ADVANCED EXPLORATIONS IN MACHINE LEARNING, COMPUTER VISION, AND IOT

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Bentham Books

Advanced Explorations in Machine Learning, Computer Vision, and IoT

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ISBN (Online): 979-8-89881-258-4

ISBN (Print): 979-8-89881-259-1

ISBN (Paperback): 979-8-89881-260-7

First published in 2026.

Bentham Science Publishers Pte. Ltd.
No. 9 Raffles Place
Office No. 26-01
Singapore 048619
Singapore
Email: subscriptions@benthamscience.net

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PREFACE

Advanced Explorations in Machine Learning, Computer Vision, and IoT is a comprehensive and forward-thinking book that focuses on cutting-edge advancements and applications within the realms of Artificial Intelligence (AI). This book is a compilation of insights, methodologies, and real-world applications from industry experts and researchers at the forefront of these fields.

The book begins by elucidating the core concepts and principles underlying deep learning, providing a nuanced understanding of neural networks, Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and their diverse applications across various domains. It delves into the theoretical foundations and practical implementations of these advanced models, illustrating their efficacy in solving complex problems in computer vision, natural language processing, and pattern recognition. Furthermore, the book delves deeply into computer vision, presenting the evolution of image processing techniques and their fusion with deep learning architectures. From object detection and recognition to image segmentation and generative models, the book offers a detailed exploration of how cutting-edge computer vision technologies are revolutionizing industries such as healthcare, automotive, surveillance, and entertainment.

In parallel, the book unfolds the significance of the Internet of Things (IoT) and its intersection with AI, elucidating how the synergy between these technologies is driving innovation in various sectors. It navigates through IoT architectures, sensor technologies, and data analytics, showcasing how machine learning algorithms and AI-driven insights leverage IoT data streams for predictive analytics, anomaly detection, and optimized operational efficiencies across smart cities, healthcare systems, and industrial automation.

Moreover, the book underscores the pivotal role of machine learning innovations as the backbone of AI systems, emphasizing diverse approaches such as reinforcement learning, unsupervised learning, and transfer learning. It showcases their applicability in personalized recommendation systems, predictive maintenance, autonomous vehicles, and adaptive learning environments. This book doesn't just confine itself to theoretical discussions; it also emphasizes practical implementation. It features case studies, research papers, and real-world examples illustrating the successful deployment of these technologies. Moreover, it highlights ethical considerations, regulatory frameworks, and the responsible use of AI technologies, addressing concerns related to data privacy, bias mitigation, and algorithmic transparency.

In essence, "Advanced Explorations in Machine Learning, Computer Vision, and IoT" serves as a comprehensive guide and reference manual for researchers, practitioners, students, and technology enthusiasts seeking to delve deeper into the forefront of AI. It serves as a roadmap for harnessing the power of AI technologies, driving innovation, and shaping a future where AI-driven solutions bring about impactful and transformative changes across industries and societies.

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CHAPTER 1

AI-Driven Gait Analysis using Wearable Assistive Devices for Personalized Healthcare

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Abstract: This chapter addresses the limitations of traditional gait analysis methods by introducing wearable assistive devices integrated with machine learning for a more sophisticated approach. The primary problem is the need for advanced and accurate gait analysis, especially in healthcare and rehabilitation. The approach involves utilizing wearable devices equipped with sensors to collect gait data and applying machine learning algorithms for analysis. The key findings showcase the effectiveness of the proposed integrated approach in providing precise insights into gait patterns. The machine learning model plays a pivotal role in enhancing the accuracy of gait analysis, allowing for more nuanced and personalized assessments. The proposed model uses the LSTM networks framework for AI-driven gait analysis. The system model is evaluated based on metrics such as joint angle time series, Gait Phase Probability Distribution, Gait Recognition for Abnormal Gait Detection, LSTM-based Gait Abnormality Detection, and LSTM-based Gait Prediction.

Keywords: Gait analysis, Healthcare, Machine learning, Rehabilitation, Wearable assistive devices.

INTRODUCTION

Gait analysis refers to the systematic study of human walking patterns, encompassing the movement of the limbs, body, and associated biomechanical aspects during locomotion. This analysis provides valuable insights into the functioning of the musculoskeletal system, helping to understand and diagnose various gait-related disorders. Gait analysis is a crucial diagnostic tool in identifying and assessing various neurological, musculoskeletal, and orthopaedic conditions [1]. It aids in detecting abnormalities in walking patterns that may indicate underlying health issues.

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Sandeep Kumar Mathivanan, Saurav Mallik, S.K.B. Sangeetha, Sudeshna Rakshit & Koustav Sarkar (Eds.)

Healthcare professionals use gait analysis to formulate personalized treatment plans for patients with conditions such as cerebral palsy, stroke, or orthopaedic injuries. It helps in tailoring interventions to address specific gait abnormalities. Gait analysis serves to monitor the progress of patients undergoing rehabilitation. It allows healthcare practitioners to track changes in gait parameters over time and adjust treatment plans accordingly [2].

Gait analysis is instrumental in orthopaedic rehabilitation after surgeries or injuries. It guides therapists in designing exercises and interventions that promote optimal gait mechanics and reduce the risk of secondary complications. Recent advancements in technology, including wearable devices and machine learning, have further enhanced the precision and accessibility of gait analysis [3]. Wearable assistive devices equipped with sensors can continuously monitor gait patterns outside the laboratory setting, offering valuable real-world data. The gait analysis is a multidisciplinary tool with significant implications for healthcare and rehabilitation. By understanding and quantifying human walking patterns, healthcare professionals can better diagnose, treat, and monitor individuals with various conditions affecting mobility. In cases of neurological disorders such as Parkinson's disease or spinal cord injuries, a gait analysis helps in understanding the impact of these conditions on walking patterns. It aids in developing targeted rehabilitation strategies to enhance mobility. Gait analysis is crucial for individuals using prosthetic limbs or orthotic devices. It ensures these devices properly fit and function, improving mobility and quality of life [4]. The problem or gap in current gait analysis methods that wearable assistive devices aim to address lies in the limitations of traditional laboratory-based assessments. Conventional gait analysis often relies on expensive and immobile equipment, such as motion capture systems, force plates, and cameras, which restrict the assessment to controlled environments like gait laboratories. This approach poses several challenges and shortcomings:

Traditionally, gait analyses are typically conducted in laboratory settings, which may not fully represent diverse and dynamic conditions in real-world scenarios. Walking patterns in everyday life can differ significantly from those observed in a controlled environment. Laboratory-based assessments only offer snapshots of a person's Gait within a limited timeframe. This may not capture the variability and nuances of Gait over an extended period or under different conditions, potentially missing relevant information about walking abnormalities [5]. Gait laboratories are not easily accessible to everyone, especially those living in remote areas or with mobility constraints. This limits the inclusivity of gait analysis, hindering its application to a broader population. The equipment used in traditional gait analysis can be intrusive and may induce changes in natural walking patterns. This can result in an altered gait, as proposed by the Hawthorne effect, which undermines the accuracy and reliability of the assessments. Conducting gait analysis in a laboratory setting requires dedicated time and resources, making it less feasible for routine monitoring and long-term assessments.

Wearable devices equipped with sensors allow for continuous, real-time monitoring of gait patterns in naturalistic settings, providing a more comprehensive understanding of an individual's walking behaviour over time, and allowing gait analysis to be performed outside the confines of a laboratory [6]. This mainly benefits individuals who cannot easily access traditional gait analysis facilities. Wearable devices are less intrusive, minimizing the impact on natural walking patterns and reducing the likelihood of the Hawthorne effect. This facilitates more accurate and ecologically valid assessments. Wearable assistive devices enable longitudinal studies by providing data over extended periods, allowing researchers and healthcare professionals to track changes in gait patterns and assess the effectiveness of interventions [7]. By addressing these limitations, wearable assistive devices contribute to a more holistic and practical approach to gait analysis, enhancing their applicability in various healthcare and rehabilitation contexts [8 - 11].

The primary goals of this chapter are to investigate and demonstrate the effectiveness of integrating machine learning into gait analysis using wearable assistive devices. The emphasis lies in leveraging machine learning techniques to enhance gait analysis's precision, efficiency, and interpretability in real-world scenarios [12 - 15]. Assess the performance and feasibility of wearable assistive devices equipped with sensors for collecting gait data in naturalistic environments. Integrate machine learning algorithms into analyzing gait data obtained from wearable devices [16]. This involves applying advanced computational techniques to extract meaningful patterns, features, and abnormalities in the gait signal. Enhance the accuracy and reliability of gait analysis by leveraging the capabilities of machine learning models [17]. This includes the ability to discern subtle variations in gait patterns that may indicate neurological, musculoskeletal, or other health-related conditions. A substantial body of literature discusses traditional methods of gait analysis using laboratory-based equipment, including motion capture systems, force plates, and electromyography. These studies emphasize the importance of understanding temporal, spatial, and kinematic parameters in evaluating gait abnormalities associated with various medical conditions [18]. Existing literature often explores the clinical applications of gait analysis in fields such as orthopaedics, neurology, and rehabilitation. Researchers highlight the diagnostic value of gait parameters in identifying and monitoring conditions like cerebral palsy, Parkinson's disease, and musculoskeletal disorders [19]. Numerous studies delve into developing and applying wearable devices for gait analysis. These devices, equipped with

CHAPTER 2

AI-Driven Transformation: Revolutionizing E-mail Marketing Through Personalization and Efficiency

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Abstract: The emergence of Artificial Intelligence (AI) sparked a fundamental shift in the communications industry since e-mail marketing is now conducted with greater efficiency, personalisation, and data-driven decision-making. The following chapter examines several applications of AI in e-mail marketing and shows how it transforms several crucial procedures, including performance analysis, content production, segmentation, and time optimisation. AI-driven segmentation algorithms enable marketers to precisely target audience segments based on nuanced criteria, allowing for more tailored and relevant messaging that resonates with individual recipients. Furthermore, AI-powered content creation tools facilitate the generation of dynamic and engaging e-mails, leveraging data insights to craft compelling narratives and visuals that capture the attention of recipients. AI algorithms that examine recipient behaviour patterns to forecast the optimal times to send e-mails to maximise open and click-through rates significantly improve the crucial timing optimisation component. Because AI-driven technologies facilitate performance analysis, marketers can easily extract meaningful insights from large datasets, allowing them to track campaign efficacy, areas for improvement, and optimisation in real-time. Businesses may greatly increase consumer engagement and return on investment by utilising these AI-driven tools and strategies. Since transparency, privacy, and fairness are the most emphasized factors in AI, it is also crucial to observe where the paper exposes ethical concerns or issues related to AI e-mail marketing. This gives businesses a competitive edge in today's digital marketplace. The study anticipates future developments and trends in the industry, imagining a world in which Artificial Intelligence (AI) continues to reshape and reinvent e-mail marketing strategies, promoting more efficacy, efficiency, and personalisation while maintaining moral principles and customer confidence.

Keywords: Artificial Intelligence (AI), Data-driven decision-making, E-mail marketing, Efficiency, Personalization, Segmentation.

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INTRODUCTION

One of the earliest pillars of digital marketing is e-mail marketing, which has advanced from bulk mailings to smart, targeted, and accurate e-mail campaigns. AI's incorporation into e-mail marketing further revolutionised the field by enabling unprecedented levels of efficacy, efficiency, and personalisation. This section provides a brief overview of e-mail marketing's history and the role Artificial Intelligence (AI) plays in contemporary marketing operations.

E-mail marketing has undergone significant transformations since its inception in the late 20th century. Initially, it began as a simple tool for sending out mass messages to a broad audience, without much personalization or segmentation. This strategy has evolved over time, mostly as a result of the widespread use of technology and the rising need for a more efficient and focused communication method. The 1990s saw the introduction of HTML e-mails, which allowed for richer and more interactive e-mail content, increasing the medium's effectiveness. As the internet expanded and customer expectations evolved, e-mail marketing tactics matured, emphasising meaning and interaction above volume. The evolution from mass e-mailing to targeted campaigns marks a significant shift in e-mail marketing strategies. In the early days, marketers relied heavily on bulk e-mailing techniques, often flooding inboxes with generic messages that had little relevance to individual recipients. This approach led to high unsubscribe rates and a general disdain for e-mail marketing. However, with advancements in data analytics and Customer Relationship Management (CRM) systems, marketers began to see the value in segmentation and personalization. By segmenting audiences based on demographics, behaviour, and preferences, marketers may focus their message on a specific target audience and help the audience understand it. This led to an increase in open and click-through rates as well as increased consumer engagement and loyalty for the marketer. The foundation of digital marketing today is targeted e-mail campaigns, which use extremely complex data and algorithms to make sure the correct message reaches the right person at the right time [1, 2].

AI is revolutionising the field of marketing. Marketing agencies have access to innovative means for achieving efficiency and creativity thanks to AI. Predictive analytics, machine learning, and natural language processing are examples of AI technologies that can process enormous amounts of data at extremely high speeds. AI offers marketers the opportunity to automate tedious activities, provide personal experiences on an unprecedented scale, and obtain more profound insights into customer behaviour. AI-based content creation, programmatic ad buying, chatbots that offer real-time customer support, and other technologies are transforming the way marketers interact with their target audience. Such targeting and forecasting skills assist in guaranteeing that marketing initiatives will be successful while remaining efficient in the face of enormous data sets. Artificial Intelligence (AI) encompasses a wide range of tools and techniques that simulate human intelligence to enhance decision-making processes. Artificial intelligence comprises several essential components. These include Natural Language Processing (NLP), which facilitates human language comprehension and production; Computer Vision (CV), which enables machines to perceive and decide based on visual data; and Machine Learning (ML), which allows systems to learn and evolve autonomously. Furthermore, statistical algorithms and machine learning approaches that provide the likelihood of specific events based on past data are used in predictive analytics. To spur innovation and improve operational effectiveness, these technologies are being incorporated into a wider range of businesses. They are important in marketing because they help with task automation, customer data analysis, and highly customised customer experiences [3].

Fig. (**1**) shows both the AI-enhanced workflow and the conventional e-mail marketing procedure. It highlights the main ways that artificial intelligence enhances timing optimisation, content production, performance analysis, and segmentation. This will provide a graphic explanation of how conventional procedures give way to AI-powered strategies. AI's incorporation into digital marketing is completely changing how companies interact with their target markets. With AI-driven tools and platforms, marketers can use large data to enable more precise targeting and individualised content distribution. Marketers can utilise predictive analytics to forecast customer behaviour and demand. AI-driven chatbots and virtual assistants can enhance real-time customer assistance. Additionally, real-time budget and ad placement optimisation is achieved using machine learning algorithms. By ensuring that the correct message reaches the right audience at the right moment, this integration not only increases the efficiency of marketing initiatives but also maximises their efficacy. Digital marketing will have an even more expansive future thanks to AI, which will also continue to offer the most sophisticated tools for engaging customers and increasing business growth [4, 5].

AI-DRIVEN SEGMENTATION

Traditional segmentation methods, based on basic demographics, have given way to more advanced AI-driven techniques that leverage machine learning and predictive analytics to create highly nuanced customer profiles. This section discusses how AI enhances segmentation, improving targeting accuracy and personalization, and ultimately boosting engagement rates.

CHAPTER 3

An Ensembled Hybrid Machine Learning Approach (EHMLA) for Enhanced Disease Diagnosis

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Abstract: Prognosing the earliest manifestation of various diseases, including Breast cancer, Lung cancer, Chronic Kidney Disease, and Cervical cancer, *etc*., is a requirement for well-timed diagnosis, therapy, and medication, as this situation is a substantial cause of demise worldwide. Machine Learning (ML), due to its vast applications in the healthcare arena, aids doctors who are already aware that those at risk of developing the diseases mentioned earlier can provide early prognosis and treatment with suitable medication suited to the patients. In this study, we introduce an Ensemble Hybrid Machine Learning Approach (EHMLA) for enhanced disease diagnosis, based on an experimental two-stage survey for various diseases. In the first stage, we have integrated feature selection techniques such as Sequential Feature Selection and Recursive Feature Elimination with the ten conventional ML classifiers. In the next stage, we applied the ensemble approaches, including weighted averaging, soft voting, and hard voting, to enhance the model's efficacy. From the experiments, it can be concluded that achieving enhanced accuracies of 98.25%, 96.77%, 93.33%, and 98.75% in the case of Breast cancer, Lung cancer, Chronic Kidney, and Cervical cancer Disease, respectively. The proposed ensembled hybrid approach employs various performance measures along with AUC that show the fruitfulness and productivity of the intended study in diagnosing the disease.

Keywords: Disease diagnosis, Ensemble learning, Feature selection techniques, Recursive feature elimination, Sequential feature selection.

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INTRODUCTION

Human life is fraught with uncertainties and challenges due to the inherent difficulty in forecasting the emergence of crises. Cancer comprises a collection of disorders characterized by the atypical proliferation of cells that may disseminate throughout the body. Indicators of the symptoms include atypical bleeding, persistent cough, alterations in bowel habits, masses, and unexplained weight loss. The predominant cancer types observed in women are colorectal, cervical, breast, and lung cancers, accounting for fifty percent of cancer cases. The second leading cause of mortality globally is cancer, with around 9.6 million deaths recorded in 2018 [1, 2]. The mortality rate of breast cancer, which has decreased over the past seventy years, has facilitated advancements in management strategies, ranging from early disease intervention to therapeutic approaches. Despite a lowering mortality rate, breast cancer remains the most significant cause of death among females globally. The paramount challenge in medical research or bioinformatics is accurately diagnosing specific, dominant information. In the field of medicine, diagnosing disease is a complex and dynamic task. Medical diagnostic data is accessible at diagnostic centers, research institutions, hospitals, and online platforms. Notwithstanding significant advancements in patient care and screening procedures, breast cancer remains the second highest cause of diagnosed mortality [3 - 6]. Lung cancer is the primary cause of cancer-related mortality. The proliferation of malignant cells in the lungs is referred to as lung cancer. The onset of lung cancer transpires in the lungs, the primary bronchus, and the trachea. Individuals with pulmonary conditions, including prior thoracic ailments and emphysema, have an increased likelihood of receiving a lung cancer diagnosis. The excessive intake of beedis, tobacco, and cigarettes is the primary risk factor for lung cancer among males in India; however, in women, smoking is less prevalent, indicating that alternative variables contribute to lung cancer. The rise in death rates for both genders is attributable to the heightened prevalence of cancer. The risk of lung cancer can be mitigated but not eliminated. Early identification of lung cancer is crucial for the survival of the affected individual. The incidence of lung cancer is directly proportional to the prevalence of chain smokers. Early-stage cancer refers to a tiny tumor localized in the lungs, but advanced-stage cancer indicates metastasis to adjacent tissues or other body regions. The first update about lung cancer patients is the enhanced accessibility of blood-based screening. Research has demonstrated an enhancement in the survival rate of lung cancer patients attributable to early diagnosis [7].

Women typically encounter several challenges during their lives. Cervical cancer is one of the primary critical ailments they may encounter. The World Health Organization (WHO) categorizes cancer cells as general, as they encompass a vast array of disorders that can affect every organ in the body. In certain instances, it may result in patient loss. Timely intervention and diagnosis of cancer can decrease the death rate associated with the condition. The primary cause of mortality globally is cancer. A 2015 survey indicated that cancer-related fatalities amounted to 8.8 million. Cervical cancer is one of the numerous kinds of cancer and a leading cause of mortality in low-income nations. Cervical cancer is a malignancy that originates in the cervix. It is the most lethal period. Cervical cancer is the predominant cause of mortality among females, surpassing other genital cancers. Its etiology is influenced by several factors, including immunodeficiency, prolonged contraceptive use, tobacco consumption, inadequate nutritional status, vitamin A deficiency, multiple sexual partners (such as a history of numerous marriages), and early childbirth. Globally, around 57,000 new instances of cervical cancer are discovered each year, with 80% originating from poor nations. The mortality rate of women due to cervical cancer is 77%. The onset of cervical cancer occurs when an HPV (Human Papillomavirus) infection of the cervix remains untreated [8]. The progression of kidney disease is gradual and asymptomatic. Numerous renal diseases exist, with Chronic Kidney Disease (CKD) being one of them. Chronic Kidney Disease (CKD) refers to kidney function impairment resulting in inadequate blood filtration. The kidneys are essential for filtering excess water and waste from the blood to generate urine; accumulation of waste in the body leads to Chronic Kidney Disease (CKD). The condition is termed chronic because of its slow and prolonged harm to the body. It is referred to as a silent killer due to the absence of physical signs in its initial stages. In its first stages, Chronic Kidney Disease (CKD) presents no conspicuous symptoms, leading to a lack of disease recognition among patients, which has made it a global concern. Currently, Chronic Kidney Disease (CKD), which is often detected late, has emerged as a significant contributor to death rates in the healthcare industry. Due to inadequate treatment and insufficient annual screening, a significant number of women and men are currently experiencing adverse health outcomes. Nevertheless, patients' lives can be preserved with prompt disease identification at an early stage [9, 10].

Data mining is the process of extracting and identifying patterns in large datasets, encompassing the fields of statistics, machine learning, and database systems. Data mining is an interdisciplinary field that combines statistics and science, aimed at collecting information from a dataset and converting it into a user-friendly format for future use. The analysis phase of data mining involves the process of extracting knowledge from databases. In addition to the raw analysis phase, it encompasses database administration and data handling, including data preprocessing, inference, and model evaluation, relevant metrics, complexity considerations, structural discovery during preprocessing, online updates, and visualization. The primary distinction between data mining and data analysis is that data analysis is employed for modeling tests and hypotheses concerning the

CHAPTER 4

IoT-Based Smart Farming for Sustainable Environment

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Abstract: Agriculture is the prime focus of any developing nation for its self-sustainability. However, most nations are finding it difficult to promote farming activities. One possible reason for this is the lack of automated tools for high-yielding cultivation methods based on local geographical features. This chapter proposes intelligent farming systems with automated watering and fertilizing based on soil and weather analytics. These models employ a time-series prediction technique that incorporates factors influencing agricultural production, including rainfall, temperature, soil moisture, soil fertility, and relative humidity, for real-time monitoring and informed decision-making regarding irrigation and fertilization. To ensure sustainability and enhance reliability, solar power is also used as a secondary power source. Based on the type of land and the cultivated crop details, the software sends updates to the farmer's mobile app. The update may include information such as when to water the crops, what fertilizer or pesticide to apply, *etc.* Thus, these systems significantly enhance automated farming by leveraging IoT and ML techniques.

Keywords: Machine learning (ML), Soil analytics, Smart farming, Internet of things (IoT), Weather prediction.

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INTRODUCTION

Farming is the main source of food production. There are over 50,000 edible crop varieties that humans have cultivated throughout history. According to the Food and Agriculture Organization (FAO) of the United Nations, there are around 100-200 types of crops that are more cultivated than others [1]. It requires complete knowledge of farmland, including the quality and quantity of water, soil fertilization, and other relevant factors.

Farming has many stages, which include planning and understanding which crop is to be planted, planting the selected crop's seeds, fertilizing the farmland, and continuously monitoring the growth and fertility of the soil until harvest. After all this hard work, there may be a chance of poor crop yield due to improper irrigation or fertilization of the crops. This puts a dent in the farmer's financial projections, resulting in a capital loss. Hence, this chapter proposes a system that automates farmland irrigation and fertilization for improved productivity.

The Internet of Things (IoT) is a technology that enables automation and robotics. IoT has three parts, which are sensors, controllers, and actuators. Sensors collect real-time data, such as humidity, temperature, and atmospheric pressure. The controller unit processes sensor data and initiates the actuators. The connection to the internet from the controller makes it remotely configurable.

Edge computing is a technology that focuses on data processing and analysis near the source of the data. This approach utilizes real-time processing, resulting in enhanced efficiency and reduced latency. Even in areas with unreliable network access, edge computing can create stronger systems by computing the data at the source end.

The proposed system for intelligent farming ensures automation by utilizing the Internet of Things (IoT) to collect data from sensors on soil moisture, atmospheric pressure, and other relevant parameters, and process them on-site. The pH sensor collects data regarding nitrogen, potassium, and phosphorus. It uses Edge computing for weather prediction by using nearby servers to compute the data and the central server to aggregate the data. Machine learning enhances the accuracy of weather forecasting by identifying patterns in the collected historical datasets. The Machine Learning algorithm used here is Random Forest, which uses multiple decision trees. Each tree is made by analyzing the data from a random subset, which makes the weather predictions more accurate. Based on the forecasted live weather data, automatic irrigation can be done. Solar power is used as the backup power source. Therefore, the system can also operate in remote areas. Since solar cells are used as a backup power supply, the system is highly sustainable.

The following are some of the objectives of a smart farming system.

- To develop an automated irrigation and fertilizing system.
- To use soil and weather analytics to make decisions based on real-time data.
- To develop a mobile application for sending alerts to farmers.
- To remotely monitor the temperature and humidity of the soil for irrigation.
- To optimize resource utilization, reduce waste, and improve crop yield.
- To promote sustainable farming practices.

The proposed precision farming system provides an efficient way to cultivate healthy crops, promising high yields. It will monitor the temperature, humidity, moisture, air pressure, and pH level of the surrounding soil. This is enabled by IoT technology for automating farmland and utilizes ML for weather prediction. It will make the system more efficient by supplementing an optimum amount of water and fertilizer. The prediction of the weather will help farmers to monitor and maintain their crops in real-time.

EXISTING SMART FARMING SYSTEMS

We have conducted a study on various smart farming systems. Some impressive smart farming models in the field of weather forecasting and computer-aided smart farming techniques are summarized below.

Bendre *et al.* introduced a Weather forecasting system targeting agricultural applications using Big Data analytics and ML models [2]. They used the concept of Hadoop's MapReduce functionality to perform data analysis and apply linear regression for data prediction. They collected the daily maximum and minimum temperature, humidity, and rainfall data from Krishi Vidyapeeth Rahuri (KVR), Ahmednagar, India. This consists of data collected by the KVR rain gauge from January 1, 2003, to December 31, 2013. MapReduce functions are used because the data does not fit in memory. The linear regression model was trained using the results of the data analysis, implemented through the MapReduce programming technique. The model was trained using historical rainfall data and historical temperature data. The trained model accurately predicted the temperature and rainfall for the year 2013. The advantage of this system is that it increases the accuracy of weather predictions by using data generated on-site, thereby enhancing the granular accuracy of the predictions. However, a wide network of sensing equipment is required for the accurate working of the predictive model.

Sneha S. Gumaste and Kadam proposed a system that predicts future weather data, utilizing the GA (Genetic Algorithm) and FFT (Fast Fourier Transform) [3]. The proposed system works on the continuous data collected by the farmer's

CHAPTER 5

Blockchain-Enabled Metaverse Platforms for Extended Reality (XR) Applications

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Abstract: The convergence of the real world with virtual and augmented reality, known as the "Metaverse," is gaining momentum, threatening to upend multiple global industries. It's undeniable that people are incredibly interested in the Metaverse. Although Blockchain is still in its infancy, it is already vital to the growth of the digital economy. The blockchain technology that underpins cryptocurrencies and NFTs (Non-Fungible Tokens) is useful for tracking the supply and circulation of digital currencies and for governance, transparency, ease of access, and interoperability purposes. Given its infinite potential, the Metaverse has ushered in a period of rapid expansion across many of the economy's most important industries, real estate included.

Metaverse platforms were being set up by people with sway in the blockchain or cryptocurrency industries so that they could acquire virtual real estate as NFTs, develop it, and stake it. Metaverse marketplaces create a virtual space using VR, Blockchain, and NFT technology, then sell access to that space to consumers in the form of NFTs. Even though many Metaverse services offer free accounts, cryptocurrency is required when buying or trading virtual assets on platforms that use the Blockchain. To buy and sell virtual assets on several blockchain-based platforms, such as Decentraland's MANA and Sandbox's SAND, Ethereum-based crypto tokens are required.

Non-fungible tokens and cryptocurrencies are used by various blockchain-based platforms today, facilitating the development, acquisition, and monetization of distributed digital assets. As centralized data storage has many drawbacks, the Metaverse concept lacks Blockchain. Blockchain's global reach and decentralized nature as a digital source fundamentally set the Metaverse apart from the capabilities of the classic internet, which, of course, takes the form of websites and applications. Without needing a trusted third party or governing body, the blockchain-based Metaverse makes all internet data accessible. This chapter mainly focuses on blockchain-enabled Metaverse platforms, which are still developing augmented and virtual reality tools to enable user interaction with the environment.

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Keywords: Decentraland's MANA, Extended reality application, Metaverse, NFTs (Non-Fungible Tokens), Sandbox's SAND.

INTRODUCTION

Snow Crash, Neal Stephenson's speculative fiction novel from 1992, is where the idea of a “Metaverse” first appeared. The word “Metaverse” is a mash-up of the Greek prefix “meta” (which means “beyond”) and the English word “verse” (abbreviation of the universe). Since 2021, when people's hopes for creating a perfect virtual society based on strong bonds between people were reignited, Metaverse has risen rapidly in popularity. As a result, major corporations began investing in creating Metaverse software like Meta Horizon Workroom [1].

What is a Metaverse Platform?

A Metaverse platform is a computer-based simulated reality environment that allows users to interact with each other and virtual objects in a three-dimensional space. Metaverse platforms are often used for gaming or social networking purposes and educational or business applications. NFTs and other blockchain-linked tokens are essential components of DAOs, often marketed as a route to the Metaverse.

The Benefits of Metaverse Technologies

- More people can invest since the threshold for doing so has been lowered for using financial products and services.
- As people's incomes drop owing to inflation and the pandemic, this strategy can help them make ends meet by capitalizing on their skills and hobbies (such as video games) [2].
- They reduce wasteful steps and save money on routine tasks like wire transfers by avoiding unnecessary intermediaries.
- Pique the interest of many people who aren't normally involved in the financial industry while ushering in fresh perspectives and possibilities.
- Through coordinated efforts, we aim to increase community involvement and interaction.

A Brief History of Blockchain

In 2008, Satoshi Nakamoto published a white paper titled “Bitcoin: A Peer-to-Peer Electronic Cash System”, which described a new kind of money and payment system that did not require trusting third parties. This history was the birth of Blockchain.

People could send and receive money without going through a bank or other financial institution for the first time in history. Blockchain allows for trustless transactions between parties. Since then, Blockchain has been adopted by many industries and is now used to create new kinds of applications beyond just payments. These include things like smart contracts, decentralized applications, and more. Despite its relatively short history, Blockchain has already had a major impact on the world and is only expected to grow in popularity in the years to come.

In What Ways does the Metaverse Fit in with Blockchain Technology?

Blockchain technology is maturing, and many businesses are dabbling in developing their internal blockchain networks. An example of such a group is Metaverse. The mission of Metaverse is to deliver a blockchain platform that is accessible, scalable, and safe. It also emphasizes the creation of digital assets and smart contracts.

Digital assets with value can be anything, and the Metaverse Digital Asset System makes it possible for users to build and distribute their own. Smart contracts are Metaverse blockchain applications that automate the transfer of digital assets.

A cryptocurrency is a great option for the Metaverse since it can create a digital economy based on a wide variety of utility tokens and NFTs. Access a wide variety of virtual goods, like real estate, businesses, apparel, artwork, and more, through NFTs. Cybercriminals will not be able to steal or hack into your data because of the NFT.

Users can make money without playing by investing in and trading irreplaceable tokens. Designing a VR environment that closely mimics our own but with added features is feasible. However, this is contingent on the widespread adoption of a cryptocurrency that can be used with a metauniverse blockchain to ensure the integrity of the data stored on the Blockchain [2]. The technical aspect of Blockchain in the Metaverse is shown in Fig. (**1**).

Blockchain-Enabled Metaverse Platforms for Extended Applications (XR)

"Blockchain-Enabled Metaverse platforms" refers to online virtual world platforms that use blockchain technology to store data and enable transactions. These platforms provide a shared, decentralized space for users to interact with each other and create content. One popular blockchain-enabled Metaverse platform is **Decentraland**, which uses the Ethereum blockchain to track ownership of virtual land parcels and facilitate user transactions. Decentraland features a 3D virtual world divided into zones, each with its own theme or

CHAPTER 6

Unleashing the Power of Smart City Solutions for Urban Transformation

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Abstract: In the face of rapid urbanization, this study explores the transformative potential of smart city solutions with the goal of promoting effective and sustainable urban settings. Globally, major cities suffer a variety of complex issues, including a lack of resources, deteriorating environmental conditions, heavy traffic, and unequal access to essential services. Emerging technologies, however, present viable ways to address these problems and promote inclusive and thoughtful urban environments. The research explores the foundational components of smart cities, including big data analytics, Artificial Intelligence (AI), Internet of Things (IoT), and renewable energy systems. It elucidates how these technologies synergize to optimize urban services such as waste management, public safety, energy conservation, and transportation networks. Highlighting the imperative of stakeholder collaboration and citizen involvement, the study underscores their pivotal roles in the planning and execution of smart city initiatives. Real-world case studies from various global contexts underscore the tangible benefits of integrating intelligent solutions into urban governance and development frameworks. Moreover, the study meticulously examines the ethical, security, and privacy ramifications inherent in smart city development, advocating for responsible deployment strategies. Targeting technologists, policymakers, urban planners, and engaged citizens, this analysis serves as a comprehensive guide for leveraging smart city solutions to forge resilient, equitable, and sustainable urban futures. It seamlessly integrates theoretical insights with practical applications, offering invaluable resources for those seeking to navigate the complexities of urban development in the digital age.

Keywords: Artificial intelligence, Blockchain, Internet of things, Smart City.

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INTRODUCTION

A smart city is a metropolitan region that uses sensors and a variety of electrical devices to gather data. In return, such data is electronically employed to enhance citywide operations. The insights extracted from that data are utilized to effectively manage assets, resources, and services. In order to monitor and manage traffic and transportation systems, power plants, water supply networks, waste management, law enforcement, information systems, schools, libraries, hospitals, and other community services, data that is gathered from residents, devices, and assets is processed and analysed [1].

Why is a Smart City needed?

Smart Cities are needed because urbanisation is happening so fast and with it come numerous issues. As cities grow in size, the existing resources, infrastructure and public services are being stretched further and further. It's becoming apparent that current city management systems just can't meet the complex demands of modern urban living. Smart Cities provide a viable solution by utilising technology to enhance the quality and performance of urban services [2]. Smart traffic management systems, for example, can cut down on congestion within a smart city by monitoring traffic flow in real time and reacting to changes quickly and efficiently. They can also manage waste much more effectively through the use of advanced waste management systems that increase recycling levels and optimise collection schedules.

Furthermore, energy use reduction and a concurrent decrease in the associated emissions, thanks to smart grids and green, sustainable and reliable electricity from renewable sources, are other positive contributions of smart cities. Response times for emergency response systems as well as surveillance cameras can be improved, resulting in enhanced safety and security. Smart Cities drive economic growth by providing an environment that is conducive to innovation and attracts capital, besides raising the efficiency of infrastructure and with services [3]. They provide the necessary infrastructure to ensure that residents have access to opportunities, while businesses flourish. In short, smart cities are crucial if we want to ensure that our cities, despite the challenges posed by growing urbanisation, remain robust, liveable places to inhabit. They represent the future of city living – where people's ingenuity combines with the know-how of machines, making a city more intelligent, more efficient and enjoyable.

COMPONENTS OF A SMART CITY

Infrastructure: Road, Building, Public Spaces

The base of any smart city is its infrastructure. This implies the actual infrastructural formations that are implemented and maintained with the use of intelligently directed aids: the roads, buildings, and other communal areas. To monitor the flow of traffic, climate, and necessary repair works, intelligent roads are equipped with sensors and IoT gadgets. These highways may well connect with other automobiles that are linked so as to reduce traffic and congestion [4]. Conducting business in smart cities, buildings are often characterized by energy efficiency and ecological nature, often with smart lighting, heating, and security systems. Blinds, a Wi-Fi network, and CCTV are introduced to the space in order to create the feeling of protection and coziness among people. Smart infrastructure's goal is to generate a new, efficient and successful urban environment that significantly improves the quality of life for all people.

Information and Communication Technology (ICT)

Information and communication technology (ICT) is the ultimate foundation on which the smart city concept is based. ICT refers to the information technology that is used by various establishments operating in a city for data gathering, processing, as well as information sharing across the city's various departments. This relates to cloud computing facilities, data centres and fast broadband. ICT may also help to integrate some services and processes in smart cities and the resultant may be the enhancement of their sensitivity to service or process change. For instance, real-time information is processed by ITS units to optimize traffic signalization and reduce traffic jams [4]. Online availability of services makes e-governance effective in increasing the transparency level and reducing bureaucratic procedures for the public. That is why ICT also helps in the field of emergency response and various surveillance systems. In general, ICT plays the role of the foundation and integration of all elements for the efficient functioning of the smart city [5].

Smart Energy: Renewable Energy, Smart Grids

Smart Energy, which includes efficient usage of energy resources, also forms part of smart cities. This includes integrating hydro-electric, solar and wind energy technologies amongst others into the energy sector of the city. Smart grids are advanced utility systems that follow and manage the generation, distribution, and consumption of electricity with the help of digital communications. An overview of the dynamics of energy consumption by these networks in real time reduces wastage while also increasing reliability [2]. Smart meters are installed in homes

CHAPTER 7

Mechatronic Systems in Smart Agriculture: Potentials and Challenges

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Abstract: With the global population set to reach 10 billion by 2050, smart agriculture must ensure consistent input application despite variable field conditions. Climate change and environmental issues exacerbate productivity challenges, complicating agricultural expansion. To address these challenges, automation, IoT, and AI are essential. Digital technology now enables the real-time monitoring and control of farm operations, with autonomous mechatronic systems handling tasks such as thinning, pruning, harvesting, planting, spraying, mowing, and weeding. These systems enhance efficiency in various applications, including grain drying, irrigation, tractor operations, food processing, environmental management, and aquaculture. By reducing human intervention and minimizing environmental errors, mechatronics significantly enhances productivity. This chapter examines the methods, recent technological innovations, applications, and challenges of mechatronic systems in smart agriculture. Besides it provides comparative results of different autonomous farm machinery in agriculture.

Keywords: Artificial intelligence, Autonomous farm, Agriculture, Internet of things, Mechatronics systems, Machinery.

INTRODUCTION

The Food and Agriculture Organization (FAO) estimates that 821 million people worldwide are affected by hunger due to a global food supply shortage. The 2023 Global Hunger Index highlights that extreme famine remains a critical issue in several African countries, including Ethiopia, Kenya, Sudan, Somalia, Nigeria, and Mali. According to the Food and Agriculture Organization, around 821 million people. The main root cause is the low agricultural productivity in most

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countries due to a lack of appropriate machinery for agricultural fields. Many European countries use machines and semi-automated systems to boost production. To develop the range of production in the future, developing countries need advanced, fully automated mechatronic systems. These technologies reduce the human labor involved in farming, with less time spent on ground operations and increased efficiency in post-harvesting as a whole. Smart mechatronics systems are considered very important for society to meet agricultural demands [1 - 7].

The introduction of automation and robotics has made manufacturing and product handling in industries more cost-effective and efficient. In agriculture and agricultural processing, technologies such as precision farming, smart irrigation, biotechnology, automation, and other advanced mechatronics systems are being used to enhance the efficiency, sustainability, and productivity of food production. Significant technological innovations have also occurred in areas such as modern greenhouse production, blockchain, artificial intelligence, indoor vertical farming, and livestock management. Examples of advancements in agriculture include self-guiding harvesters and tractors. Recent years have seen improvements in the agricultural sector, including the introduction of self-guided harvesters and tractors. Robotic platforms help workers in the agricultural field production industry by reducing human error, crop damage, and problems associated with mechatronics, which can boost productivity and yield. Although the best outcomes are achieved using conventional control system modules.

Many researchers have recommended that mechatronics modules are not suitable for high performance and can lead to unnecessary settings, a short attention span, increased multitasking, privacy invasion risk, limited learning, dependence, and a higher time commitment. Due to their limited use of mechatronics system technologies in agriculture in developing countries, such systems can raise production rates and lower poverty. The ultimate aim is to raise awareness among farmers about the use of mechatronics systems in agriculture and irrigation. The agricultural industry is growing rapidly to meet global demand for food transparency in food supply chains, driven by consumer expectations. Advanced mechatronics systems are significantly enhanced and utilized for complex methods. Precision agriculture is considered one of the major developments in mechatronics, where decreased labor requirements and increased crop production costs are achieved.

Many academics argue that the use of mechatronics modules may not always lead to optimal performance and could result in unnecessary configurations, reduced focus, excessive multitasking, privacy risks, limited learning opportunities, increased dependency, and time inefficiencies. While mechatronics devices have the potential to boost production rates and alleviate poverty, their adoption in agriculture, especially in developing countries, remains limited due to these challenges. The key goal is to educate farmers on the use of mechatronic irrigation and agricultural systems. As the agricultural sector expands to meet global demand for food supply chain transparency, more advanced mechatronic devices are being used for complex processes. The integration of mechatronics systems in agriculture offers the advantage of significantly increasing efficiency, doubling that of manually operated machinery, and enabling a revolution in the establishment, management, and harvesting of agricultural products [8 - 11].

The adoption of technology is crucial, as traditional farming methods are unable to meet the growing demand for food. The **Internet of Things (IoT)** has significant potential to transform agricultural automation. When integrated with an effective intelligent decision-making system, IoT drastically reduces the need for human intervention in various agricultural tasks. The combination of **Artificial Intelligence (AI)** and IoT has demonstrated that advanced systems can make decisions with greater accuracy than humans [12]. AI-powered systems are capable of performing tasks that require human intelligence, such as speech recognition, visual perception, translation, and decision-making. In the realm of agricultural and irrigation automation, these technologies are considered two interconnected components working together.

Big Data and IoT systems have converged for data analysis, becoming more advanced and capable of processing vast amounts of information. **Artificial intelligence (AI)** algorithms can analyze this data, extracting valuable insights that lead to better decision-making. New intelligent approaches, such as **machine learning (ML)**, **natural language processing**, **machine vision**, and **Artificial Neural Networks (ANN)**, are used for automation and problem-solving. ML and ANN, in particular, are widely applied in farm automation research. Machine learning algorithms can perform both supervised and unsupervised learning tasks [13]. Compact IoT devices generate a large amount of unstructured, real-time data, which is extremely sparse. Consequently, supervised learning techniques are commonly employed in the majority of automation-driven data and associated tasks. Because artificial neural networks performed well on challenging categorization tasks, contemporary agricultural automation systems are quite dependable. Biological neurons that are stacked in an architectural structure stimulate an ANN. They can learn intricate non-linear correlations because of the design. Convolutional neural networks and DL based computer vision techniques are employed in agricultural automation.

Deep learning techniques are revolutionizing smart agriculture by enabling advanced data analysis and decision-making. These techniques, particularly

CHAPTER 8

Deep Learning in Cancer Diagnosis, Prognosis, and Therapeutics

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Abstract: Cancer is a leading global cause of mortality, with various underlying conditions and molecular pathways contributing to its onset and progression. Recent strides in computational biology have yielded diverse data sources such as high-resolution scan imaging, genomic profiles, transcriptomic data, and histopathological information linked to cancer. Analysing this data comprehensively can unveil the disease's complex biology, aiding in early, precise diagnosis and targeted drug development. Deep Learning, an advanced branch of Artificial Intelligence (AI), leverages multi-layered neural networks to mimic intricate decision-making like the human brain. Its robust learning capabilities enable efficient analysis of vast biological datasets. While early findings are promising, the dynamic nature of this field continually yields new insights into both deep learning and cancer biology. The intersection of these domains holds promise for revolutionising cancer diagnosis, prognosis, and therapeutic strategies. This chapter outlines emerging deep learning techniques applied in oncology, specifically focusing on MRI image analysis, genomic profiling, histopathology, and transcriptomic data analysis. Examples highlighting how deep learning can enhance cancer diagnosis, prognosis, and management are discussed. The chapter concludes with a discussion of current limitations and challenges in applying deep learning in oncology and proposes strategies to overcome these hurdles and maximise its efficient utilisation.

Keywords: Artificial intelligence, Cancer diagnosis, Cancer classification, Deep learning, Drug discovery, Multi-omics, Prognosis.

INTRODUCTION

Artificial Intelligence (AI) has witnessed remarkable development in the past few years. Being a multidisciplinary field, AI encompasses a wide range of technologies and methodologies aimed at replicating human-like intelligence in

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computers and systems. From machine learning algorithms that enable data-driven decision-making to natural language processing systems that facilitate human-computer communication, AI has permeated various aspects of our daily lives and industries. In the healthcare sector, AI is being used due to the increasing amount of complex data [1].

Machine Learning is the most common form of AI and is used widely in various industries [2]. In ML, the computer is trained to identify an underlying pattern from a dataset and draw inferences from it. Deep Learning (DL) is a subgroup of ML that implements a neural network to mimic human intelligence and make predictions. In comparison to other ML techniques like logistic regression, the presence of a larger number of hidden layers in DL offers higher scalability while dealing with higher-dimensional datasets [3]. This enables DL to be an ideal method for the processing of biological datasets due to their large sizes and underlying complexity.

Recent advancements in cancer biology have increased the availability of various types of data, including diagnostic imaging data, histopathological data and transcriptomic data. Analysis of these diverse high-dimensional data for clinical evaluation is significantly time-consuming and requires expertise in these diverse fields. Integration of all these various types of data could reveal new insights about the disease, which would help develop targeted treatment. More sophisticated algorithms that can comprehend the high complexity of the underlying characteristics are required for these types of tasks. The use of ML in cancer diagnosis is rapidly gaining popularity and becoming an increasingly prevalent method [4]. Various trained DL models can analyse high-dimensional data sets like expression datasets and could provide newer insights and identify the significant features [5]. This chapter deals with the latest trend of DL in cancer diagnosis, prognosis, and therapeutics, with a focus on its application in image processing and multi-omics data processing.

With the rising global burden of cancer, efficient management of the disease has become increasingly difficult, particularly due to the increase in demand for a highly trained workforce owing to the high complexities involved in the disease, which often falls short in developing and underdeveloped countries. Recent advancements in the fields of computational methodologies and AI present promising solutions to this problem. Consequently, the prime objective of this chapter is to examine both traditional and advanced deep learning methods currently employed in oncology. By delving into these methodologies, we aim to highlight their potential to enhance cancer diagnosis, treatment, and management, particularly in contexts where resources and expertise are limited. We have also discussed the prevailing limitations of using DL in these datasets. Finally, we have concluded with a potential strategy that would address all these limitations and make it feasible to use DL in standard clinical settings.

TYPES OF BIOLOGICAL DATASETS

With the rapid advancement in the field of computational sciences, twenty-firs- -century biology is a data-intensive field. Biological data may be broadly classified into the following primary types:

- *Sequential data*: With the advent of automated sequencing technology, sequential data such as sequences of DNA, RNA or the sequence of amino acids present in a peptide chain. In sequence data, appropriate bases are typically indicated by text strings; however, gap lengths, or bounds on gap lengths, must also be stated when gaps exist in the sequence data.
- *High-dimensional data*: Data points that may be related to the behaviour of a single biological unit must be gathered for thousands or tens of thousands of similar units, since systems biology heavily relies on comparing the behaviours of different biological units. A good example of this type of data is the gene expression datasets, which contain the expression profiles of tens of thousands of genes belonging to different test conditions.
- *Graphs*: Graphs capture the relationship between different components of a biological system. A cell works in a complex interconnected network of pathways that require different functions (Fig. **1**). The study of these complex networks is very significant for the overall understanding of diseases like cancer and they play an important role in the identification of potential therapeutic targets.
- *Scalar and Vector fields*: In every dynamic system, there are scalar and vector fields that vary continuously in space and time. In biology, the scalar and vector fields are associated with different chemical fields. For example, the tumour microenvironment is significantly perturbed by the different chemotaxis, which in turn is linked to phenomena like angiogenesis and metastasis.
- *Imaging data*: In biological research, both artificial and real imagery are involved. Several types of microscopic techniques are used to probe cellular functions. Diagnostic imaging techniques like X-ray, CT, and MRI generate detailed imagery of the organ structure and function. High-resolution optical imagery of tumour tissue reveals intricate details of the underlying morphology and is crucial for tumour classification.

CHAPTER 9

An Extensive and Comparative Research of Premature Stroke Prediction using Various Machine Learning Algorithms

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Abstract: This study explores the effectiveness of various machine learning algorithms in predicting premature stroke. For this purpose, the effectiveness of nine algorithms is compared, namely Random Forest, Decision Tree, Support Vector Machine, Logistic Regression, *etc*., in predicting the likelihood of a person experiencing a stroke. The dataset used in this research includes demographic information, lifestyle, and medical history of individuals. The accuracy, precision, recall, f1-score, confusion-matrix, and area under the AUC-ROC curve (Receiver Operating Characteristic) are employed to assess how well the algorithms work. The feature importance of some algorithms is also computed. The findings from these algorithms can demonstrate machine learning algorithms' potential in early prediction of premature stroke and can be useful in identifying individuals at high risk for preventative interventions. Since stroke is one of the main causes of death and morbidity worldwide, with an estimated 17 million cases and over 6 million deaths annually. Early prediction of stroke risk is crucial in preventing the onset of the disease, especially in cases of premature stroke, which occurs before the age of 60. Machine learning algorithms have shown great potential in predicting various diseases, including stroke, by analyzing large amounts of data and identifying patterns that may not be apparent to human experts.

Keywords: AI in healthcare, Data analysis, Medical informatics, Healthcare, Premature stroke, Prediction modelling, Risk assessment.

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INTRODUCTION

Stroke is a serious medical problem that happens when a portion of the brain's blood flow is disrupted, leading to brain damage and impairment of neurological function. There are two main types of strokes: **ischemic stroke**, which accounts for about 85% of all strokes and is the result of a blood clot that is obstructing a blood artery in the brain, and **haemorrhagic stroke**, which occurs whenever a cerebral blood vessel bursts and provokes bleeding (haemorrhage) [1].

Worldwide, the leading contributor to death and disability is stroke. According to the WHO (World Health Organization), the second biggest cause of death worldwide is stroke, accounting for an estimated 11% of all deaths [2]. In addition, the primary factor causing long-term impairment is stroke, with survivors often experiencing significant physical, cognitive, and emotional impairments [3]. Some of the risk factors for stroke include high blood pressure, diabetes, smoking, high cholesterol, obesity, physical inactivity, and a family history of stroke. Certain demographic factors, such as age, gender, and race, also contribute to stroke risk [4].

Stroke symptoms include the following [5]:

- Numbness or weakness in the arm, face, and leg
- Problem in communicating
- Problem with response
- Change in Behaviour
- Problem with vision
- Trouble in walk
- Dizziness
- Headache
- Nausea or vomiting

Preventing stroke involves managing risk factors through lifestyle modifications, such as maintaining a healthy diet, exercising regularly, quitting smoking, and managing chronic conditions such as hypertension and diabetes. Medical treatments, such as anticoagulant therapy, may also be used to prevent stroke in high-risk individuals.

Despite advances in stroke prevention and treatment, stroke remains a significant health burden. Early detection and intervention are crucial in minimizing the impact of stroke and improving outcomes for stroke survivors despite the fact that different table text styles are offered, multi-levelled formulae, graphics, and tables are not required. These elements must be created by the formatter, who must also take into account the following criteria [4].

Machine learning can be used to predict early stroke by analysing large datasets of patient information and identifying patterns and risk factors that can indicate a higher likelihood of stroke. By training machine learning algorithms on such datasets, researchers can develop models that can predict stroke risk with high accuracy, potentially allowing for earlier intervention and better outcomes for stroke patients. The decision-making procedures of the suggested prediction system may also benefit greatly from machine learning [6]. There is a connection among the diseases/attributes such as average glucose level, BMI level, heart disease, and hypertension with stroke [7]. Here is how we contribute to this research study:

- The feature importance is suggested for anticipating stroke using attributes/conditions like age, average blood sugar, body mass index, heart disease, history of stroke, hypertension, and smoking status.
- Performance of state-of-the-art classifiers such as XGBoost Classifier, Random Forest, Decision Tree, Support Vector Machine, AdaBoost Classifier, K-Nearest Neighbour, Logistic Regression, Stochastic Gradient Descent, and Gaussian Naïve-Bayes are compared with each other.

The remaining sections are structured as follows: A literature survey of recent studies is covered in Section 2. Section 3 provides an explanation of research methods that are divided into six sub-sections: data description, data analysis, data preparation, its partitioning, data normalization, and then procedures for implementation are outlined. The results and discussion are presented in Section 4, and the specifications about the results of the correlation and performance analysis are provided. The conclusion is discussed in Section 5 in detail.

LITERATURE REVIEW

To predict stroke, numerous academics have been experimenting using technological methods. A few such examples are as follows:

A. Khosla *et al.* in 2010 conducted a literature review of stroke prediction methods, specifically comparing examples of the Cox proportional hazards model to other approaches. The authors also discussed common challenges in medical datasets, such as missing data and feature selection. A brand-new automatic feature selection algorithm was suggested, and a margin-based censored regression algorithm was used to improve stroke prediction accuracy. Overall, the paper presents a new approach that outperforms traditional methods and identifies potential risk factors that were previously unknown [8].

CHAPTER 10

Next-Gen Finance: Decoding the Role of AIML in Finance

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Abstract: Financial intelligence is an umbrella term that encompasses financial planning, savings, risk management, debt management, and the ability to sustain, which nurtures a sense of financial freedom. The entire financial industry is based on quantitative data to understand complex market trends/patterns and forecast future opportunities and risks. Owing to recent advancements in computing resources, technology, and access to vast amounts of data, ML (Machine Learning) and AI (Artificial Intelligence) are penetrating large financial/ monetary data to aid decision making. This chapter starts with a description of foundational AIML algorithms in finance. It continues with case studies focusing on AIML usage in the finance sector for risk assessment, decision making, *etc.* The topics of responsible AI, the legalities, and ethical considerations for AIML on finance are addressed in later sections. Overall, the study underlines the advancements and challenges, and emphasizes continued research in this domain.

Keywords: AIML, Finance, Risk management, Trend analysis.

INTRODUCTION

Financial literacy is a basic need of humans. It cultivates the knowledge and skills within an individual to attain financial well-being, which ensures the access, stability, and security of fiscal assets. Individuals with high financial well-being make significant contributions to economic growth. Financial intelligence is a comprehensive concept that includes financial planning, saving, risk management, debt management, and the ability to sustain oneself, all of which contribute to a sense of financial independence [1]. This enables people with decision-making abilities to deal with complexities and lead a financially satisfactory life.

The finance sector relies entirely on quantitative data to comprehend intricate market trends and patterns, as well as predict forthcoming opportunities and hazards.

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Due to recent progress in computational resources, technology, and the availability of large datasets, Machine Learning (ML) and Artificial Intelligence (AI) have become increasingly prevalent in the finance sector. These technologies are being used to analyze extensive financial data in order to assist in decision-making.

Financial intelligence, defined as the ability to understand and interpret financial data for informed decision-making, has undergone a transformative shift with AI and ML technologies [2]. This integration holds profound importance for enhancing decision-making processes in finance, enabling improved risk management, predictive analytics, and adaptive strategies.

Beginning with an examination of the foundations of financial intelligence in AI, the chapter delves into the applications of ML in trading, risk management, and data-driven decision-making. It underscores the critical role of high-quality financial data and the utilization of big data analytics for extracting actionable insights.

Furthermore, various ML models for financial forecasting are explored, including predictive modeling in stock markets and credit scoring. The chapter highlights the application of reinforcement learning for adaptive investment strategies and risk management, emphasizing AI-driven hedging techniques and real-time risk assessment [3]. Ethical considerations and regulatory frameworks in AI-driven finance are also addressed, focusing on challenges related to bias, fairness, and responsible deployment of AI. Case studies illustrating successful AI implementations in financial institutions, alongside lessons learned from failures and challenges, are provided. The chapter concludes with an outlook on future trends and innovations, such as the role of quantum computing, explainable AI, and collaboration between financial experts and AI specialists. Overall, this exploration underscores the achievements, encourages continued research, and emphasizes the importance of collaboration in advancing financial intelligence through AI.

FOUNDATIONS OF FINANCIAL INTELLIGENCE IN AI

Predictive Modeling in Stock Markets

Time series analysis is an essential element of predictive modeling in stock markets, as it is used to forecast future price fluctuations and market trends. Time series analysis involves analyzing historical data points collected over a specific time period in order to identify trends, seasonal patterns, and cyclical behaviors [4]. Financial analysts employ several approaches, such as autoregressive integrated moving average (ARIMA), exponential smoothing, and machine learning models like LSTM (long short-term memory) networks, to analyze stock price data. These approaches aid in understanding historical market trends and predicting future price movements. Traders can utilize time series analysis to make informed assessments, enhance their entry and exit positions, and optimize their investment strategies by exploiting expected market trends.

Sentiment analysis improves time series research by incorporating qualitative data to evaluate market patterns and investor sentiment. This process involves analyzing a large volume of written information gathered from news stories, social media, financial reports, and other sources to determine the prevailing emotional and dominating feelings in the market. Machine learning algorithms analyze the data to identify and classify sentiments as positive, negative, or neutral, and build a correlation with changes in stock prices. Financial institutions can predict market trends and potential variations in stock prices by understanding the collective emotion of investors [5]. Sentiment analysis provides a broader view of the market, allowing for enhanced risk management and the utilization of more advanced trading strategies. When combined with time series analysis, sentiment analysis enhances the accuracy of prediction models, offering a broad range of tools for navigating the complexities of financial markets.

Credit Scoring and Risk Assessment

Algorithmic approaches to credit risk have significantly improved credit scoring and risk assessment by utilizing modern data analytics and machine learning techniques. Conventional credit scoring models, such as FICO scores, depend on a limited range of factors, such as payment history and credit use. On the other hand, contemporary computational methods encompass a wider range of data points, such as transaction histories, social media behavior, and even psychological data. Machine learning algorithms examine these various data sources to provide more precise and dynamic risk profiles. These algorithms can detect subtle patterns and correlations that traditional approaches may miss. This allows lenders to accurately evaluate creditworthiness and offer customized credit solutions that align with the specific risk levels of individuals.

Fraud detection and prevention are essential elements of efficient risk assessment in the financial sector, and machine learning also plays a crucial role in this regard. Advanced algorithms have the capability to examine large quantities of transaction data in real-time, detecting irregularities and patterns that suggest fraudulent behavior. Methods such as neural networks, decision trees, and clustering algorithms are utilized to identify atypical spending patterns, instances of account hijacking, and other fraudulent activities. Through ongoing assimilation of new data, these systems enhance their proficiency in

CHAPTER 11

AI in Education and Adaptive Learning

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Abstract: The way individuals acquire and communicate knowledge has drastically changed as a result of the transformational expansion of technology integration in education, research, and online learning in recent years. The study addresses the implications for the future of education and information sharing while providing a broad overview of the diverse roles that technology plays in these fields. Technology has transformed conventional pedagogical approaches in the field of education. Learning has become more enjoyable and accessible for students of all ages due to the usage of digital resources, including interactive learning platforms, multimedia presentations, and online textbooks. Additionally, the inclusion of tools like virtual reality, augmented reality, and artificial intelligence has opened up opportunities for personalized learning experiences that respond to different needs and learning preferences. Technology has immensely aided e-learning, a concept that has gained prominence in recent years. With the COVID-19 pandemic underscoring the need for online learning, technology moved in to offer creative solutions. With the use of learning management systems, online testing, and video conferencing, people can now access education at any time, from any location. Learners have flexibility with a variety of learning demands met through synchronous and asynchronous learning styles. For increasing participation, enhancing cooperation, and furthering knowledge, technology in education, research, and e-learning has emerged as a vital tool. To ensure that everyone can benefit from this digital transformation, regardless of their socio-economic background, it is crucial that equity issues are addressed as we continue to take advantage of the power of technology. These fields have exciting prospects for the future, since new technologies are expected to fundamentally alter how we find, learn, and invent.

Keywords: Artificial intelligence, Big data, Education, E-learning, Technology.

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INTRODUCTION

The past few years have witnessed a rapid improvement in technology, which has resulted in a new era in the fields of e-learning, research, and education. Innovative techniques have emerged as a result of the union of pedagogy with cutting-edge technology that not only transform how knowledge is acquired and communicated but also rethink the fundamental principles of learning and study [1, 2]. Technology has evolved in this era of digital transformation to serve as a catalyst for democratic transformation, empowerment, and the development of dynamic learning environments that extend across geographical boundaries.

Technology integration in education is no longer a side issue; rather, it has evolved into an essential component of realistic, personalized, and adaptive learning experiences. The digital age has changed the face of education, from the adoption of Learning Management Systems (LMS) that expedite course delivery to the incorporation of virtual and augmented reality for experiential learning [3]. The tools and procedures made possible by technology have also renewed research efforts, allowing academics to explore unknown areas and tackle challenging problems on a scale and with a level of precision never before possible. As a part of this digital revolution, e-learning is a testament to how innovative technology can enhance education. It goes beyond the conventional classroom setting and provides access to information for students of all ages, socio-economic backgrounds, and life experiences. In addition to changing education, the increasing popularity of the internet and the plethora of online resources have led to a new era of continuous, lifelong learning.

The various effects of technology on learning, research, and education are extensively examined in this book. It looks at how technology and pedagogy interact dynamically, how research approaches have evolved in the digital era, and how the potential of e-learning is constantly developing. This study attempts to offer useful insights into the difficulties, opportunities, and future directions of this technology-driven educational landscape through a mix of academic research, case studies, and creative practices. We explore a number of aspects of technology's use in education, research, and online learning in the sections that follow. We look at how novel educational paradigms are being shaped by modern innovations like artificial intelligence, data analytics, and immersive experiences. We also take into account the pedagogical and moral implications of this shift and emphasize the best ways to use technology to improve educational performance. We invite readers to explore the many opportunities and difficulties that technology brings to the fields of education, research, and e-learning as we continue on this journey of study. By doing this, we aim to add to the ongoing discussion about how to effectively use technology to build an educational environment that is inclusive, dynamic, and revolutionary.

AI guarantees a learning process that is more productive and enjoyable. AI-powered analytics provide teachers a comprehensive understanding of student performance and engagement, enabling prompt assistance and interventions. This introduction establishes the context for the remainder of the paper by emphasizing the transformative role that technology has played in research, e-learning, and education. Fig. (**1**) illustrates the general architecture of the E-learning process.

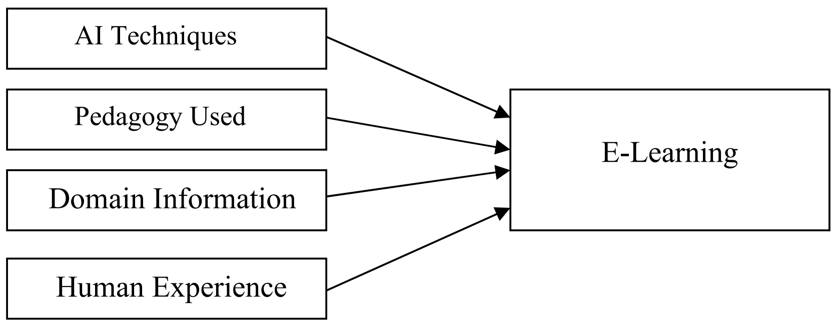

Fig. (1). Architecture of E-learning.

HISTORY AND BACKGROUND

Examining technology in education from a historical angle offers an exciting journey of advancements that have completely changed the way knowledge is taught and learned [4]. Here, we examine significant turning points and advancements in the use of technology in the classroom. Johannes Gutenberg's creation of the printing press in the fifteenth century was a revolutionary advancement [5]. As a result of books becoming more widely available, knowledge expanded, and formal educational institutions were founded. The first projectors and lantern slides were used in classrooms during the 19^{th} century. By displaying pictures and diagrams, these devices helped teachers improve visual learning. Radio shows intended to spread knowledge to a large audience were utilized for educational reasons. Phonograph records and other audio recordings allowed the spoken word to be preserved.

• **Early Digital Learning Tools:** The introduction of computers in the middle of the 20th century is when digital learning first got its start. Early Computer-Assisted Instruction (CAI) programmers were tested in educational institutions during the 1960s and 1970s. These frequently mainframe-based programmers provided basic instructional materials and tests.

CHAPTER 12

Healthcare Innovations

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Abstract: The digitized healthcare era has generated vast amounts of patient data, holding immense potential for medical advancements. However, patient privacy is a pressing concern. This chapter explores innovative techniques for confidentiality-preserving big data analytics in healthcare. It balances data utilization with patient privacy, delving into anonymization, differential privacy, and homomorphic encryption. Collaborative models, such as Secure Multi-Party Computation and Federated Learning, are examined. The chapter also anticipates future trends, including secure enclaves and blockchain. It underscores the coexistence of data-driven healthcare and robust privacy protection.

Keywords: Big data, Data analytics, Healthcare.

INTRODUCTION

The use of big data analytics to improve patient care and advance medical research has undergone a paradigm shift in the healthcare industry in recent years. The exponential growth of “big data,” encompassing digital health records, medical imaging data, genomic information, and patient-generated data, is the driving force behind this paradigm shift. The process of extracting useful patterns and insights from vast and varied datasets is referred to as big data analytics [1]. This enables healthcare professionals and researchers to make informed decisions, enhance clinical outcomes, and develop individualized treatment plans. This paper examines the significant implications of large-scale data analysis in healthcare while addressing the fundamental challenges posed by privacy and data security. Analytics for Big Data: In today's digital landscape, the term “Big Data” refers to

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the proliferation of massive and varied datasets that exceed conventional data processing capabilities [1].

Sensor data, healthcare records, financial transactions, and social media interactions are just a few examples of the many sources that comprise these datasets. Huge datasets ranging from terabytes to petabytes and beyond have emerged as a result of the rapid expansion of digital information [1].

To effectively manage and analyze data, novel storage and processing solutions are required due to the sheer volume. Real-time or near-real-time processing is required for the rapid influx of data streams [1]. Big Data is not limited to structured databases; streams from financial markets, social media, and Internet of Things (IoT) devices require immediate analysis to obtain timely insights. It encompasses structured, semi-structured, and unstructured data, including text, images, audio, and video, among other types [1]. Integrating and analyzing these various kinds of data presents unique difficulties. To extract value from Big Data, organizations deploy Big Data Analytics. This advanced methodology leverages computational techniques and algorithms to uncover patterns, correlations, and insights that would otherwise remain concealed within the data deluge [2]. This process entails:

Data Collection and Aggregation: Gathering data from diverse sources and consolidating it into a unified repository, often using tools such as Hadoop or cloud-based solutions [2].

Data Preprocessing: Cleaning, transforming, and structuring the raw data to ensure accuracy and consistency, thereby preparing it for analysis.

Exploratory Data Analysis (EDA): Unearthing initial insights by visualizing and summarizing data. EDA helps identify trends, outliers, and potential relationships.

Analytics Methods: Machine learning, deep learning, data mining, natural language processing, and statistical analysis are employed to uncover intricate patterns, make predictions, and inform decision-making.

Visualization and Reporting: Presenting insights in a comprehensible manner through visualizations, dashboards, and reports to aid stakeholders' understanding and guide strategic actions.The fusion of Big Data and advanced analytics has catalyzed transformative changes across industries. In healthcare, personalized treatment and disease prediction are driven. In retail, it facilitates targeted marketing and inventory optimization. In finance, it aids in fraud detection and risk assessment. The era of Big Data and Big Data Analytics has led to a profound shift in data utilization and comprehension. The confluence of voluminous data and advanced analytical techniques serves as a powerful catalyst for innovation, paving the way for unprecedented insights and opportunities across diverse sectors. By processing and analyzing large-scale datasets, healthcare practitioners can gain a comprehensive understanding of disease trends, treatment responses, and patient demographics. This knowledge facilitates early disease detection, accurate diagnosis, and the identification of optimal interventions. Additionally, big data analytics empowers medical researchers to accelerate drug discovery, predict disease outbreaks, and identify novel biomarkers for various conditions. The integration of real-time patient-generated data from wearables and mobile health apps further enables remote monitoring and timely intervention, fostering a patient-centric approach to healthcare. Critical obstacles, particularly those related to patient privacy and data security, hinder the widespread adoption of big data analytics in healthcare, despite its enormous potential. The digitization and consolidation of sensitive clinical data create vulnerabilities that can be exploited by malicious actors. Unauthorized access to, sharing of, or misuse of health data can result in significant breaches of trust, as patient privacy is a fundamental ethical principle in the healthcare industry. Identity theft, insurance fraud, and discrimination are all consequences of healthcare data breaches. Additionally, the intimate nature of medical data raises the risk of data exposure. If people are concerned that their health information could be used in employment, insurance, or legal proceedings, they may be reluctant to share it. The accumulation of diverse and representative datasets can be hampered by this reluctance, which ultimately limits the validity and generalizability of analytical findings. Coupled with protection concerns, it is essential to ensure robust information security. Medical care associations should implement robust encryption, access controls, and review trails to protect patient information throughout their lifecycles. Continuous monitoring and rapid response mechanisms are necessary to mitigate risks and prevent unauthorized access, particularly in the event of data breaches.

By enabling evidence-based decision-making, personalized medicine, and ground-breaking research discoveries, big data analytics hold enormous potential to transform healthcare. However, it is impossible to overstate the ethical need to safeguard patient privacy and data security. Finding a balance between technological advancements and the protection of sensitive health information is crucial. To establish comprehensive regulations, standards, and best practices that promote the responsible use of big data analytics, uphold patient rights, and maintain trust, policymakers, healthcare providers, and technology developers must collaborate. Only through deliberate exertion could the medical services local area at any point completely influence the capability of huge information investigation while protecting the security and privacy of people's private data.

CHAPTER 13

Revolutionizing Education: AI and Emerging Cloud Technologies for On-Demand Learning

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Abstract: A variety of multimedia formats are used in on-demand education, which frequently includes video, interactive simulations, and downloadable instructions. Infographics, slideshows, blog articles, and recorded webinars are among the additional resources frequently used. Because of this training's accessibility and ability to be optimised for desktop and mobile devices, distance no longer serves as a barrier to knowledge acquisition. Cloud technologies have evolved to provide world-class education and manage today's education system. With the advancement in the internet and technology, the term cloud computing has become popular. There is a wide range of applications of cloud technologies in every field. The benefits enhance the quality of the outcome with maximum results at minimal expense. Cheaper, faster, and greener are the three terms for the hype of cloud computing. Educators can access robust software with lower or no upfront expenditures and fewer administrative hassles in the classroom, on campus, and elsewhere, without making any infrastructure investments. This study investigates the impact of cloud technologies on the on-demand education system. E-learning is essential and common in most educational institutions, where content management systems and virtual networks are used to enhance student learning. The Cloud has demonstrated considerable promise for transforming the way the education sector operates, particularly by providing online programs to alter the established working environment. From the perspective of offering online curricula to transform the current working environment, the Cloud has demonstrated significant potential for revolutionizing the education sector.

Keywords: Cloud technology, Learning analytics, Metaverse, On-demand education system, Revolution.

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INTRODUCTION

An on-demand education system refers to the anytime, anywhere access of the content. This can be viewed as the demanded video interactive content, including simulations of the e-content. The other resources that fall under the cloud umbrella include recorded videos, webinars, and blogs.

It is not surprising that the education industry has been impacted as technology keeps changing our lives and the way we operate. The ability to provide on-demand access to computing resources and services *via* the internet has made cloud computing a technology that is revolutionizing the field of education.

To provide learners with an excellent education and equal opportunities worldwide, the use of technology in learning is essential. Governments and educational institutions develop strategies for digital transformation and put those strategies into action to confirm that every student's learning experience is seamless and relaxed.

The influence of digital transformation in education is that it enhances the learning process for everyone involved, including instructors, students, and other stakeholders. These adjustments center on enhancing accessibility and engagement through engaging and flexible learning. Online education becomes more affordable, thorough, and comprehensive as a result. Fig. (**1**) illustrates the components associated with on-demand education systems.

Fig. (1). On-demand education system.

Integration of Cloud Computing in Education

Cloud computing is closely tied to the education sector.

Software-as-a-service (SaaS)

The development of cloud technology enables institutions to access the software and apps.

Platform-as-a-service (PaaS)

Tools, Services, and programming languages are provided by the cloud providers, where the educators can create and customize their own applications. A good example used by most college faculty members and students is the virtual lab.

Infrastructure-as-a-service (IaaS)

The faculty members can install and run applications and an OS.

The impact of cloud computing in education is:

• Quick response

Cost Reduction – Without the cloud, resource scaling requires high cost and takes much time.

• Reduced complication

• Evaluating the students and the faculty members' performance

• Implementation of Smart classrooms

• Learning Management Systems (LMS)

Fig. (**2**) displays the characteristics of On-Demand Systems. The information is accessed instantly, and it is consistent. This system is convenient for all end-users and providers. The information that is resized with abstract information with minimal time is named as Bite-Sized Content. This form of data is predominantly used in social media.

Gross Enrolment Ratio (GER) at Higher Education in India

GER measures the number of students enrolled in higher education as a percentage of the qualified population aged 18 to 23 years.

CHAPTER 14

Precision Agriculture and Smart Monitoring Using IoT Technology

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Abstract: Precision agriculture is revolutionizing the farming landscape by utilizing advanced technologies to improve productivity, sustainability, and resource management. This chapter delves into the integration of Internet of Things (IoT) technology within precision agriculture, emphasizing the role of smart monitoring systems that enable real-time data collection and analysis. The advent of IoT has transformed traditional farming practices by providing farmers with the tools to monitor environmental conditions, soil health, and crop performance continuously. Through the deployment of various IoT devices, such as sensors, drones, and smart machinery, farmers can gather critical data on parameters like soil moisture, temperature, and nutrient levels. This data-driven approach allows for optimized resource allocation, reducing waste and enhancing crop yields. The chapter reviews current research and applications of IoT in precision agriculture, highlighting successful case studies that demonstrate the effectiveness of these technologies in improving agricultural practices. Moreover, the chapter addresses the challenges and limitations faced in the adoption of IoT solutions, including issues related to data security, infrastructure, and the cost of technology. It also explores future directions for research, particularly the potential integration of artificial intelligence and machine learning with IoT systems to enhance predictive analytics and decision-making processes in agriculture. By providing a comprehensive overview of the intersection between IoT technology and precision agriculture, this chapter aims to inform researchers and practitioners about the transformative potential of these innovations.

Keywords: Agriculture, Crop management, FAO, IOT, Precision agriculture, Productivity, Optimization, Sustainability, SDG.

INTRODUCTION

The agricultural sector is at a critical juncture, facing a myriad of challenges that threaten its sustainability and productivity. Climate change, resource scarcity, and

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the increasing demand for food due to a growing global population are pressing issues that require innovative solutions. According to the Food and Agriculture Organization (FAO), the world will need to produce 70% more food by 2050 to feed an estimated 9.7 billion people. This daunting task necessitates a paradigm shift in agricultural practices, moving from traditional methods to more advanced, data-driven approaches [1].

Precision Agriculture (PA) is an innovative farming management concept that utilizes information technology to ensure that crops and soil receive exactly what they need for optimum health and productivity. This approach is characterized by data-driven decision-making, which allows farmers to optimize inputs such as water, fertilizers, and pesticides, thereby improving crop yields while minimizing waste and environmental impact.

The traditional agricultural practices often rely on broad strategies that do not account for the variability within fields. This can lead to over-application of inputs, resulting in increased costs and negative environmental consequences, such as soil degradation and water pollution. In contrast, precision agriculture employs advanced technologies to monitor and manage field variability, enabling farmers to make informed decisions based on real-time data.

The integration of Internet of Things (IoT) [2, 3] technology into precision agriculture has revolutionized the way farmers monitor and manage their crops. IoT refers to a network of interconnected devices that communicate and exchange data over the internet. In the context of agriculture, IoT devices include sensors, drones, and smart machinery that collect data on various parameters such as soil moisture, temperature, humidity, and crop health [4, 5]. Fig. (**1**) shows the precision agriculture and smart monitoring using IoT technology.

One of the most significant advantages of IoT technology is its ability to facilitate real-time data collection. IoT sensors can be deployed throughout agricultural fields to continuously monitor environmental conditions. For instance, soil moisture sensors can provide farmers with immediate feedback on soil hydration levels, allowing them to adjust irrigation schedules accordingly. Real-time monitoring enables farmers to respond promptly to changing conditions, optimizing resource use and improving crop health. The data collected through IoT devices can be analyzed to provide actionable insights that enhance decision-making. By leveraging these insights, farmers can make informed decisions regarding planting, fertilization, and pest management, ultimately leading to increased productivity and sustainability [6].

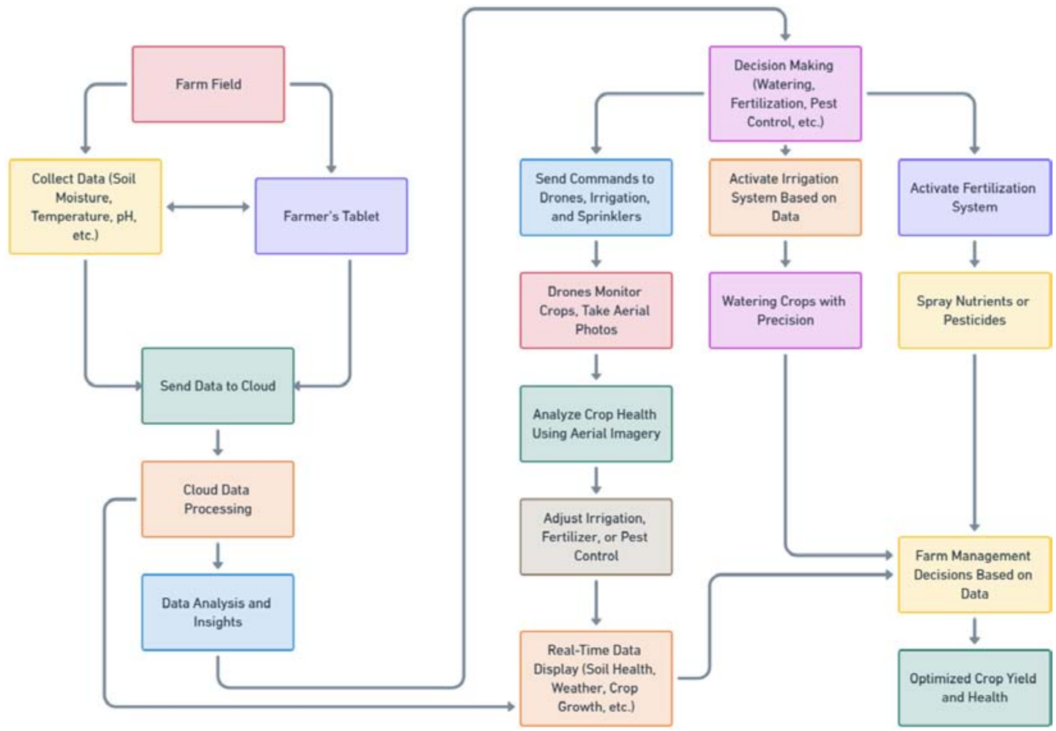

Fig. (1). Precision agriculture and smart monitoring using IoT technology.

The integration of IoT technology into precision agriculture offers numerous benefits, including [7]:

- **Resource Optimization:** By utilizing real-time data, farmers can optimize the use of water, fertilizers, and pesticides, reducing waste and costs. For instance, smart irrigation systems can adjust water application based on soil moisture levels, ensuring that crops receive the right amount of water without over-irrigation.
- **Increased Crop Yields:** Precision agriculture has been shown to improve crop yields significantly. By monitoring environmental conditions and crop health, farmers can identify and address issues such as nutrient deficiencies or pest infestations early, preventing yield losses.
- **Sustainability:** The data-driven approach of precision agriculture promotes sustainable farming practices by minimizing chemical usage and improving resource allocation. This not only benefits the environment but also enhances the long-term viability of agricultural systems.
- **Risk Reduction:** Precision agriculture helps mitigate risks associated with volatile markets, pest outbreaks, and unpredictable weather conditions. By

CHAPTER 15

Beyond Boundaries: Exploring Advanced AI Applications

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Abstract: In the rapidly evolving landscape of artificial intelligence, this chapter delves into uncharted territories, pushing the boundaries of what is conceivable and achievable. "Beyond Boundaries: Exploring Advanced AI Applications" provides a comprehensive exploration of cutting-edge applications that showcase the unprecedented potential of advanced AI technologies. From sophisticated machine learning algorithms to groundbreaking neural network architectures, this chapter unravels the intricacies of AI's transformative impact across diverse domains. Through insightful case studies and examples, readers will gain a deep understanding of how advanced AI applications are reshaping industries, solving complex problems, and pushing the limits of what was once deemed impossible. Join us on a journey beyond the familiar as we navigate the frontiers of artificial intelligence and witness its extraordinary applications that promise to revolutionize the way we live, work, and interact with technology.

Keywords: Advanced AI applications, Artificial intelligence, Industry transformation, Machine Learning, Neural networks, Technological innovation.

INTRODUCTION

Artificial intelligence (AI) has grown rapidly in recent years, transforming from a niche research area into a fundamental technology reshaping industries worldwide. Advanced AI applications in machine learning, neural networks, and reinforcement learning are driving innovation across domains, providing robust solutions to complex problems in healthcare, finance, logistics, and beyond. The proliferation of big data and computational power, combined with recent breakthroughs in AI algorithms, has led to the creation of systems capable of

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processing and analyzing vast amounts of data with accuracy and efficiency. These developments in AI are not only advancing technology but are also redefining the boundaries of human problem-solving, innovation, and industry practices, thus changing how society functions on a fundamental level [1, 3].

The field's rapid evolution has also prompted a re-evaluation of its potential and limitations. Whereas early AI systems were rule-based, modern AI leverages sophisticated models that learn from data, enabling systems to generalize from previous experiences to tackle new challenges. The contemporary landscape of AI involves high-dimensional data analytics, deep learning architectures, and reinforcement learning frameworks that power autonomous systems. These technologies enable advanced applications like Natural Language Processing (NLP), autonomous driving, and personalized healthcare, highlighting the diverse and transformative applications of AI [4, 6].

In light of these advances, this chapter explores the frontiers of AI applications, focusing on cutting-edge implementations across healthcare, finance, logistics, and creative industries. Each section will discuss key technologies, including neural networks, machine learning models, and reinforcement learning, and examine how they are being deployed in real-world settings. Additionally, this chapter addresses the ethical implications and societal impact of AI, providing a balanced perspective on its advantages and challenges in today's world.

HISTORICAL CONTEXT AND EVOLUTION OF ARTIFICIAL INTELLIGENCE

The history of artificial intelligence reflects its development from theoretical constructs to practical applications. Early AI was primarily symbolic, relying on logic-based systems and rule-based reasoning to simulate aspects of human intelligence. However, these systems were limited in scalability and adaptability, leading to a shift toward data-driven approaches in the late 20th century. Machine learning (ML), which enables systems to improve from experience without explicit programming, marked a significant departure from traditional AI methodologies [7].

The 2010s saw the rise of deep learning, a subset of ML involving neural networks with multiple layers, which significantly enhanced the capabilities of AI. By learning complex representations of data, deep learning models outperformed traditional approaches in image recognition, NLP, and speech recognition [8]. Convolutional neural networks (CNNs) and recurrent neural networks (RNNs) became the foundation for tasks such as object detection and language translation, while transformers—an architecture introduced in

2017—revolutionized NLP applications by enabling context-aware understanding of language sequences [9].

Today's AI systems are characterized by their ability to process complex data structures and make autonomous decisions. Reinforcement learning (RL) has introduced AI to dynamic, goal-oriented environments, as seen in applications like autonomous vehicles and robotics. RL models learn optimal strategies through trial and error, making them well-suited for tasks where real-time decision-making is essential [10].

KEY TECHNOLOGIES DRIVING ADVANCED AI APPLICATIONS

The influence of AI on modern industries is rooted in three core technologies: machine learning algorithms, neural network architectures, and reinforcement learning. Each of these technologies contributes uniquely to the ability of AI to address complex problems and innovate within various fields.

Machine Learning Algorithms

Machine learning remains a cornerstone of AI, comprising supervised, unsupervised, and reinforcement learning approaches. Supervised learning is commonly used for classification and regression tasks, while unsupervised learning aids in clustering and association analysis. Algorithms, such as Support Vector Machines (SVMs), k-nearest neighbors (k-NN), and ensemble methods, have enabled precise predictive modeling, applicable to areas like finance for fraud detection, and healthcare for disease prediction [11 - 13].

Neural Networks and Deep Learning

Neural networks, particularly deep learning models, are essential for handling high-dimensional data in tasks that involve image and speech recognition, language processing, and more. Convolutional Neural Networks (CNNs) are widely used in computer vision, excelling in object detection and image classification tasks, while transformers, which employ self-attention mechanisms, dominate NLP applications. The adaptability and scalability of these models have made them indispensable for complex, large-scale tasks that require real-time processing and adaptability [14 - 16].

Fig. (**1**) A compelling visual depiction of various neural network architectures, set against the backdrop of their specific application domains. Each architecture is meticulously illustrated, highlighting essential components and distinctive functionalities. The scene is softly illuminated, representing the capability and potential of these sophisticated systems.

CHAPTER 16

Machine Learning Model Comparative Analysis for IoMT Data Security

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Abstract: The Internet of Medical Things (IoMT) signifies a groundbreaking development in healthcare, facilitating real-time monitoring of patients and data gathering. Nevertheless, the rise of connected medical devices introduces substantial security issues, especially their vulnerability to cyber threats. This study performs a comparative evaluation of various machine learning models for detecting anomalies in IoMT data, with an emphasis on their ability to identify harmful activities. We assess four well-known algorithms: Random Forest, Support Vector Machine (SVM), Logistic Regression, and K-Nearest Neighbors (KNN). We also analyze performance metrics such as accuracy, precision, recall, and F1-score to identify the most effective model for protecting IoMT environments. The results indicate that ensemble methods like Random Forest exhibit superior performance, offering valuable insights for professionals seeking to improve IoMT security.

Keywords: Data security, IoMT, Machine learning.

INTRODUCTION

Overview of IoT

Internet of Things (IoT) is a new technological paradigm that escalates the conventional applications to new automation heights. Hence, the low-power lossy IoT network has gained popularity in the past decade, with applications consisting of the interconnection of low-power devices known as sensors, which can automatically collect and communicate data over the internet without human

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intervention [1]. Various applications—including healthcare, agriculture, transportation, and environmental monitoring—use IoT-based automation techniques to enhance their efficiency and effectiveness. However, the actual deployment of IoT applications faces various challenges like the involvement of resource-constrained devices, multi-hop routing, unattended deployment, high heterogeneity, *etc.* In addition to all these problems, the biggest problem is the generation of a tremendous amount of streaming data.

Cloud Computing

Cloud computing is a framework that enables widespread, accessible, and on-demand network access to a shared pool of flexible resources. These resources can include networks, servers, storage, applications, and various services offered to users. They are often quickly provisioned and may sometimes be available for free, depending on resource availability, requiring minimal management effort or interaction with the service provider. Recently, this technology has emerged as a means to deliver a broad range of computing services remotely. The architecture of cloud computing is generally divided into two components: the Front End and the Back End [2]. These components are linked *via* the Internet. The front end represents the client side of the cloud computing system, while the back end refers to the cloud itself. The front end includes the interfaces and applications required to access cloud computing platforms, such as web browsers. The back end encompasses all the resources needed to provide cloud computing services, including extensive data storage, virtual machines (VMs), services, security measures, deployment models, and servers [3].

The back end also incorporates built-in security mechanisms, protocols like middleware for communication with connected devices, and traffic management. The primary demands of cloud security include privacy, integrity, trust, confidentiality, and availability. Recently, there has been a surge in users connecting to the digital realm for resource sharing, content access, and service provision, mainly due to technological advancements. A key aspect of this technology is its user-friendly environment, which can be accessed from anywhere. Progress in virtualization technologies has facilitated the straightforward implementation of cloud services and related solutions for diverse groups, including business professionals, researchers, and students, across various application areas. Cloud service providers offer highly scalable computing resources as an external service to end users on a pay-per-use basis, with convenient network access that helps optimize an organization's resource management costs [4]. This reduces the burden of software or hardware maintenance for users, leading to decreased spending and time spent on infrastructure management. Consequently, organizations and users can focus on pursuing innovative projects that contribute to growth. As a result, organizations gain advantages in time savings and enhanced performance through reduced infrastructure-related expenditures. Cloud infrastructure combines various hardware resources *via* virtualization to create shared resources that users can access for computation, storage, and networking needs, effectively utilizing traditional IT infrastructures. Scalability is improved, and operating costs for the user side are lowered. Currently, cloud-based data centres are experiencing significant growth.

Internet of Medical Things

The Internet of Medical Things (IoMT) represents a segment of IoT focused on the healthcare sector. By the end of 2030, IoMT devices are expected to make up 40% of the IoT market. This segment is projected to grow in the coming years, primarily due to the ability of IoMT devices to help lower expenses in healthcare. The sector might be able to conserve as much as $300 billion by implementing IoMT devices, especially for managing chronic diseases and telehealth services. In 2024, IoMT produced $25 billion in revenue and is projected to hit $150 billion by 2030, which makes it attractive to investors. However, maintaining the security of IoMT devices and the overall healthcare systems (referred to as IoMT systems) poses a considerable challenge. The healthcare data linked to IoMT systems must be protected at every phase, including data collection, transmission, and storage. According to the 2024 CyberMDX report, almost half of IoMT devices have vulnerabilities that could be exploited [5]. The Internet of Medical Things (IoMT) systems significantly impact patient outcomes; however, they also raise privacy concerns if personal identifiers are compromised.

The Internet of Medical Things (IoMT) systems significantly impact patient outcomes; however, they also raise privacy concerns if personal identifiers are compromised. Healthcare data is highly valuable and worth approximately 50 times more than credit card information in illegal markets. To ensure that IoMT systems operate effectively, there are eleven key security protocols centred around data confidentiality, integrity, availability, non-repudiation, and authentication. Together, these protocols are referred to as CIANA [6]. Although traditional security measures can meet these needs, their high energy consumption and various operational constraints often limit their ability to provide strong security guarantees. As a response, researchers have proposed several techniques explicitly tailored for IoMT and IoT environments. These approaches can be categorized into three main types: symmetric cryptography, asymmetric cryptography, and keyless noncryptographic methods that leverage cryptographic principles.

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