images through the security solution enabled by blockchain, prescription data embedding, and multi-secret sharing encryption. The project aims to solve the problems of non-trivial protection of medical image transmission, patient data confidentiality, and data integrity. Medical images are entirely unlike standard images because they contain a large volume of tremendously important data. Therefore, effective measures to enhance security, apart from other traditional methods and techniques, need to be drawn up.

Prescription data in medical images is a combination of concealing prescription data within the medical image using a steganographic approach. This approach provides an extra layer of protection to the greater mass of data incorporated into the images. Through steganography, there are ways that unauthorized people will not be easily able to see what is hidden; hence, the data's privacy and confidentiality will be intact. In addition, for the remainder of the project, the technology being applied is Blockchain, a distributed, unalterable ledger. Due to the distributed nature of Blockchain, clinical data is thus highly robust in terms of issues of hacking or alteration by unauthorized persons. This makes it difficult for the attackers to modify or foolproof the images transmitted by this technology.

For higher security, build multi-secret sharing-based encryption into the project. This encryption divides the security data into portions distributed among the approved parties. The raw data can be disaggregated only when authorized parties merge their shares. It also has a security feature that prevents anyone unauthorized from making any changes or accessing the data in question. This project aims to provide a multi-faceted solution to the problem of insecure medical image transmission. Solutions such as hiding prescription details in the medical images, the use of Blockchain function, and multi-secret sharing-based encryption ensure the enhanced security of patients' information within the framework of the project. Applying these techniques ensures the medical images' security during transmission across public networks while remaining intact and private. Fig. (**1**) shows the concept of managing healthcare data through blockchain security for medical image transfer. It comprises several parts and their relationships to secure an efficient healthcare data management.

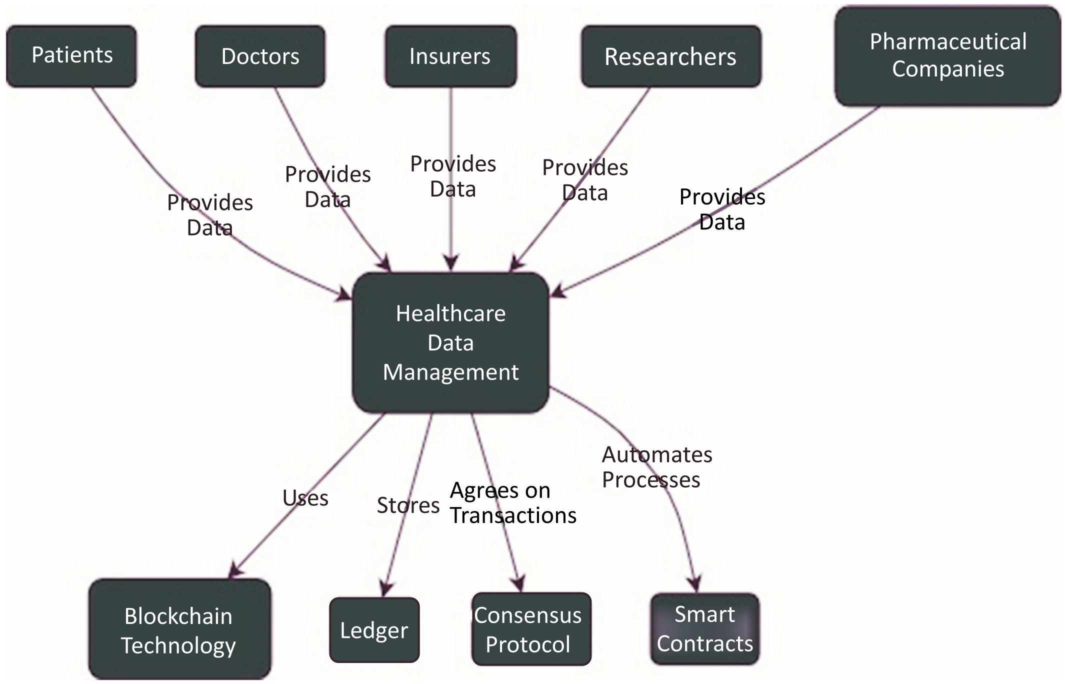

Fig. (1). The framework of healthcare data management.

Objectives of this Chapter

- **Implement Prescription Data Hiding:** In general psychopathology, using steganography, it is possible to create approaches to hide prescription data in medical images, such as X-rays or MRI scans. This makes the process secure since it is difficult for unauthorized personnel to penetrate the hidden images.
- **Utilize Blockchain Technology:** Some of the best use cases can be using blockchain technology's decentralized and tamper-proof features to store and share medical data. With the project's blockchain implementation, it becomes challenging for attackers to manipulate the data transmitted or stored as images.
- **Enhance Security with Multi-secret Sharing-based Encryption:** This includes the encryption concept that divides information into several parts and distributes the segments to relevant users. This method ensures that only proper people can restore the information, thus adding another layer of security.

The research is expected to achieve the following objectives, hence developing a broader security framework for medical image transmission. It aims to ensure patient information's privacy, confidentiality, and integrity and alleviate the risks of transferring medical images over public networks.

CHAPTER 2

Dynamic Resource Allocation for Internet of Thing Devices in Edge Computing: An Intelligent Fuzzy Approach

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Abstract: IoT devices call for optimum resource management solutions regarding edge computing reliability and performance. This chapter presents an intelligent and fuzzy-based adaptive resource management solution for IoT devices in the context of edge computing. In this specific method, fuzzy support is applied to enable a resource dynamic allocation according to the devices' IoT needs and requirements. This is because the resource allocation process is intelligent and adaptive; hence, the system can modify its past resource allocation decisions to provide better functions. The proposed approach also acknowledges exploiting the particularities of the edge computing environment. It entails factors like the availability of the resources at the edge and the associated limitations, for example, in terms of power consumption and the processors' capacity. To consider the feasibility of the proposed approach, extensive simulations and experiments were conducted, and the performance of resource management by utilizing the proposed approach is compared with those of existing approaches. From the results obtained, the proposed method is superior to the current methods concerning resource usage, energy consumption, and system performance. In general, the presented intelligent and fuzzy-based adaptive resource management strategy presents great potential in increasing the efficiency and effectiveness of resource management of IoT devices in the context of edge computing, which would help establish more effective IoT systems shortly.

Keywords: Edge computing, Energy efficiency, Fuzzy logic, Internet of things, IoT devices, Resource management.

INTRODUCTION

The concept of the Internet of Things has changed the touchpoints we have with our appliances and our reality. Technological advancements have exponentially

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increased the number of IoT devices producing data at the network's edge. It is known that edge computing facilitates the computation process near the data source as a solution to low latency and less bandwidth utilization. Nevertheless, resource management for IoT devices in an edge computing environment is still a major issue [1]. This challenge has been tackled by designing an intelligent and fuzzy-based adaptive resource management architecture for IoT devices in edge computing environments. This architecture uses fuzzy logic techniques for managing the resources of IoT devices according to their needs, importance level, and other factors [2]. The architecture that has been suggested here consists of three primary components: The components of the IoT device manager, the resource allocation engine, and the fuzzy logic controller.

This IoT device manager executes a constant function that assesses the status and demands of every IoT device integrated with the edge computing setting. The resource allocation engine will make intelligent and adaptive decisions for the data that the IoT device manager would have gathered. The concept followed in the fuzzy logic controller includes fuzzy logic, where the resources are provided concerning the device's priority, the amount of resources required, and the time at which the resources are required. This type of architecture means that resources can be distributed wisely and flexibly in a system, minimizing resource wastage and boosting the system's performance.

The advantage of using the fuzzy logic-based approach is that the mechanism for the allocation of resources is adaptable to both device requirements and environmental changes. The above-mentioned architectural proposal is needed to enhance the quality of resource management in IoT devices for edge computing, focusing on the maximum use of all available resources and minimal interference with the functioning of the devices. Edge computing is enhanced through optimizing resource usage, making IoT systems more efficient and reliable [3]. Altogether, the discussed architecture is an attempt to create intelligent and adaptive solutions for resource management in IoT devices in the edge computing context that may find applications in a wide range of industries and domains.

The organization of the chapter is as follows:

Section 1 introduces the chapter and discusses the importance of context-aware resource management in IoT devices in the context of edge computing. As discussed in section 2, a literature review of previous studies was performed regarding resource management of IoT devices in an edge computing context and the drawbacks of prior work. Section 3 discusses the adopted framework, intelligent and fuzzy-based adaptive resource management for IoT devices in the edge computing environment. This one encompasses the general system design, the system's components, and the algorithms used. Section 4 discusses the proposed approach through the results of digital simulation experiments. It also involves establishing a relationship between the proposed method and other methods regarding performance aspects and performance analysis outcomes. It defines the proposed system's objectives and the areas of concern. Finally, the last section provides the conclusion, showing that adaptive resource management for IoT devices in the edge computing environment is crucial and provides future research directions.

Literature Survey

Today's trends in edge computing have caused the emergence of IoT devices and the necessity for resource management. Several studies have introduced intelligent and adaptive resource management architectures for IoT devices in edge computing scenarios in this context. A selected literature review outlines some of these investigations' important characteristics and implications.

The Intelligent and adaptive resource allocation makes the utilization of resources more efficient: Anjum *et al*. [4], study the resource allocation to IoT devices using fuzzy logic with an approximation of their requirements and other parameters. Resource utilization is required to be intelligent and dynamic; hence, the utilization of all the available resources must be efficient and optimum to minimize wastage and, thus, optimize the performance of the system. The approach assigned resource allocation using fuzzy logic, while a genetic algorithm was employed for the resource allocation strategy. According to the experimental results, it has been found that their proposed method was better than or at least equal to baseline methods in terms of energy efficiency, resources consumed, and task completion rate.

Another study by K. S. Wang and other researchers [5], presented a scheme for adjusting resources for the IoT devices that are used in edge computing scenarios. The method will involve game theory in distributing resources depending on the needs of the devices and power consumption, among others. The authors proved that the proposed approach worked faster and more efficiently when allocating resources than conventional methods. The Heir's approach identified the dynamic character of the resource allocation strategy and applied the Markov decision process and the deep Q-network to design the best policy. The experimental results further indicated that their proposed approach had a superior performance against other baseline methods in terms of energy efficiency as well as the rate of task accomplishment.

CHAPTER 3

Improved GarbGenius: An AR Approach to Outfit Recommendation Systems

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Abstract: Finding well-fitting clothing that aligns with personal style preferences remains a significant challenge in the fashion industry. Existing solutions, such as online shopping platforms, lack accurate prediction capabilities for how garments would fit individuals. GarbGenius proposes an innovative approach integrating Artificial Intelligence (AI) powered recommendation systems and Augmented Reality (AR) enhanced virtual try-on experiences to address this gap. GarbGenius will deliver personalized recommendations based on current fashion trends by leveraging user-image input submission and comprehensive clothing datasets. Implementation involves developing user-friendly interfaces for user image input submission, clothing datasets, and algorithmic analysis of Vision Transformer (ViT) with recommendations, ensuring a seamless and immersive fashion wardrobe experience. Through iterative testing and maintenance, GarbGenius aims to empower users to confidently explore and embrace the latest trends tailored to their unique preferences.

Keywords: Algorithmic analysis, Artificial Intelligence (AI) powered recommendation systems, Augmented Reality (AR), Clothing datasets, Fashion trends, Vision transformer.

INTRODUCTION

The fashion industry is characterized by its ever-changing trends and diverse consumer preferences, often posing unique challenges for retailers and consumers. In this modern digital age, the proliferation of online shopping platforms has provided convenience and accessibility to consumers worldwide. However, the inability to accurately predict a garment's size, fitting and appearance remains a persistent issue, leading to customer's dissatisfaction and increased return rates. To address these challenges, innovative solutions leveraging advanced technologies are imperative.

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Overview of Fashion Retail Challenges

Traditional methods of purchasing clothes, in-store or online, often result in uncertainties regarding fit, style suitability, and overall satisfaction. While convenient, online shopping platforms cannot provide accurate representations of garments fit for individuals, leading to a lack of connection between consumer expectations and reality. Furthermore, existing recommendation systems fail to offer personalized suggestions based on evolving fashion trends and individual style preferences.

Motivations for GarbGenius Development

Our development of GarbGenius is motivated by recognizing these pervasive challenges within the fashion retail landscape. By harnessing the capabilities of Artificial Intelligence (AI) and Augmented Reality (AR) technologies, GarbGenius seeks to revolutionize how consumers interact with an enhanced fashion wardrobe experience. Our goal is to empower users with personalized recommendations tailored to their style preferences and current fashion trends. GarbGenius aims to enhance user confidence, satisfaction, and engagement in the fashion wardrobe experience by bridging the gap between consumer expectations and reality.

LITERATURE SURVEY

The paper “A cost-efficient approach for creating virtual fitting rooms using Generative Adversarial Networks (GANs)” [1], describes a cost-effective method for developing a virtual fitting room using Generative Adversarial Networks (GANs). It addresses customers' challenges during online shopping, particularly after the COVID-19 pandemic. It proposes using AI technologies to develop a virtual fitting room application for mobile devices and web platforms. The application allows users to try on clothing items virtually without needing physical trials, saving time and reducing crowding in physical stores. From a business perspective [2], the virtual fitting room is expected to increase online sales and preserve product quality. The method uses GANs and image processing techniques to generate output images from input images of a person and a clothing item. The results demonstrate superior performance compared to existing approaches in the literature. The enhanced virtual fitting room described in the paper addresses common challenges faced in traditional fit-on rooms, such as long queues, individual clothing changes, privacy issues, and time wastage. This convolutional neural network-based system utilizes deep learning and augmented reality to overcome these problems. It has a TV screen, two web cameras, and a computer to capture and display the customer's clad body. By leveraging CNN and AR technologies, the system accurately detects the customer's body and recommends clothing styles based on age, gender, face type, and skin tone. It also allows for customization of styles according to customer preferences and achieves a high accuracy rate in suggesting different clothing styles using FFNN. Additionally, the system enables customers to select clothing for those not physically present. Overall, this innovative product has the potential to significantly impact the textile and fashion industry by providing efficient customization options and competing with other applications in the market.

Online Fitting Room: An online fitting room mobile application that makes use of Augmented Reality (AR) technology to address the issues of online clothing purchases is discussed in the study[3]. It highlights the guesswork involved for customers who cannot physically try on clothes, leading to dissatisfaction and increased company return rates. By implementing an AR online fitting room, customers can virtually try on clothes in their environment and bodies, using their fitting measurements for accuracy [4]. This technology offers convenience, saving shoppers' time and money by eliminating the need to visit physical stores. The paper emphasizes the potential impact of such an application on improving the online shopping experience for customers.

This study is on consumer adoption of virtual fitting rooms for purchasing decisions during e-commerce. This article presents research on customer acceptance of virtual fitting rooms for making purchasing selections during e-commerce. It describes the creation and evaluation of a virtual dressing room prototype and a proposed research and testing strategy based on relevant usability and user experience studies. The experimental setup and execution of the usability and user experience tests are explained, followed by a presentation of the results and a discussion of their relevance to user-oriented design and virtual dressing room development.

The literature "Augmented Reality Shopping System and Experience: Overview of the Literature," reviews the architecture of AR shopping applications that are being developed presently[5]. The system consists of a cloud server for object identification, localization, and the retrieval and analysis of product information, as well as a progressive web app client for rendering augmentations and tracking. The review finds design elements essential to constructing the suggested system by looking at previous cloud-based augmented reality apps. The study advances knowledge of the technological specifications and factors required to create a successful augmented reality shopping experience.

CHAPTER 4

Machine Learning in Multidisciplinary Predictions – A Contemporary Study on Tool Wear Prediction for Milling Process

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Abstract: One of the intriguing subfields of Artificial Intelligence (AI) is Machine Learning (ML). The ability to learn without explicit programming has been referred to as machine learning. Over the past few years, machine learning has emerged as an important research topic in several business verticals. Big data's technological developments have made accessing vast amounts of diverse data simple. With the help of new hardware capabilities, this enormous volume of data may be processed quickly and efficiently in a manageable amount of time. Therefore, Machine Learning algorithms have proven to be the most successful at using big data to solve difficult business challenges in almost real-time. This chapter briefly overviews some popular machine learning approaches and their uses in mechatronics, particularly in the tool wear prediction process for milling.

Keywords: Acoustic emission, Decision boundaries, Force, Frequency component, Machine Learning, Milling machining, Multidisciplinary, Support vector machine, Tool wear, Vibration.

INTRODUCTION

Mechatronics is an interdisciplinary field that develops contemporary engineering solutions by combining computer science, mechanical engineering, electronics, and control engineering. The incorporation of ML into Mechatronics denotes a significant improvement in this field, enabling systems to perform tasks autonomously while learning and adapting to changing conditions over time. By leveraging algorithms that can analyze large datasets, identify patterns, and make informed decisions, ML enhances the functionality and intelligence of Mechatronic systems.

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This fusion of technologies is paving the way for more sophisticated automation, precision engineering, and intelligent manufacturing processes, driving innovations in various industries ranging from robotics to automotive engineering. In this paper, we explore the critical role of machine learning in advancing Mechatronics, examining its impact on system efficiency, adaptability, and the potential for future technological breakthroughs.

Robotics and Autonomous Systems

ML algorithms for Path Planning and Navigation help robots navigate complex environments by learning optimal paths, avoiding obstacles, and adapting to dynamic changes in real-time. Through the use of computer vision techniques for Object Recognition and Manipulation powered by ML, robots can identify, categorize, and interact with various objects, improving their ability to perform tasks like assembly, sorting, and inspection.

Predictive Maintenance

Sensor data is analyzed using ML fault diagnostic and detection algorithms to prepare for potential problems before they arise. This proactive method lowers maintenance costs and downtime by facilitating timely interventions. By continuously monitoring the health of components, ML can predict wear and tear, optimize maintenance schedules, and extend the lifespan of the equipment.

Smart Manufacturing

Process optimization of machine learning algorithms analyzes production data to find inefficiencies, allocate resources optimally, and enhance product quality. Real-time quality control may be achieved by using machine learning approaches to quality control. These techniques use picture recognition and data analysis to detect variations in processes or product faults.

Adaptive Control Systems

Self-tuning controllers in ML can enhance control systems by enabling them to self-tune and adapt to changing conditions, improving performance in environments where traditional control systems might struggle. Intelligent control, which combines Machine Learning with control theory, enables the creation of systems that can learn from their surroundings and gradually enhance their control approaches. An example of this may be seen in automobile cruise control systems that adjust to changing traffic situations.

Human-machine Interaction

The Gesture and Voice Recognition feature of ML enables machines to recognize and respond to human gestures and voice commands, enhancing the usability of systems in applications like industrial robots, smart appliances, and assistive devices. Emotion recognition in advanced Human-robot Interaction (HRI) systems, ML, can recognize and respond to human emotions, making interactions more intuitive and personalized.

LITERATURE REVIEW

The combination of Machine learning (ML) and Mechatronics has emerged as a dynamic research area, significantly advancing automation, robotics, and intelligent systems. This literature overview summarizes the main conclusions of current research on the application's benefits and the challenges of incorporating machine learning into mechatronics. The development of ML in mechatronics began in the 1990s when neural networks were initially used to regulate robotics systems, opening the door for more complex applications [1]. The discipline has been further transformed by the advancements of deep learning and reinforcement learning, which allow machines to learn from enormous datasets and carry out difficult tasks independently [2].

ML has been applied across various domains within Mechatronics, including robotics, predictive maintenance, and smart manufacturing. For instance, ML in adaptive control systems improves performance by adjusting to environmental changes [3]. Predictive maintenance increases dependability and decreases downtime by employing ML algorithms to evaluate sensor data and predict problems [4]. ML facilitates advanced functionalities such as autonomous navigation and object manipulation in robotics, which significantly improves task efficiency [5].

Integration of ML into Mechatronics offers numerous benefits, including enhanced adaptability, precision, and efficiency. ML enables systems to process real-time data, improving decision-making capabilities and responsiveness, which is crucial in dynamic environments where traditional control methods may fall short [6]. Furthermore, ML allows for better handling of nonlinearities within Mechatronic systems, particularly in complex tasks such as robotic manipulation and quality control [7]. Despite these advantages, several challenges remain. Data quality and availability are critical for training robust ML models, yet collecting large, labeled datasets in many industrial applications is challenging [8]. Additionally, the computational demands of ML, especially in real-time applications, present significant concerns, including latency and processing power. Another challenge is the interpretability of complex ML models, where

CHAPTER 5

Laser Cladding on Magnesium Alloys: A Review of Surface Modification Technique

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Abstract: Magnesium alloys possess excellent lightweight properties but are limited by their low hardness, wear resistance, and susceptibility to corrosion. Laser cladding, a surface modification technique, offers a promising solution to enhance the performance and expand the application range of magnesium alloys. This chapter aims to provide an in-depth analysis of laser cladding on magnesium alloys, focusing on the benefits, challenges, and recent advancements in this field. The chapter discusses the enhancement of wear resistance, corrosion protection, resist against heat, and tailored properties achieved through laser cladding. Additionally, it addresses the challenges related to thermal concerns, material compatibility, and surface preparation. The chapter concludes by highlighting the potential of laser cladding as a valued technique for enhancing the performance and durability of magnesium alloy components.

Keywords: Additive manufacturing, Corrosion, Laser cladding, Magnesium alloy, Surface modification.

INTRODUCTION

Magnesium alloys have gained considerable attention in various industries owing to their light weight, high strength-weight ratio, and exceptional castability. However, they also possess certain limitations because of their low hardness, wear, and susceptibility to corrosion. These limitations can restrict their application in demanding environments where enhanced surface properties are required [1]. To overcome these limitations, surface modification techniques like laser cladding have emerged as effective methods for improving the performance of magnesium alloys. It comprises the deposition of a protective film or coating

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on the magnesium alloy using a laser beam. The process offers several advantages, including precise control over the clad layer thickness and lesser heat-affected zones to tailor the material properties [2].

This review article discusses an overview of laser cladding on magnesium alloys. It discusses the process, types of laser systems used, and important process parameters. Furthermore, it explores the benefits of laser cladding, such as enhanced wear resistance, resistance against corrosion, heat resistance, and the ability to tailor properties. This article also addresses the challenges and considerations associated with laser cladding on magnesium alloys, including thermal concerns and material compatibility [3].

IMPORTANCE OF MAGNESIUM ALLOYS IN SEVERAL INDUSTRIES

Magnesium alloys play an important role in numerous industries due to their unique properties and characteristics. Here are some of the key reasons for magnesium alloys being important in different industrial sectors. Magnesium alloys are being used in a wide range of industries by reason of their unique properties and characteristics. One of the key reasons for their significance is their lightweight nature, making them highly sought after in different industrial sectors. Let us explore some of the major industries where magnesium alloys play a vital role [4].

Magnesium alloys are gaining popularity because of their ability to reduce overall vehicle weight. These alloys offer a high strength-to-weight ratio, which contributes to enhancing fuel efficiency, reduction of emissions, and performance enhancement. Magnesium alloys in vehicle components allow manufacturers to produce lighter vehicles without compromising structural integrity [5]. The aerospace industry also heavily relies on magnesium alloys. Their lightweight properties contribute to fuel efficiency, allowing for longer flights and reduced operating costs. Magnesium alloys are commonly used in aircraft frames, engine components, and interior parts where weight reduction is critical. By utilizing magnesium alloys, aerospace companies can achieve significant advancements in terms of efficiency and cost-effectiveness [6].

In the electronics and consumer goods industries, magnesium alloys are valued for their excellent electromagnetic shielding properties. These alloys are often utilized in the manufacturing of laptops, smartphones, cameras, and other portable electronic devices. By incorporating magnesium alloys, manufacturers can ensure both structural integrity and electromagnetic compatibility, thereby enhancing the performance and durability of their products [7]. The medical industry has also recognized the benefits of magnesium alloys. These alloys are biocompatible and biodegradable, which are suitable for medical implants in orthopedic screws and plates. The ability of magnesium alloys to be absorbed by the body over time without causing adverse reactions is a significant advantage. Additionally, the lightweight nature of these alloys makes them suitable for medical devices like wheelchairs and surgical instruments [8]. Defense and military applications also rely on magnesium alloys due to their lightweight and high-strength properties. These alloys are used in armor plating, weapon systems, missile components, and lightweight vehicles. By utilizing magnesium alloys, the military can enhance mobility, fuel efficiency, and overall operational effectiveness [9].

In the sports and recreation industry, magnesium alloys find applications in the manufacturing of sports equipment. Bicycles, golf clubs, tennis rackets, and other sporting goods benefit from the lightweight properties of magnesium alloys, improving performance and maneuverability for athletes [10]. Furthermore, magnesium alloys are gaining prominence in the sustainable energy sector. They are used in the manufacturing of wind turbines, solar panels, and energy storage systems. Magnesium alloys contribute to lightweight designs and improved energy efficiency, playing a significant role in the advancement of renewable energy technologies [11]. In summary, the importance of magnesium alloys across various industries lies in their lightweight nature, high strength-to-weight ratio, electromagnetic shielding properties, biocompatibility, and biodegradability. These unique characteristics make magnesium alloys a preferred choice for applications where weight reduction, performance improvement and sustainability are crucial factors.

LIMITATIONS OF MAGNESIUM ALLOYS

Magnesium alloys have several limitations that can restrict their application in certain environments and industries. The challenges of magnesium alloys used in industrial and biomedical applications are shown in Fig. (**1**) [12].

The major limitations of magnesium alloys include:

Low Hardness

Magnesium alloys exhibit relatively low hardness compared to other structural metals. This low hardness can make them susceptible to wear, deformation, and surface damage in high-stress applications [13]. Components made solely from magnesium alloys may experience premature failure or reduced durability under heavy loads or abrasive conditions.

CHAPTER 6

CNN-based Classification for Leaf Disease Identification

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Abstract: Plant diseases present a substantial challenge for farmers, causing significant crop losses and diminishing yields. Timely detection and effective treatment are crucial, yet traditional methods often fall short due to their reliance on human expertise and the potential for misdiagnosis. These conventional approaches can be slow and cumbersome, leading to delays in addressing plant health issues. Our proposed system addresses these challenges by employing Convolutional Neural Networks (CNNs) for precise and efficient leaf disease detection and targeted fertilizer recommendations. Using CNNs for image classification, the system can accurately identify plant diseases from leaf images and suggest appropriate fertilizers, thereby optimizing treatment strategies. This CNN-based approach was rigorously tested on a comprehensive dataset of plant leaf images, demonstrating impressive accuracy in disease detection and fertilizer recommendations. The system's advanced capabilities streamline the diagnostic process and enhance crop yield by providing farmers with timely and precise recommendations. Integrating CNN-based analysis with actionable insights reduces reliance on extensive human expertise and fosters more sustainable and efficient farming practices.

Keywords: Convolutional neural network, Internet of Things, Machine Learning, Multiple linear regression.

INTRODUCTION

Agriculture, crucial to India's economy, faces significant threats from population growth, climate change, and crop diseases, all of which endanger food security and farmers' livelihoods. With the global population projected to rise by 2 billion in the next 30 years, food production must increase by 70-90% to meet demand. Crop diseases, particularly fungal and bacterial, cause substantial economic losses, and traditional methods of disease identification are slow and prone to errors. These diseases impact plant growth and yield, leading to social, ecological, and financial consequences for agriculture. Recent research highlights the

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significant damage caused by leaf diseases, resulting in considerable monetary losses for farmers. Early disease detection is crucial for effective management. Existing literature on plant diseases predominantly focuses on their biological causes and relies on visible symptoms on leaves and plant surfaces. Early identification of disorders is an essential first step in managing plant health effectively [1]. Traditionally, disease detection is performed by human specialists who visually identify diseases. However, this approach poses challenges, including limited scalability and the potential for human error, which can compromise accuracy and efficiency.

Computer vision and deep learning advancements, particularly Convolutional Neural Networks (CNNs), offer promising solutions [2]. CNNs can analyze leaf images to detect and classify plant diseases with an accuracy of 86%. This technology enables timely intervention, reduces reliance on human expertise, and effectively provides a scalable solution for managing agricultural diseases.

Objectives

The study aims to develop an efficient system for identifying plant diseases and recommending fertilizers; create a streamlined platform that provides accurate disease identification and fertilizer recommendations to optimize plant health; utilize CNNs for real-time disease detection and fertilizer suggestions; implement Convolutional Neural Networks (CNNs) to analyze leaf images in real-time, enabling quick disease detection and precise fertilizer recommendations; create a decision tree linking diseases to fertilizers based on plant needs, soil type, and climate; develop a decision tree that integrates plant species, soil conditions, and climate to tailor fertilizer suggestions for specific diseases; evaluate the system's performance against conventional methods to enhance crop yield and reduce losses; compare the CNN-based system with traditional methods to show improvements in crop yield and reduced losses due to diseases.

This study also aims to minimize crop loss due to diseases and save time and resources for farmers; offer a solution that reduces the time and resources needed for disease management, minimizes crop loss, and supports efficient farming practices. Convolution Neural Networks (CNNs): CNNs are deep learning models that learn features from images through convolution, pooling, and fully connected layers, mimicking human brain function. This allows CNNs to achieve high accuracy and low error rates in image-based tasks, making them ideal for plant disease detection and recommendation systems [3].

SYSTEM DESIGN BLOCK DIAGRAM

CNN Based System

The proposed system uses a Convolutional Neural Network (CNN) to detect plant diseases and recommend fertilizers, as shown in Fig. (**1**). Images of plant leaves are captured, preprocessed to enhance quality, and analyzed by a CNN, which has been trained on a large dataset of labeled images to classify diseases accurately. Once a disease is detected, the system suggests the appropriate fertilizer [4]. The user interface displays the captured images, diagnosis, and recommendations, as shown in Figs. (**2** and **3**). This method, achieving 88.8% accuracy across 12 disease classes, offers an efficient and accurate solution for improving crop yield through targeted disease detection and fertilizer advice.

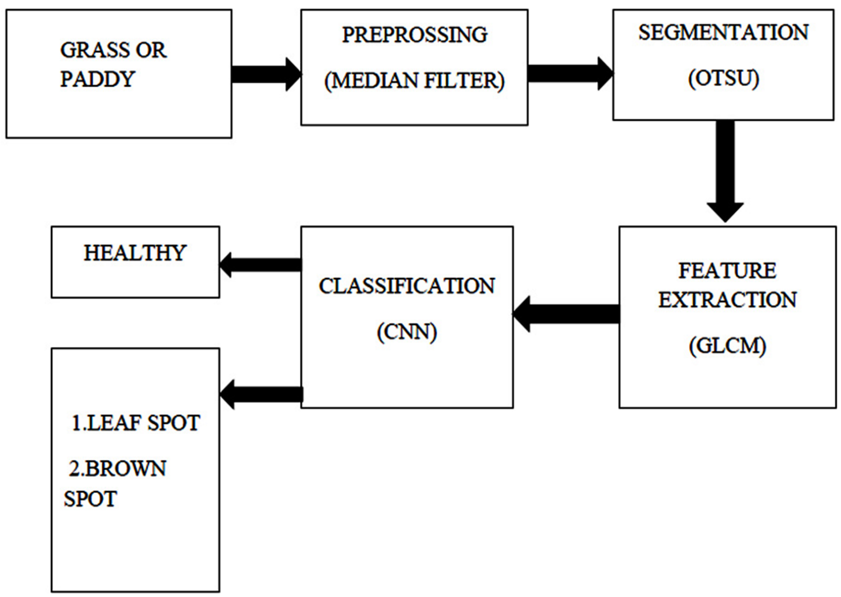

Fig. (1). System design.

CNN Model Layers

1. **Conv Layer 1**: 32 filters (3x3), ReLU.
2. **Conv Layer 2**: 64 filters (3x3), ReLU.
3. **Max Pooling**: 2x2, stride 2.
4. **Conv Layer 3**: 128 filters (3x3), ReLU.
5. **Max Pooling**: 2x2, stride 2.
6. **Conv Layer 4**: 256 filters (3x3), ReLU.
7. **Max Pooling**: 2x2, stride 2.
8. **Flatten**: Converts to 1D vector.

CHAPTER 7

Fast Terminal Sliding Mode Controllers (FTSMC) Based on MPPT for Photovoltaic Modules

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Abstract: This chapter compares two MPPT algorithms—Conservative MPP and Fast Terminal Sliding Mode Controllers (FTSM)—under consistent partial shading conditions. Methods include Artificial Neural Networks (ANNs), Fuzzy Logic (FL), and FTSM MPPT. FTSM algorithms may be applied in partly shadowed situations on a global MPP. This study proposes an FTSM technique that, when employed, establishes the efficient FTSM controller settings such that the global maximum PV device, power point, is monitored while partly shaded. It is designed in MATLAB for dynamically changing shadow patterns, as evidenced in its setup and test performance. ANN, (FL), and FTSM are compared in the findings. A less accurate method for measuring the global MPP has been found. The following strategies are compared in a solar array under partial shade situations. Nonlinear experimental effects justify the model's control strategy and stability analysis.

Keywords: FTSMC, Interleaved boost converter, Microprocessor, Maximum power point tracking, Photovoltaic.

INTRODUCTION

This method addresses both steady-state and dynamic parameters such as temperature and solar irradiance. It aims to provide a low-cost and accurate MPPT technique to enhance the overall performance of solar PV installations. Incremental Conductance (IC) control improves upon the traditional Perturb and Observe (P&O) method [1, 2]. A direct-control fuzzy logic IC controller has been proposed to overcome the limitations of conventional control algorithms. Various MPPT techniques, including P&O, IC, Hill Climbing (HC), and Fuzzy Logic Control (FLC), are compared. Studies by Cortajarena and Chaieb *et al.* have suggested MPPT-based approaches involving methods such as SMC, SAPSO, and

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HC. Among these, P&O and IC remain widely adopted due to their simplicity and ease of implementation.

It used Variable Climate Parameters (VWP) to monitor the MPP rapidly. Compared to P&O and fuzzy control [3, 4]. FTSMC was compared to P&O and SMC by Jamal *et al.* [5]. MPPT in partial shade is a PV system issue. Application, hardware availability, cost, convergence time, precision, and system dependability affect the MPPT control approach. Hadji *et al.* Ramos-Hernanz *et al.* recommended SMC control. Comparing actual and simulated algorithm performance. Simulation findings were accurate. Fuzzy MPPT controllers [6].

In this work, a hybrid system design (FTSM) was built to determine the MPPT controller, and ANN, PSO, and FTSM were examined. PV system efficiency studies using MatLab/Simulink simulation. Standard PV array simulation with consistent sun irradiation. The PV system features two partial-shading prototypes [7, 8]. This chapter is organized as follows: The PV interface and modeling are covered in Part II. The MPPT algorithm's operation is described in Part III, and its effectiveness is shown and contrasted with alternative approaches in Part IV and conclusion in Part V.

PROPOSED SYSTEM MODELING

Fig. (**1**) of this chapter shows an imposed PV cell with a parallel resistance and an anti-parallel series-related diode. The circuit and mathematical modeling are described in [9]. Fig. (**2**) shows the modified Interleaved boost converters.

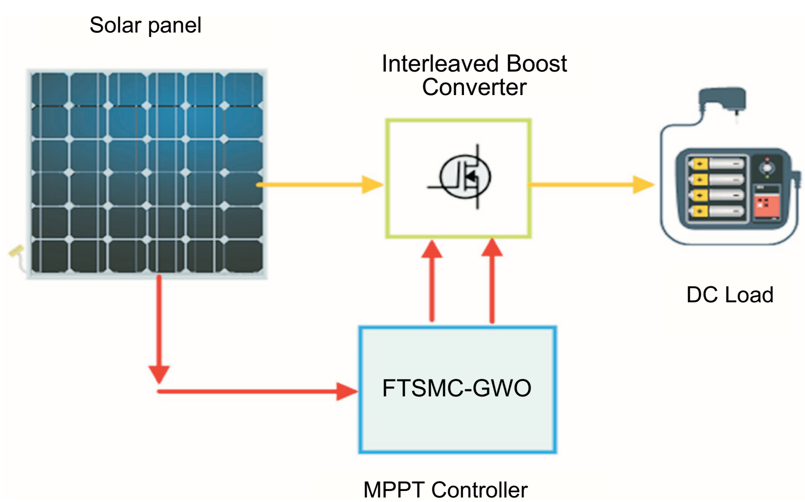

Fig. (1). General diagram of the proposed system.

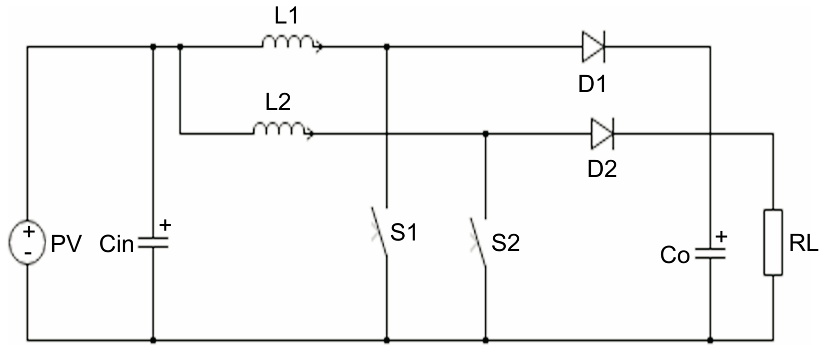

Fig. (2). Modified Interleaved boost converters.

MODIFIED INTERLEAVED BOOST CONVERTER (IBC)

Fig. (**3**) illustrates how the IBC circuit is configured to handle maximum power and optimize the solar system's performance. Interconnected step-up converters enable 180-degree binary branching, where each stage functions as a boost converter. Two switches activate the current in Inductor 2, while Diode 2, an energy-saving induction source, is deactivated. This results in output voltages exceeding input voltages. When both switches are off, the two diodes connect to the capacitor, supplying it with current. The downstream current flow depends on the source and load voltages. A transition is added to the same case loop to complete the cycle half a switch later. Due to effective switching frequency enhancement, the IBC exhibits low ripple at the input level, reducing the need for extensive output and input condenser filters [10]. Sharing current between the two arms increases system stability and minimizes power losses (I^2R). Dividing and balancing the input current between the two branches further reduces power loss (I^2R). The partitions in the converter reduce stress on both passive and active components, thereby improving the efficiency of the power conversion process [11 - 14]. However, the cost of the circuit's components increases when a boost converter is incorporated. Fig. (**4**) shows the flow of FTSMC.

PROBLEM FORMULATION

Photovoltaic (PV) cells convert sunlight into electricity within PV panels, offering a reliable solution for long-term electricity generation. The efficiency of sunlight-to-electricity conversion depends on solar exposure and the performance of the cells. Solar PV technology is utilized for various applications, including lighting, battery charging, water pumping, and powering satellites.

CHAPTER 8

Identification of Complex Problems in Social Networks using Neural Network Models with Representation Learning

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Abstract: Social network analysis is a crucial aspect of data mining, requiring the encoding of network data into low-dimensional representations called network embeddings to preserve topology structure and attribute information. This enhances applications like classification, link prediction, anomaly detection, and clustering, with deep neural network techniques gaining interest. This survey explores the current literature on network representation learning, focusing on neural network models. It introduces basic models, extends them for complex scenarios, introduces embedding techniques, discusses network representation learning applications, and suggests future research directions.

Keywords: Deep learning, Deep social network analysis, Network embedding, Representation learning, Social networks.

INTRODUCTION

Social networks like Facebook, Twitter, and LinkedIn enable global communication are allowing the analysis of user interests, patterns, and events, enhancing user engagement and understanding. Analyzing social networks can provide valuable insights for various applications, such as online advertisement targeting, personalized recommendations, viral marketing, social healthcare, social influence analysis, and academic network analysis. Social network analysis faces the challenge of extracting useful features from non-Euclidean structured networks for machine learning prediction models. This includes embedding network users into low-dimensional spaces for easy distance metrics. Previous efforts rely on handcrafted features, which can be time-consuming and expensive,

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making them ineffective for real-world applications [1]. To overcome network limitations, feature representations can be automatically learned, mapping nodes, subgraphs, or the entire network to a low-dimensional feature space. This allows machine learning models like classification, clustering, and outlier detection to be used directly for target applications. Deep learning has significantly improved performance in image recognition, text mining, and natural language processing tasks, leading to increased attention towards developing network representation methods using neural network models. This chapter provides a comprehensive overview of recent advancements in network representation learning utilizing neural network models [2]. This chapter discusses representation learning models for node embedding in homogeneous networks, categorizing them into three types: embedding look-up-based, auto-encoder-based, and graph convolution-based. The article provides an overview of various approaches for learning representations for sub-graphs in networks, which largely rely on node representation learning techniques. The text presents various applications of network representation models and discusses potential research directions for future work.

NOTATIONS AND PROBLEM DEFINITIONS

This section defines terminologies and the network representation learning problem. Matrices are denoted by boldface uppercase letters, vectors by boldface lowercase letters, and scalars by lowercase letters, with matrix entries denoted as Aij, Ai*, and A*j.

Network Analysis in G

- Defines G as a network with i-th node (vi) in V and edge (ei,j) in E.
- X and Y are node attributes and labels.
- Defines adjac;olency matrix A in R N×N.
- Aij represents the weight of ei,j, indicating connectivity.
- For undirected graphs, Aij = Aji.

A homogeneous network is a system where all nodes and edges in a given graph belong to a single type.

A heterogeneous network is a network with |Tv| + |Te| > 2, consisting of at least two types of nodes or edges.

This work focuses on network representation learning, which involves training a mapping function f to map components like nodes or subgraphs into a latent space, typically D, where D” |V|. The focus is on learning node and subgraph representation.

Node representation learning involves creating a mapping function that maps nodes with similar roles or characteristics in the latent space to ensure that nodes with similar characteristics are mapped close to each other [3].

The subgraph representation learning process aims to learn a mapping function f that satisfies z = f(g), where z ϵ R D represents the latent vector of g, by defining g as a subgraph of G with nodes and edges VS and ES, respectively.

Fig. (**1**) illustrates a toy example of network embedding with three distinct subgraphs (VS1, VS2, and VS3).

The example generates one representation for each node and each of the three subgraphs, using a network as input.

NEURAL NETWORK-BASED MODELS

Neural networks are proven to effectively capture complex data patterns, achieving significant success in computer vision, audio recognition, and natural language processing.

Recent efforts have focused on extending neural network models to learn representations from network data, categorizing them into three subgroups: look-up table-based models, autoencoder-based models, and GCN-based models based on their application type [4].

This section provides an overview of network representation learning from the encoding and decoding perspectives and discusses the details of well-known network embedding models. It focuses on representation learning for nodes, with models dealing with subgraphs introduced in later sections.

Framework Overview From the Encoder-decoder Perspective

The study suggests that different techniques can be derived from the aspect of encoding and decoding schema, as well as their target network structure constrained for a low-dimensional feature space, and can be reduced to solving an optimization problem.

$$\min_{\psi} \sum_{\phi \in \Phi_{tar}} \mathcal{L}\left(\psi_{dec}\left(\psi_{enc}(\nu_{\phi})\right), \phi \mid \Psi \right),$$

The embedding algorithm expects to preserve target relations with nodes in Vφ. The encoding function maps nodes into representation vectors, while the decoding

CHAPTER 9

Virtual Reality in Education: Enhancing Student Engagement and Learning

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Abstract: Virtual Reality (VR) technology has opened new avenues for enhancing student engagement and learning outcomes in education. The special issue of the Journal of Virtual Reality in Education brings together cutting-edge research, case studies, and expert opinions on the potential of VR to transform the educational landscape. The articles in this issue explore how VR can be leveraged to create immersive, interactive, and personalized learning experiences that cater to diverse learning styles and needs. From anatomy education to language learning, and virtual field trips to STEM education, the contributions in this issue demonstrate the versatility and effectiveness of VR in enhancing student engagement, motivation, and academic achievement. Through a mix of quantitative and qualitative research methods, the authors investigate the impact of VR on learning outcomes, student attitudes, and teacher professional development. The findings suggest that VR has the potential to increase student participation, improve knowledge retention, and foster deeper understanding and empathy. This chapters aims to provide educators, researchers, and policymakers with a comprehensive understanding of the opportunities and challenges of integrating VR into educational practice. We aim to inspire further research, experimentation, and adoption of this promising technology by showcasing the latest developments and innovations in VR-based education.

Keywords: Education, Immersive learning, Learning outcomes, Personalized learning, Student engagement, Teacher professional development, Virtual Reality.

INTRODUCTION

The landscape of education is undergoing a significant transformation, driven by the rapid advancement of technologies that are changing how we learn, teach, and interact [1]. Among these technologies, Virtual Reality (VR) has emerged as a promising tool for enhancing student engagement and learning outcomes. By

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providing immersive, interactive, and personalized experiences, VR has the potential to revolutionize the way we approach education, making it more effective, efficient, and enjoyable.

OVERVIEW OF CHALLENGES IN EDUCATION USING VR

Using Virtual Reality (VR) in education can be difficult. One of the main challenges is that VR equipment is expensive, and not many schools can afford it. Additionally, teachers must learn to use VR technology and develop new teaching methods [2]. Furthermore, not all students have access to VR technology, and schools need to make rules about using VR in education. Moreover, VR experiences can be uncomfortable for some users, and teachers must ensure that VR experiences align with what students are learning. Overall, there are many challenges to overcome before VR can be widely used in education.

MOTIVATIONS FOR VIRTUAL REALITY IN EDUCATION

Virtual Reality (VR) in education is motivated by its potential to increase student engagement, motivation, and participation. According to research, VR can provide an immersive and interactive learning experience that enhances student engagement, motivation, and problem-solving skills. Additionally, VR experiences improve learning outcomes and help students build important interpersonal skills such as empathy, collaboration, and social skills [3]. Furthermore, VR provides a rich and engaging education context that supports experiential learning as students can experience learning by doing, which raises interest and motivation. Overall, the benefits of using VR in education are numerous, and it has the potential to play a unique role in addressing educational challenges.

LITERATURE SURVEY

A comprehensive literature survey reveals that Virtual Reality (VR) has been increasingly explored in educational settings to enhance teaching and learning experiences. Research has shown that VR can improve learning outcomes, increase student engagement, and provide personalized learning experiences. Studies have also investigated the use of VR in various subjects, including Science, Technology, Engineering, and Mathematics (STEM) education, language learning, and medical education. For instance, a study [4] found that VR-based instructions improved students' learning outcomes in STEM education, particularly regarding spatial awareness and problem-solving skills. Similarly, VR-based earth science education improved students' understanding of complex geological concepts.

Furthermore, researchers have explored the potential of VR to support special people in education, such as people with autism and disabilities. For example, a study by Parsons and Mitchell [5] found that VR-based instruction improved social skills and reduced anxiety in individuals with autism. VR-based education improved learning outcomes for students with disabilities, particularly regarding accessibility and inclusivity. The literature also highlights the importance of teacher training and professional development in effectively integrating VR into educational practices. Training and support were critical factors in successfully implementing VR-based instruction. Professional development was essential for overcoming the technical and pedagogical challenges associated with VR-based education.

Moreover, the literature suggests that VR can potentially transform the education landscape, but further research is needed to fully understand its impact and address the challenges associated with its implementation. For instance, a study by Merchant *et al*. [6] found that VR-based instruction effectively improved learning outcomes but noted that further research was needed to explore the long-term effects of VR on student learning. Similarly, a study by Baydas and Gülbahar [7] found that VR-based education improved student motivation, but further research was needed to explore the impact of VR on student engagement and participation.

The literature suggests that VR can provide an immersive and interactive learning experience that enhances student engagement, motivation, and participation. For instance, VR-based education improved [8] student engagement and motivation, particularly in increasing students' interest and enthusiasm for learning. VR-based education improved students' participation, particularly in increasing students' involvement and interaction.

However, the literature also highlights the challenges associated with implementing VR in education, including technical issues, cost, and accessibility. For instance, a study by [9], found that technical issues, such as hardware and software compatibility, were significant barriers to implementing VR-based education. Similarly, a study by Kim *et al*. [10] found that cost and accessibility were significant challenges to implementing VR-based education, particularly in ensuring equal access to VR technology for all students.

EXISTING TECHNOLOGY

Head-mounted Display (HMDS)

A Head-mounted Display (HMD) is a wearable device that displays virtual content in front of the user's eyes, providing an immersive and interactive Virtual

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