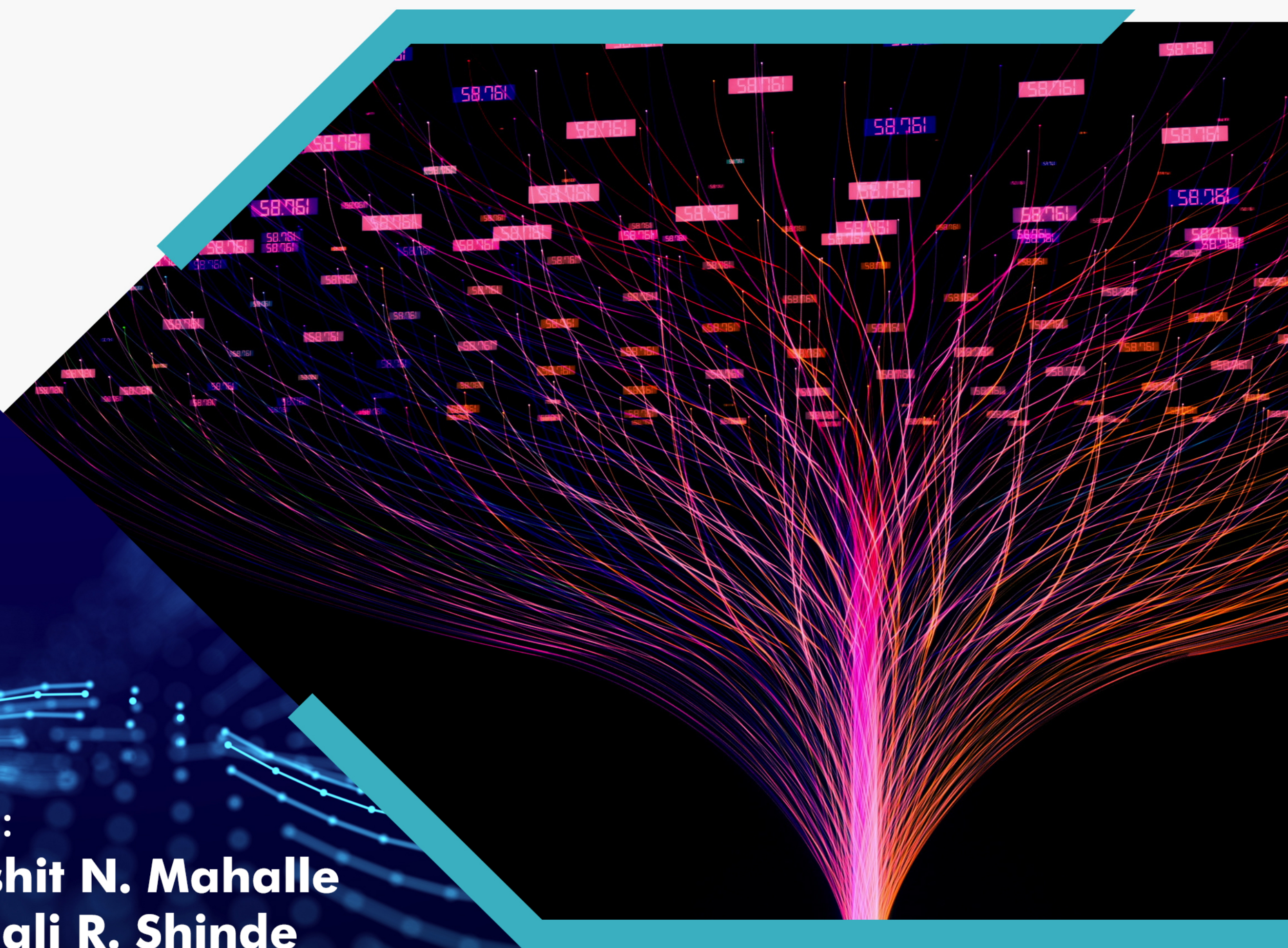
INDUSTRY 4.0 CONVERGENCE WITH AI, IOT, BIG DATA AND CLOUD COMPUTING: FUNDAMENTALS, CHALLENGES AND APPLICATIONS



Editors:
Parikshit N. Mahalle
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IoT and Big Data Analytics

(Volume 4)

Industry 4.0 Convergence with AI, IoT, Big Data and Cloud Computing: Fundamentals, Challenges and Applications

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FOREWORD

The boundaries between the physical and virtual worlds are becoming progressively blurred in what are known as cyber-physical production systems as a result of information and communications technology (ICT) being widely used by the manufacturing industry and traditional production operations (CPPSs). Intelligent machines are constantly exchanging data regarding current stock levels, issues, and modifications in orders or demand levels. In order to increase productivity and optimise throughput times, capacity utilisation, and quality in development, production, marketing, and purchasing, processes and deadlines are coordinated. Robotics, drones, nanotechnology, 3D printing, and artificial intelligence are just a few examples of the exponentially developing technologies that are accelerating and reshaping industrial processes.

The book outline and contents show that the major topic of the book is the brief introduction to the domain, research challenges, literature reviews and state-of-the-art, different algorithms/techniques/deployment methods. The book is divided into three sections that include challenges, convergence with AI and IoT Applications and Industry 4.0.

It starts with a comprehensive study of AI, IoT, Cloud Computing, and Blockchain Technologies. The Internet of Things (IoT), blockchain technology, and Artificial Intelligence (AI) are now acknowledged as advancements with the potential to change entire industries and enhance existing business processes. Blockchain, for instance, offers a shared and decentralized distributed ledger that can improve corporate operations' trust, transparency, security, and privacy. Similar to a register, a distributed ledger or blockchain can be used to hold any type of asset. For the German and European industries, automation of industries and user-friendliness of business processes are crucial. Finally, AI enhances business processes by identifying trends and maximizing their results. AI is structured based on a human mindset and an approach that is human-centered.

These key enablers for Industry 4.0 focusing on IoT, AI and Blockchain Technologies will help readers to empower their research and learning in these areas. Buyers, who belong to the category of researchers, will be benefited from the state-of-art and future research directions provided in the book. Practicing engineers will be benefited from the knowledge of the current challenges in technology, deployment methods and solutions. Postgraduate students will be introduced to new AI domains, and their related recent advancements. They will also be made aware of the rapid growth in the technology.

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PREFACE

Artificial Intelligence (AI), the branch that has now captured the entire world with its power in dealing, predicting, and estimating with large amounts of data is on a roll. The need to apply intelligence, augment knowledge and enhance communication has made the AI domain more prevalent in emerging technologies. Moreover, the wide availability of varied types of media has made it desired to deliver and provide a robust communicating platform. The existence of potential approaches and techniques to deal with them has opened new avenues for researchers to combine AI methodologies to utilize the media and produce efficient outcomes in the process.

Further, the transformation and automation of traditional practices in industries – manufacturing and production have geared up in Industry 4.0. Integrating IoT, communication media and this digital transformation has become valuable as it has revolutionized the technology. The potential to transform with increasing demand to deliver smart solutions is opening broad perspectives for researchers and thus demanding more attention.

Working towards these new dimensions of AI - to deliver, communicate and process is gaining momentum. New solutions are being looked at to accommodate and improve the business domain. Detecting trends with analytics, interpreting the communicating data, and capturing futuristic estimates are the key factors required in today's networking world. In recent years, researchers are gaining interest in this domain for various ubiquitous applications. To develop and deliver robust next-generation solutions with the applicability of Machine Learning, Deep learning and Data Sciences are used to overcome the challenges possessed by traditional approaches. This ranges from robotics to healthcare, and agriculture to sustainability.

This book focuses on the recent research that introduces new methods and techniques of AI for communicating media along with Industry 4.0.

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CHAPTER 1

A Comprehensive Study of State-of-the-Art Applications and Challenges in IoT, and Blockchain Technologies for Industry 4.0

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Abstract: The Internet of Things (IoT) is a network of smart and self-configuring devices that exchange data by interacting with the environment to make decisions without human intervention. Endowed to sense surrounding events, these physical objects generate large amounts of real-time data that need an acceptable architecture with better security to process and convert it into meaningful information. Implementation of blockchain in IoT offers a secure, transparent and efficient mechanism to store and manage data generated by connected IoT devices. Even though the integration of blockchain with IoT is pretty recent, there are at present a huge number of applications that include smart healthcare, smart homes, e-government, automotive industry, smart education, precision agriculture *etc*. However, there are several challenges encountered in Blockchain-IoT integration which include anonymity, standardization, interoperability, heterogeneity, data privacy, smart contracts, legal issues, transparency, storage capacity and scalability, security, *etc*. This chapter presents the current state-of-the-art Blockchain-IoT integration in order to examine how blockchain could possibly improve the IoT ecosystem catered towards Industry 4.0. This chapter investigates the various application domains of Blockchain-IoT integration. It also discusses the main challenges faced in the adoption of blockchain in IoT environments for I4.0.

Keywords: Blockchain technology, Internet of things, Industry 4.0, Smart home, Smart education.

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1. INTRODUCTION

The rapid advancement of Internet of Things (IoT) technology has led to the increased use of a number of devices in a wide range of applications contributing to an extraordinary improvement in our day-to-day lives. IoT has led to an abrupt shift toward the digital world and has changed an ordinary world into a smart world. It has been estimated that there will be 20 to 50 billion IoT devices connected over the Internet by 2025. Therefore, the aim of IoT is to connect the entire world where objects sense the data about the surroundings and interact with each other making a digital representation of the real world. In an IoT system, a number of IoT devices, equipped with sensors and actuators, monitor surroundings and take necessary actions *via* intensive sensing and data aggregation over a network. The collected data from the IoT devices are transferred to fog or cloud *via* gateways (or edge) that perform pre-processing of data before transmitting over the network. IoT devices take the necessary action by executing commands using their actuators. The cloud gateway facilitates secure data transmission between the edge gateway and cloud servers. Cloud servers perform data processing such as data cleaning and structuring to store the required data in a particular context. Various data analytics techniques are used to find the insight into the data such as correlations and pattern findings, outlier detections, *etc*. Various machine learning models are used to create precise models for IoT control applications that send automatic alerts to actuators. The concept of blockchain came into existence in recent times because of its decentralized and peer-to-peer architecture. Blockchain finds its applicability in many fields such as healthcare, industry, supply chain management, *etc*. In most of these applications, there is a tremendous problem of trust due to a lack of the verification mechanism for sensitive information. Blockchain provides a mechanism where transactions are verified by a group of unreliable actors *via* a secure, distributed, transparent and audible ledger. Blockchain provides open and full access to all transactions occurred to date at any time. There are a number of protocols in blockchain for organizing the information in the form of blocks with each block storing the set of transactions performed at a given time. These blocks are linked together by a reference to the previous block, forming a chain of blocks. In blockchain systems, there are various services that should be provided by network peers to operate in the blockchain environment. The services include routing, storage, wallet, and mining. Fig. (**1**) shows the architecture for blockchain. Blockchain is considered an application software that is installed on several computers (nodes) in a network for registrations and transactions. In blockchain systems, a new block of information for each new register is created to the system. This new block is combined with the previous block of information using complex mathematical algorithms. The node which first calculates the new block transfers it to the other node on the network for approval. If approval comes, it is added as a new block in the blockchain system and accordingly updated on all nodes. Therefore, this creates a chain of blocks and is hence referred to as the blockchain.

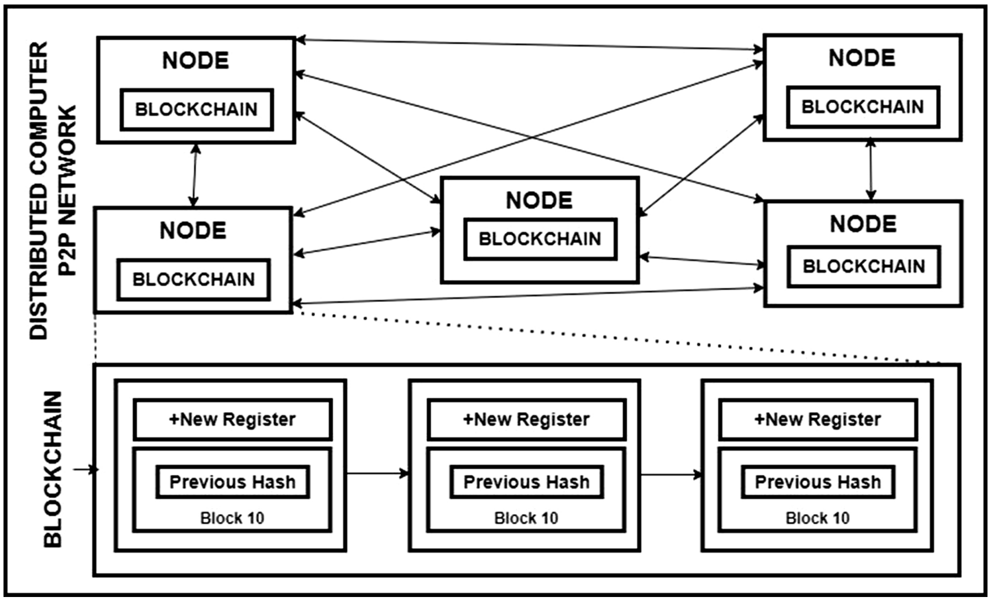

Fig. (1). Blockchain architecture.

Mining, storage, routing and wallet services should be provided by network peers to operate with the blockchain [4]. Different types of nodes can be part of the network as per the functions they provide. Table **1** summarizes some of the common node types in the Bitcoin network. Depending upon the level of security required and budget and nature of problem, we can have different types of nodes in a Bitcoin network based on the following characteristics.

Table 1. Common node types in bitcoin network.

Characteristics	Open	Secluded	Hybrid
Consensus Mechanism	Pricey Proof of work (Pow) required	Light Pow	Light Pow
Identity Secrecy	Malicious	Trusted	Trusted
Ownership and Supervision	Public	Centralised	Semi-centralised
Time taken for Transaction	Minutes	Microseconds	Microseconds

CHAPTER 2

Role of Blockchain Technology in Industry 4.0

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Abstract: Challenges in the industrial world are evolving rapidly. The game-changing technologies for overcoming these challenges on the path to Industry 4.0 are digitization and automation. We can control and improve every area of supply chain and manufacturing processes with the aid of Industry 4.0 technologies. It offers access to the real-time data and insights we need to run a company more profitably and efficiently. As a result, one can make better, quicker business choices. Supply chains and manufacturing processes may be built with the use of Blockchain technology. In this chapter, the connection between Blockchain and Industry 4.0 is made clear. The nine pillars of Industry 4.0 are defined as the core value drivers of the manufacturing process. The next part provides a quick overview of the characteristics of Blockchain technology. The final section investigates the function of Blockchain in Industry 4.0 through the use of different applications.

Keywords: Blockchain, Supply chain, Manufacturing, Immutable, Transparent, Trust.

1. INTRODUCTION OF INDUSTRY 4.0

The fourth industrial revolution, also known as Industry 4.0 (Industry 4.0), is now underway, and as a result, new disruptive technologies are being explored for integration into the manufacturing environment. One of these approaches is the Blockchain, which handles financial transactions, interconnects heterogeneous systems, and promotes asset traceability in a transparent and secure way. As a result, this technology helps to build an efficient supply chain that might have an influence on the worldwide market. The intersection between Blockchain and Industry 4.0 is revealed in this chapter.

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1.1. Core Value Drivers

Manufacturing businesses must identify and define their core value drivers enabled by digital technology in order to succeed in the upcoming industrial era. The core value drivers are depicted in Fig. (**1**). Industry 4.0 will boost prospects through innovation and custom solutions to raise customer value as well as operational efficiencies through Smart Factories and Smart Supply Chains. They will eventually result in whole new business models and service offerings enabled by digitalization [1].

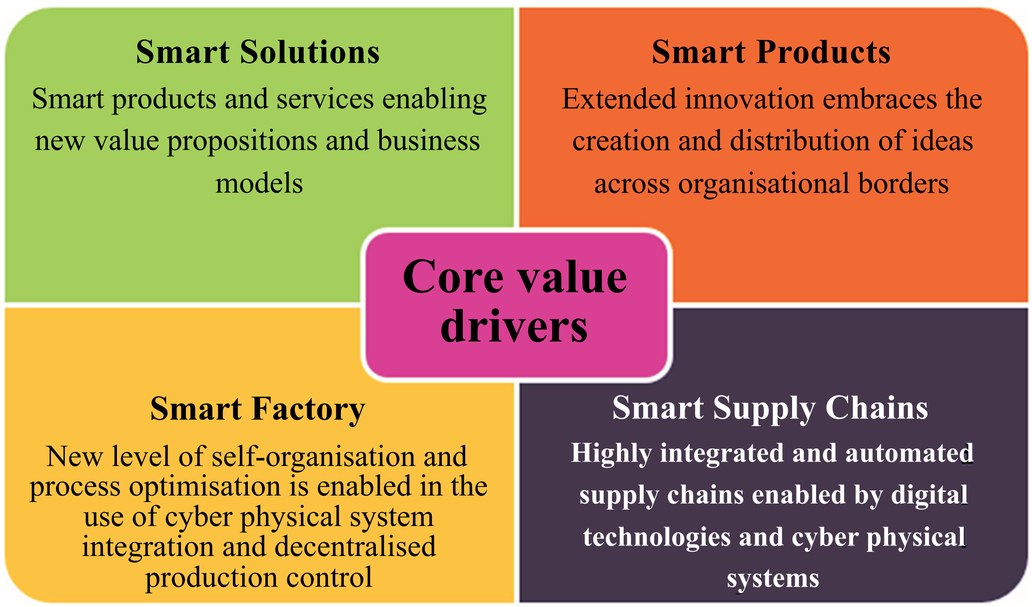

Fig. (1). Core value drivers.

1.2. The Nine Pillars of Industry 4.0

Industry 4.0 refers to a state of business that will be completely digitalized in terms of both production and financial flows. Every stage of the production process, in connection with the equipment, needs to be horizontally integrated. Machines communicate with one another in the globally networked environment of Industry 4.0 [2].

According to the Boston Consulting Group, Industry 4.0 is supported by nine technological pillars as shown in Fig. (**2**).

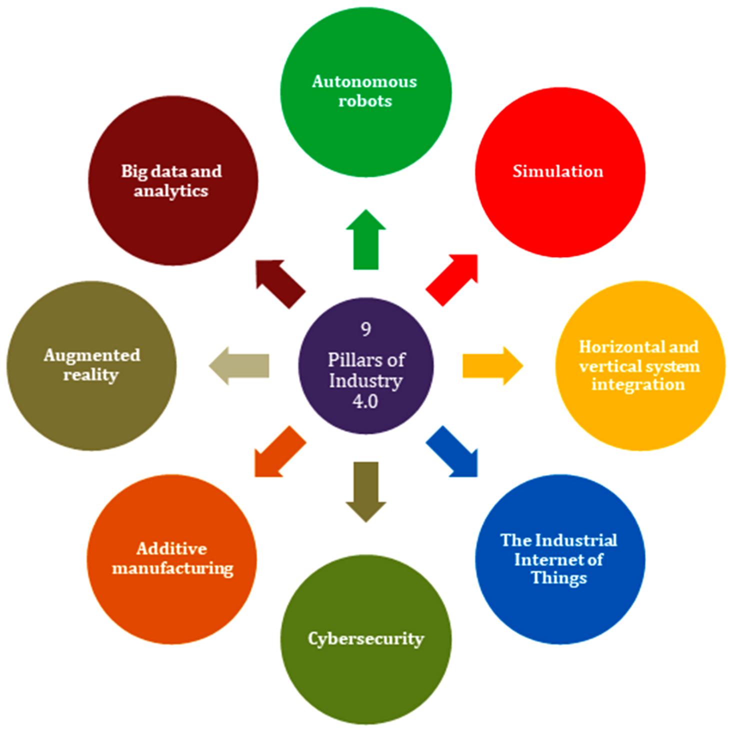

Fig. (2). 9 Pillars of Industry 4.0.

• Autonomous Robots

Robots have long been employed to complete complex jobs, and they now offer a greater range of services while also becoming more independent, adaptable, and collaborative. The term "robotics" is used to describe robots that assist operators in carrying out their responsibilities, and they will interact with one another and work safely with humans. They'll eventually be able to pick up knowledge from people. Robots have been employed by manufacturers across many industries to complete difficult tasks, but they are now becoming more useful. They are evolving toward increased adaptability, independence, and cooperation. They will consequently engage, collaborate, and learn from people in a safe manner. Compared to the current production robots, these analytic chatbots and robots will be more capable and affordable.

A company of robotic equipment in Europe named Kuka, for instance, provides communicative, autonomous robots. These robots are linked together so that they can cooperate and execute tasks that are automatically adjusted to the needs of the

CHAPTER 3

Adoption of Industry 4.0 in Remotely Located Industries

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Abstract: The manufacturing industry is revolutionized by introducing information and communication technology for productivity, flexibility, and agility. This Industry 4.0 has revolutionized the way companies manufacture, update and distribute their products. Manufacturers are integrating new technologies, like the Internet of Things (IoT), cloud computing, data analytics, and AI, into their production facilities and business operations. This digitization of manufacturing has increased the productivity of plants, reduced the dependency on human resources and improved logistics. This led to a better return on investment in the manufacturing sector and started blooming again. Many start-ups are coming up with new business ideas based on new technologies. These ideas are now easy to integrate with Industry 4.0-ready facilities. Now it is challenging to take advantage of this wave of new business opportunities for the traditional manufacturing industry. These industries strive to implement this technology for their plants, which are also located geographically remote. To sustain these older plants to new generation competition and expectations, it is necessary to shift and adopt the technology of Industry 4.0. Transition business models need to be developed for shifting to a "new business model" of the company, along with the "old business model" that is slowly "decommissioned". In this chapter, we will discuss the need, challenges, and advantages of integrating new technology into old manufacturing processes for the sustainability of a business. Organizations that wish to shift to a new paradigm face many challenges. The most challenging aspects include the skills and qualifications of their human resource, the ability of their machines to connect and communicate with each other, and the adoption of various new technologies.

Keywords: Cloud computing, Industry 4.0, IoT.

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1. INTRODUCTION

Global competitions, unpredictable markets, and demand of highly customized products become important factors for the manufacturing industry for survival in the market. Digitalization and new affordable technology are playing a vital role in changing the market trend. (Kumar *et al*., 2018). The manufacturing industry is now in the age of Industry 4.0. This Fourth Industrial Revolution, with its high data connectivity and scale, allows you to take a more data-driven approach to industrial operations. The data is pulled from available resources; value addition is done and used for more intelligent decisions. We can integrate more assets into business workflows with technologies like 5G, edge computing, and AI. Real-time production planning is possible in Industry 4.0 with dynamic optimization [1, 2]. Industry 4.0 enables the implementation of processes that are autonomously controlled and dynamic. The value chains are optimized and could combine with the integration of information and communication technologies. Modern information and communication technologies could be implemented in manufacturing machines, production workers, and logistics. This set better communication among all participants in the product manufacturing process. The data collected is continuously analyzed according to defined algorithms, and production flow is controlled for continuous improvement. In order to have process competitiveness along the value chain, it is necessary to design productive, efficient, and flexible methods. These production processes need to be personalized to cater to the need of a customer. Therefore the volume of products manufactured in a plant is limited. To cater to this need for production, Industry 4.0 provides fast communication and autonomous, flexible manufacturing processes. Business houses can take advantage of the new age revolution using technology like 5G, Industrial IoT(IIoT), AI, and other advanced technologies. Transparency in the processes increases the understanding of business [3]. This gives the right information to the right person, who can make the right decision. The main goals of Industry 4.0 are personalized production, servicing, as well as real-time usage by customer interaction and avoiding the inefficiencies, irrelevance in design, and costs of intermediaries in a digital supply chain model. This customer-centric approach who demands cost efficiencies, value-added innovative services and speed of delivery.

The organizations that have an old plant with earlier manufacturing processes now want to shift to new paradigms of Industry 4.0. The challenges faced by them are many. Affordable new technologies like fast communication, high data transfer, Internet of Things (IoT), machine learning, and cloud computing, help these organizations for adopting new manufacturing processes. Other issues of firms are related to innovation, technological components, digital transformation, and interconnectivity developments between various resources that play an essential role [4]. Industry 4.0 consists of providing a new way of manufacturing and depends upon end-to-end digitization of all physical assets and integration into digital ecosystems of all value chain partners. This evolution from old manufacturing processes to new manufacturing processes needs insulation of the upcoming business model from old behaviors, metrics, processes, and reporting norms. It is challenging to develop a new business model with full access to existing core competencies, expertise, and networks. Adopting Industry 4.0 leads to diverse technological challenges to implement in existing manufacturing setups. Therefore it is required to develop a strategy for all stack holders involved in the entire value chain, to reach a common agreement on security issues and the allied architecture before implementation begins. To take the old manufacturing setup to a new digitized plant, it is necessary to define new metrics, technical solutions, and value propositions to tackle the issues. Human resource plays an important role in digitization. Proper awareness about new technology, advantages, and roles should be provided. Once the benefit of digitization in making working simple and controlled is well explained, people support the transition.

The convergence of 5G, IoT, and cloud computing technologies is the main facilitator and accelerators of Industry 4.0. The emergence of high-speed networks and data transfer helps in shifting computing from local sites to the cloud. The cloud also brings the advantage of low cost of computing without the setup of a costly hardware platform at the local site [5]. High-performance computing using cloud setup improves the decision from end-to-end digitization of value chain processes. The predictive demand will help to control inventory, thereby reducing the cost of production. Similarly, as the whole chain of production is monitored by collecting data from various points, it is easy to apply predictive maintenance to reduce downtime of plant or machinery.

In this chapter, we discuss the conversion of an old manufacturing unit into a digitized manufacturing unit. For this, a leather manufacturing unit is considered. The leather-producing unit is considered as polluting manufacturing, hence located in a rural area or outskirts of an urban area. Such units do not have the advantages of technology and communication. Converting such units into modern, flexible manufacturing has many challenges. This chapter discusses the issues and solution of such conversion with respect to leather manufacturing units.

2. COMPONENTS OF INDUSTRY 4.0

Manufacturing in today’s era has changed from mass production to customized production. Innovation, flexibility, and real-time response are challenges in today’s production processes to keep the challenges of modern business

CHAPTER 4

Predictive Analytics Algorithm for Early Prevention of Brain Tumor using Explainable Artificial Intelligence (XAI): A Systematic Review of the State-of-the-Art

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Abstract: Advancement in the medical field promotes the diagnosis of disease through automation methods and prediction of the brain tumor also plays an important role due to the fact that millions of people are affected by brain tumor and the rate of affected people is increasing every year randomly. Hence, in saving the lives of many individuals, the early detection of the disease plays an important role. Using the MRI Images, it's easy to find the location and existence of the tumor. Expert manual diagnosis is playing a vital role in detecting the information about the tumor and its type. Though there are various models that can detect tumor location with the help of ML models in the medical field, somewhere there is a lag in the success of these models. Deep learning is one of the widely used approaches for the same. But the black-box nature of these machine-learning models has somewhat limited their clinical use. Explanations are essential for users to know, trust, and well manage these models. The chapter proposes dual-weighted deep CNN classifiers for early prediction of the presence of brain tumor along with the explanation-driven DL models such as Local Interpretable Model-agnostic Explanations (LIME) and SHapley Additive explanation (SHAP). The performance and accuracy of the planned model are assessed and relate with the existing models and it is expected that it will produce high sensitivity as well as specificity. It is also expected to perform well by means of precision and accuracy.

Keywords: Deep Learning, Dual weighted deep CNN classifier, Explainable artificial intelligence, LIME, Machine learning, SHAP.

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1. INTRODUCTION

In order to produce an action, a complex network of fiber tissues and nerves that stimulate nerve impulses all over the body comes into play. There are two types of nervous systems: peripheral and central. As the central component of the nervous system, the human brain coordinates the functions of the various parts of the body in order to control it [1]. The activities of the brainstem are controlled by the various components of the brain, such as the movement of the muscles, the sense of touch, and the perception of things. The brain tumor consists of irregular cells that develop a structure in the form of a mass [2]. Any expansion within this region, which is only a small area, will trigger severe problems.

Non-malignant and benign brain tumors can be of different types. When these tumors grow, the pressure within the skull increases, which can lead to permanent brain injury [3]. Most brain tumors cause headaches, changes in mood, and difficulties speaking. Other symptoms such as vomiting and high blood pressure can also be caused by these types of tumors [4, 5]. Brain cancer is a benign or malignant development of anomalous cells in the brain that can be cancerous or non-cancerous. Benign tumors have a uniform structure but no active cells, whereas malignant tumors have aggressive cancerous cells and a non-uniform structure [6].

These cancers are categorized as either primary or metastatic. However, in tumors, cancer cells have expanded into the brain from another afflicted body area [7] and the cells in initial brain tumors are essentially brain cells. Early identification and categorization of brain tumors is a heavily researched subject in the medical imaging field, as it aids in determining the much more suitable treatment options to save patients' lives [8]. Brain and other cancers killed more people than any other type of neurological illness. It is the 10^{th} largest cause of death for women and men. According to brain tumor estimations, "it is predicted that 23,890 individuals (13,590 men and 10,300 women) in America would be clinically tested with the cancer of the brain and spinal cord in the present year." Furthermore, primary malignant brain and CNS tumors are estimated to kill 18,020 individuals (10,190 men and 7830 women) in 2020. Furthermore, "the survivability percentage for persons along with malignant brain or CNS tumor is about 36% for 5 years and 31% for 10 years" [9]. The implementation of deep learning algorithms to identify brain tumors with greater accuracy and reliability has been an area of substantial possibility and interest [12]. Brain tumors affect 700,000 people in America, with that number predicted to rise to more than 79,000 by the end of 2020. 25,000 of them may have malignant tumors, with the rest having non-malignant tumors [15]. The most frequent category of brain tumor is Glioma and it is classified as low and high-rank brain tumors, with high rank being more deadly than low-grade [16].

Researchers have recently researched brain tumor categorization using machine learning algorithms, particularly in recent spans. The advancement of AI and DL-based technological advances has had a significant influence on medical image processing, particularly in illness detection. Because it provides extensive information, brain MRI is commonly used to diagnose malignancies. Some tumors, such as gliomas and glioblastomas, are extremely hard to locate in MRI, whereas meningiomas are quite simple. Despite X-ray and computed tomography (CT) scan pictures, the measure of cluster values in MRI is not uniform. While some brain segmentation approaches use handmade characteristics. Deep Neural Networks (DNNs) for feature extraction have recently been used. The identification, segmentation, and tracing of brain tumors over time are critical for detection, treatment planning, patient care, and tracking and for prediction as well. For radiologists, tumor segmentation is time-consuming as per as the traditional process is concerned, and also laborious, and prone to human error in practice. Because of the tumor's unexpected appearance, penetration into adjacent tissue, intensity, heterogeneity, size, shape, and position fluctuation, and longitudinal brain tumor segmentation is a significant chore [17]. However, computer-aided medical image processing tools are increasingly assisting clinicians in identifying brain cancers [20]. Because of their complicated anatomical structure and importance in studying human behaviour, there has been an extensive variety of applications in computer-aided medical image study and diagnosis, and segmentation in MRI brain images.

1.1. Explainable AI

XAI (Explainable AI) incorporate strategies and procedures in the field of AI technology that allow humans to understand the outcomes can be understandable to the humans. Fig. (**1**) illustrates the idea of the XAI.

Explainable Artificial Intelligence is an edge that focuses on creating a collection of ML methods that 1) guarantee a high level of learning performance by creating more explainable models (*e.g.* accuracy of prediction); and 2) facilitate humans to grasp, and adequately believe in the next generation of artificially intelligent stakeholders.The goall of such an initiative is to prevent explainable AI from reducing the efficiency of today's AI systems.

CHAPTER 5

Designing a Human-centered AI-based Cognitive Learning Model for Industry 4.0 Applications

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Abstract: The aim of this chapter is to focus on the status of data mining approaches for e-learning and identify the gaps in them. It is seen that a predominant work has been done in e-learning through data mining techniques such as educational recommenders, association rules, clustering, profile-based approaches, personalization, prediction techniques, and decision support systems. However limited work is done on e-learning from a cognitive science perspective, which gives us the motivation to work in this field. The proposed work aims at proposing a cognitive model for e-learning systems using data mining for Industry 4.0 applications which shall usher in a new datum for e-learning in cyber-physical systems.

Keywords: Artificial intelligence, Cognitive learning model, Cognitive e-learning.

1. INTRODUCTION

The main objective is performance evaluation of e-learning systems in order to identify the learner's learning style and propose a cognitive e-learning model to improve students' experience. The main emphasis of this work is on delivering content based on their behavior while learning. Learning style differs with respect to multiple dimensions which are demographic features, social and economic content, emotional condition of the learner, and physiological and physiological elements. The learning style can also be predicted from the behavior of learners such as how people gain knowledge and preserve skills, ways of accessing information to help their progress, *etc*. The aim is to make e-learning similar to classroom learning.

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More specifically, the following are the main objectives and methodologies:

1. Encounter Cold-Start Problem in e-learning,

2. Explicit feedback from students and teachers for questionnaire collection and statistical analysis related to learning styles,

3. Determination of the cognitive factors that affect student's learning,

4. Identifying the constraints *(e.g*. time constraints) present in the e-learning system,

5. Weighting the cognitive factors and constraints,

6. Evaluation of the performance of learning of student according to these cognitive factors,

7. Designing a cognitive model for e-learning applications using data mining techniques,

8. Identification of patterns present in learning styles for students, and

9. Recommendations to the students *(e.g*. course preferences).

The proposed cognitive model for e-learning will assist in students' learning and provide teachers with the necessary feedback. The only crucial step in this model is weighting the cognitive and constrained factors of e-learning because the priority of each factor can differ from one university to another. The end results of the cognitive e-learning model will also provide significant information to teachers and decision-makers for improving e-learning programs in the future.

The work will be carried out by comparing our proposed model with the standard model in order to prove the efficiency of our model. Analysis of cognitive data will be carried out in MATLAB and data mining tools.

2. NATIONAL AND INTERNATIONAL STATUS

With the advancement in information technology, electronic learning (e-learning) has played a key role in teaching and learning which has become more and more important in colleges and schools nowadays [1]. Further, the COVID-19 pandemic has led to a rise in teaching and learning courses through online portals [2]. Various educational institutes have adopted video conferencing platforms such as Microsoft platform, Zoom and Webex Blackboard, and Google Classroom, leading to the enhancement of e-learning globally [3]. There are many advantages of e-learning which include no time and space constraints for learners to study courses, saving internal training costs, improving classroom teaching, *etc*. The design of e-learning objectives focuses on providing opportunities for students to learn through virtual experience the functional value of the material by working directly with the content. There has been a recent shift in attention toward web-based e-earning systems that provide us a virtual educational environment independent of any specific hardware platforms [4].

Research in e-learning systems has been focusing on various methodologies to keep learners as active learners for longer duration and how to deliver appropriate learning and learning material for them. Authors [5] developed a learning model using various research works on psychology and cognitive science. Learning is the process of retrieving the relevant information by integrating knowledge/behavior of the learners. Learning goals should be compatible with learner's background knowledge, their interest and learning style. Research on learning face challenges in terms of explicit issues such as indirect suggestions and implicit issues e.g. course recommendations [6]. Learner personalization characteristics play a vital role in e-learning. Authors [7] proposed that learning is a process to acquire knowledge that can be created through the transformation of experience. Some authors [8] define learning style as an instructional strategy which helps in improving cognition, based on the context and content of learning. Learning style can be predicted from the behavior of learners like how people gain knowledge and preserve skills, their way of accessing information to help in their progress, *etc*.

According to a study [9], the most important aspect in the design of active learning applications should be grounded in the principles of cognitive science. Cognitive e-learning focuses on best practices for designing an online course, organizing and presenting its content, helping students develop skills, deciding on teaching and assessment methods, incorporating social interaction and providing students with feedback [10]. Designing a cognitive model for a real-time e-learning application should clearly distinguish between two things whether the system is a rule-based system or a constraint-based model. The working principle of a rule-based model purely depends on the knowledge of the end-user and the constraint-based model expresses its requirement by raising queries. These queries should be resolved with the help of problem related e-learning [11].

The concept of cognitive e-learning has led to several technological developments in teaching which include intelligent tutoring systems that redirect the students to the next steps in learning; artificial intelligence that represents the mental learning processes; pre-determined learning outcomes based on different cognitive activities; and instructional design approaches that ensure the success of learning

CHAPTER 6

Integrating Internet of Things (IoT), Machine Learning (ML), and the Cloud Infrastructure to Monitor Driving Behavior for Usage-based Insurance in the Indian Context

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Abstract: Although Usage-Based-Insurance has a wide range of applications, it is practically nonexistent in India. We have done research to help design a system that combines IoT, ML, and cloud to help us overcome this problem as a next step. The goal is to create a machine learning model for the cloud that will allow us to calculate driver and customer safety scores based on where and how the car has been driven. We were able to do this by evaluating information from our smartphone's sensors. Utilizing this data and classification system, problems like Usage-Based-Insurance can subsequently be resolved in the real world (UBI). Usage-based insurance has proven to be efficient and appealing to both insurers and the ones insured in a wide range of countries. The use of this method is sparse to nonexistent in India, but it is on the horizon. As a result, there is a lot of potential for our research and suggested works on UBI in India.

Keywords: Cloud, Driver Behavior, IoT, Machine Learning, Pay-as-you-drive, Smartphone, Sensors, Usage Based insurance.

1. INTRODUCTION

Having the appropriate kind of knowledge, but more importantly, data, is critical in today's world. It's not about how much information you can receive, but about what kind of information you can get and why you want to have it. That is why data is so crucial. Because the world is constructed on data, it makes sense to learn how to use the information to improve the world in a variety of ways.

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As a result, the goal of our work is to collect driving data [1] and create a categorization system that will provide us with information about the driver's behavior and profile while driving. Utilizing this data and classification system, problems like Usage-Based-Insurance can subsequently be resolved in the real world (UBI).

Usage-based-insurance, also known as the Pay-As-You Drive (PAYD) model, is effective for giving cheaper insurance to consumers who have strong safety scores rather than relying solely on other statistical characteristics such as age and gender (age, gender, marital status *etc*.) [2]. This system will assist us in identifying driver behavior based on characteristics such as aggressive braking, sudden turns, speeding, and cornering, which will aid us in preventing vehicle accidents caused by road rage. The fundamental goal of UBI is to provide a more practical and equitable method for determining risk, with customers who have demonstrated aggressive driving behavior being required to pay a higher premium [3, 4].

Usage-based insurance, sometimes referred to as pay-as-you-drive insurance, is a type of auto insurance that, depending on the specific insurer's programme, can track how far, where, and how a vehicle is driven [5]. We plan to accomplish this by performing analysis on the data obtained from sensors on our Smartphone. The number of cell phones in use around the world continues to rise year after year, resulting in new signal processing applications.

The Smartphone is a ubiquitous gadget that comes pre-loaded with a variety of environmental sensing capabilities. Modern smart phones also have adequate processing power to clean data and run classification models [6]. Usage-based insurance has been shown to be efficient and desirable to both insurers and insured in a wide range of countries. The usage of this approach is sparse to nonexistent in India, but it is on the horizon. As a result, there is a lot of potential for our works' utilization in India.

On top of standard rating procedures, age, gender, marital status, credit and driving records, and insurance ratings, which have all been shown to be predictive over time, are the risk factors and variables that are being examined in the context of UBI. UBI broadens the range of pertinent data, enabling risk to be evaluated in light of actual driving behavior, propensities for safe or dangerous behaviors, trip specifics, vehicle condition, location of operation, weather circumstances, and more [7, 8]. When combined with standard rating criteria, UBI demonstrates a more accurate evaluation of risk, allowing insurers to give the best drivers the biggest discounts while yet maintaining a healthy profit margin.

2. BACKGROUND

The country's insurance regulator, Insurance Regulatory and Development Authority of India (IRDAI), has granted general insurance companies' permission to introduce tech-enabled concepts for the Motor Own Damage (OD) cover in order to provide customers with usage-based insurance covers as add-ons to the basic policies of Motor Own Damage. The regulator claims that the concept of auto insurance is always evolving. It is enabling general insurers to add complex add-ons to Motor Own Damage coverage, like "Pay as You Drive" and "Pay How You Drive," in an effort to facilitate technology-enabled policies. Additionally, the regulator has authorized insurers to design floater policies for two-wheelers and private vehicles owned by the same person.

Planning, labor, technology and equipment, logistics, and support all contribute to the efficient deployment of UBI and analytical tools to record and analyze driving data. However, the financial benefits of usage-based insurance often justify these costs:

- Recruiting low-risk drivers
- Increasing customer retention
- Lowering the cost of claims
- Annual increases in the number of potential touchpoints
- Providing insurance plans with individualized, revenue-generating value-added services in order to better satisfy consumer interests.

Telematics can assist insurance carriers in strengthening their market position through the addition of low-risk drivers to their customer base, the use of driving data to enhance pricing, enhancing the customer's perception of the business as more technologically advanced, and strengthening long-term relationships through improved communication [9]. The likelihood of success when creating a telematics programme can be increased by employing certain tactics such as rigorous planning and testing, the use of value-added services, the management of customer interactions, the pricing model, and efficient data analytics use within the programme. Overall, it is evident that the auto insurance sector is evolving quickly. Usage-based insurance programmes will give early adopters a substantial edge over those who wait and run the risk of losing important clients to more creative competitors.

The survey's findings [10] suggest that aggressive driving practices and episodes of road rage, such as speeding in congested areas, cutting lanes, and abrupt braking by drivers, need to be addressed. Attempts to identify the risk posed by aggressive driving by taking into account a driver's behavioral and emotional

CHAPTER 7

Academic Emotion Prediction in Online Learning Utilizing Deep Learning Approach

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Abstract: As the world is progressing more towards new technology, more and more people are getting close to computers to perform their tasks. Computers have become an integral part of life. In recent years, web-based education has been perceived as a support tool for instructors as it gives the comfort of use at any time, and any place. In this situation, recognizing the user's engagement with the system is important to make human-computer interaction more effective. Recognizing user engagement and emotions can play a crucial role in several applications including advertising, healthcare, autonomous vehicles, and e-learning. We focus on understanding the academic emotions of students during an online learning process. Four academic emotions namely, confusion, boredom, engagement, and frustration are considered here. Based on the academic emotions of students, we can incrementally improve the learning experience. In this paper, we have developed a system for identifying and monitoring the emotions of the scholar in an online learning platform and supplying personalized feedback to reinforce the online learning process.

To achieve this, we have extracted images from the videos of the DAiSEE dataset and performed pre-processing steps like convert it into greyscale, detect a face from that image using OpenCV, change the size of the image, and then save it. Then labeling of the emotions is done and the model is trained using a convolution neural network (CNN) on the said images. In this way, the neural network is trained and can predict the emotion.

Keywords: Academic emotions, Convolution neural network (CNN), DAiSEE dataset, E-learning.

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1. INTRODUCTION

With the modern education paradigm shifting towards the online mode from conventional classroom teaching, a good online platform is needed in today's world for both the learner and the teacher. This online platform should take advantage of modern technology and research like machine learning and neural networks. In this modern world, we cannot rely on the sheer ability of the teacher to recognize the ability of students. We can take advantage of this new emerging and convenient technology of machine learning to better help our students to achieve their goals and help our teachers ease their tasks.

In the current scenario, many times students lack interest in the lecture due to distance learning. Hence even an important lecture becomes boring for them and all the efforts made by the faculty become ineffective. So, the need is to have more interactive lectures to recognize students' emotions during learning. Hence there is a necessity for a system that can recognize the state of mind of the student.

The improvement in online learning platforms has been made by researchers in the last few years. By understanding the emotions of students, faculty can change the teaching style or give more/less attention to particular students which might change the performance of the student. The academic emotion detection system is used to figure out the emotions of a student throughout his learning process. Thus giving the teacher feedback on the progress of the student. This system helps the teachers to take corrective action at a certain point for the students who are in states of confusion, boredom, and frustration, instead of waiting till the end of the course. Teachers may give an alarm to the students and ask for reasons for not concentrating on the course. In the same way, this system is really helpful to the students as they get an alarm from the teacher so they start concentrating on their studies to avoid further failure.

It is possible to implement such systems using approaches based on interaction log, the expressions, eye movements, head movements, and various sensors like Galvanic Skin Response (GSR), Electromyography (EMG) sensor, and Electrocardiogram (ECG), *etc*. while the student is watching the online lectures.

Some experiments predict emotions with the use of bio-heart rate sensors [1, 2]. The sensors would record variations in the autonomic nervous system (ANS) of the body. They also used a Support Vector Machine (SVM) algorithm for training data and predicting emotions [1, 3, 4]. But for making use of sensors, data need to be collected in a close environment.

If the video is captured through the student's webcam and the processing is done to know how much the student is concentrating and perceiving the contents, then this information can be viewed by the teacher to track the progress of the students and then he/she can make changes accordingly in either the curriculum or in the teaching method. In this work, we are using DAiSEE (Dataset for Affective States in E-Environments) dataset to train the machine learning model [5]. DAiSEE dataset is available to the community for research. We are focusing on academic emotions engagement, frustration, confusion, and boredom here, which are relevant to students' learning.

2. LITERATURE SURVEY

A literature survey was initiated to understand the role of academic emotions in learning. Many researchers have worked on eye movement [6]. By keeping track of the movement of the eyes, researchers have classified the state of mind. In a paper [6], the researcher measured the concentration level based on eye movement and head position. A person's body gesture is also taken into consideration to get the correct output [7]. Here authors have considered the upper portion of the body. Commercial sensors like Kinect are used to capture the data which helps identify gestures but they are of high cost. Few researchers have built a robust technique called field-programmable gate array (FPGA) with some algorithms for Regression Modeling.

It is estimated that a person's eye gaze performs an important role in understanding emotions [8]. Facial expressions, voice, and bio-potential signals also play an important role in predicting emotions [9]. For capturing data of signals, commercial sensors are required which are costly. For doing such an experiment, a close environment will be required due to the limitation of resources and it is a bit difficult to make use of them. As far as the interaction log is concerned, you need a platform where it is possible to collect data that is required for prediction. But as far as facial expressions are concerned, it is possible to capture video using a webcam while learning and then either extract frames from it or do processing on videos to predict various emotions.

Various tools and techniques are proposed to identify emotions [9, 10]. Gupta, A, and their team [11] developed DAISEE: Dataset for Affective States in E-Learning Environments, the first multi-label dataset having 9068 videos captured from 112 users. It has images of confusion, boredom, engagement, and frustration.

Researchers Brigham TJ and team [12] used a mix of various information sources – facial expressions, voice recognition, and gestures to predict the emotions of an individual. Authors [13] have recognized emotions using commercial sensors.

CHAPTER 8

Implementation of Fruit Quality Management and Grading System using Image Processing and ARM7 Platform

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Abstract: Throughout the history of the industry, producers and retailers have focused on fruit quality as a major concern. Over the past ten years, the market for high-quality fruit has expanded quickly, raising the price of the upscale item. However, the state-of-the-art methods have some major drawbacks such as the mechanical systems are bulky, require more manpower to operate the system, are less accurate, slow, expensive and with more chances of human mistakes. In this paper, we have addressed these drawbacks and proposed systems for the management of the fruit quality and grading of fruits in different categories. These fruits can be sorted automatically depending upon their different characteristics such as color, size, shape, weight, specific gravity, sugar contents, and ph. In this paper, we have selected three characteristics of fruit namely color, size, and weight for measuring the quality of fruit and grading them accordingly. The result shows that the proposed system has successfully implemented fruit quality management and grading. The system is automatic and results in lightweight, simple and inexpensive hardware, increased speed of operation and reduces manpower, and mistakes.

Keywords: ARM7, Fruit quality, Image processing.

1. INTRODUCTION

The field of electronics has made a tremendous revolution in almost all the fields in today's life such as communication, entertainment navigation, industrial environment, *etc*. The agriculture field is also not an exception to it. Since India is a horticultural country, the economy of India relies upon farming, and thus, there is a large scope of developments in the agriculture field.

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Throughout the history of the industry, producers and retailers have focused on fruit quality as a major concern. Over the past ten years, the market for high-quality fruit has expanded quickly, raising the price of the upscale item. In the event that the nature of the organic product is chosen physically, it has different hindrances, for example, the undesired method for taking care of the organic products, weariness, and absence of sight; quality criteria can differ from person to person. Thus, the sorting of good quality fruits becomes difficult.

2. LITERATURE REVIEW

Iqbal *et al*. [1], proposed an algorithm to categorize particular citrus fruits, for example, orange, lemon, and sweet-lime. The researchers, Nandi *et al*. [2], proposed a reviewing framework for mango natural products. Researchers Dubey and Jalal [3], proposed a texture feature for color images and validated it for fruit and vegetable sorting. The researcher Habib *et al*. [4], proposed recognition of papaya disease based on machine vision. The researchers Bhargava and Bansal [5] introduced a writing survey on PC vision-based quality assessment of fruits and vegetables. The researcher Dang *et al*. [6], proposed an image processing based fruit size detection and grading system. The researcher Njoroge *et al*. [7], proposed a picture handling based programmed natural product evaluation framework. Another researcher [8] proposed a computerized natural product reviewing framework in view of a picture acknowledgment procedure. Some of the major drawbacks of these state-of-the-art systems are as follows [8]:

- These mechanical components are substantial.
- Requires manpower to function machine.
- Less accuracy.
- Deteriorated area.
- No operation is entirely automatic.
- More probabilities of human error.
- Even when controlling is semi-automatic, accuracy suffers because it is done manually.
- Non-automatic systems are very high-priced.

Hence, we have proposed a system that overcomes all these drawbacks. The proposed system measures the quality of the fruits and sorts them into different categories automatically. The fruits can be sorted depending upon their different characteristics such as color, size, shape, weight, specific gravity, sugar contents, and ph.. In this paper, we have selected three characteristics of fruit namely color, size, and weight for measuring the quality of fruit and grading them accordingly.

The fruit quality management and grading of different circular fruits such as apple, tomato and orange, *etc*. can be achieved using the proposed system. These fruits can be graded in various classifications utilizing different reviewing standards of natural products, like products of a particular tone, products of a particular size, and products of explicit weight. In this paper, we have proposed the Tomato quality management and grading system. Fig. (**1**) shows the grading process of Tomato. Whereas, Table **1** shows different grading categories of fruits [8].

Table 1. Shows grading categories of fruit *e.g*. Tomato.

Grading Category of fruit *e.g*. Tomato		
Grade	Color and weight specification of fruit	Fruit Diameter
A	Tomatoes with Red color of more weight	Diameter 4cm
B	Tomatoes with Red color of less weight	Diameter 3cm
C	Tomatoes with Green color of more weight	Diameter 4cm
D	Tomatoes with Green color of less weight	Diameter 3cm

The proposed system has the following advantages:

- Fully automatic and smooth operation possible.
- The database of each fruit is created for quality analysis.
- Comparatively less expensive.
- The quality of fruit is decided without physical contact with fruit.
- Any damage to fruit is completely avoided.
- The scale of quality parameters can be changed.
- Completely user-friendly operation.
- Fruits are divided into three categories according to quality.

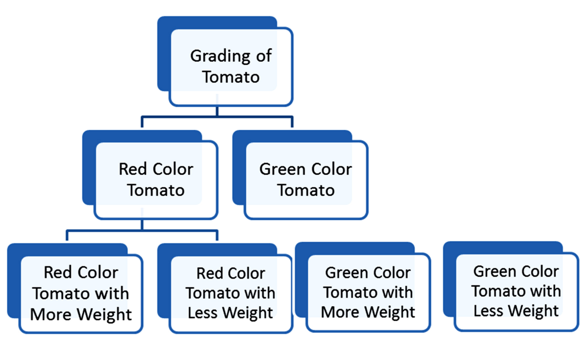

Fig. (1). Indicates the grading process of Tomato.

CHAPTER 9

Internet of Things-based Smart Sensing Mechanism for Mining Applications

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Abstract: According to the English lexicon, mining is the extraction of coal or other natural minerals from a mine. Extracting these natural minerals is extremely risky, and employees' lives are at stake. Mining workers are exposed to a dangerous underground environment that can cause harm or even death. Some of these injuries or fatalities can be traced back to human error. However, several physical factors or reasons for such a subterranean environment might be blamed for these mishaps. It is not easy to monitor without endangering someone's life. Previously, companies depended on manual processes where an individual would physically inspect the situation, make observations, and submit a report. This technique was too hazardous since the person monitoring a specific threat may be harmed by the same hazard. As a result, this has been the mining industry's most serious challenge for a long time. A smart system can detect problems and communicate information to the relevant authorities before anything hazardous occurs due to this procedure. This smart network system uses wireless sensors and an IoT platform. Gas, temperature, humidity, and vibration sensors are the various types of sensors used to detect the presence of any toxic gas, monitor the temperature, identify the amount of humidity in the air, and monitor subsurface tremors, respectively. All of these sensors are linked together, and the data collected by these sensors is subsequently sent to the cloud for processing. This analysis will assist the system in understanding subsurface behavioural changes, and as a result, it will be able to provide warnings of impending dangerous circumstances. The Raspberry Pi and the Raspberries operating system are used for data analysis. This smart system intends to lower the risk of accidents and infections, benefiting workers and the company's economy.

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Such IoT architecture in the mining industry, which combines operational technology (OT) and information technology (IT), provides a safer mine site for workers, reliable mining operations, a highly integrated environment for both traditional and innovative sensors and equipment, automation that can reduce human intervention and covert surveillance. This research aims to increase IoT adoption in the mining sector by combining a high-level architecture, complying with all industry standards and guidelines, and addressing the mining industry's specific challenges.

Keywords: IoT, IIoT, Mining Industry, Operational Technology, Wireless Sensor Networks.

1. INTRODUCTION

The Oxford vocabulary describes mining as "the process or industry of extracting coal or other minerals from a mine". Risky activities are carried out in order to obtain these mineral resources. Mine workers are exposed to a dangerous work environment that puts them in danger of dying or suffering life-altering injuries. Many of these deaths and injuries are caused by human error.

However, these situations are determined by underlying natural conditions, and these malfunctions can be attributed to them. It is challenging to monitor such circumstances without endangering lives. Fig. (**1**) illustrates how mine monitoring was done by sending someone to the mine and having them report back. However, this approach is risky because the person watching a specific potential threat could also be hurt by it. This level of close observation is inappropriate.

Fig. (1). Mining area [1].

Particular technologies or strategies are created to protect workers from harm in these challenging conditions. “Occupational health and safety” is more formal and describes these procedures. This standard intends to lower the frequency of occupational illnesses and injuries, which will benefit mine workers and the broader economy. These errors may result in underground mining damages due to early retirements and higher insurance costs. The majority of the largest mining businesses in South Africa have been certified, demonstrating the importance of this standard's cooperation. This benchmark can be strengthened using contemporary technological policies to achieve the best results.

As shown in Fig. (**2**), information technology and intelligent framework implementations have enhanced, and the number of devices connected that use the Internet of Things technology (IoT) has increased significantly. Smart grids are one of the smart city's foundations, and IoT technology is used in several applications. IoT is a technical framework that imagines a globally interconnected network of devices and machinery. Smart home devices, smart metropolitan areas, agricultural sectors, automobile sectors, medical services, the manufacturing industry, and public transit are all affected by the IoT. It is estimated that between fifty and one hundred billion smart things and objects will be linked to the internet by 2023. The manufacturing industry is being further developed to reconsider its mechanisms from this perspective, which can inspire primary production developed early.

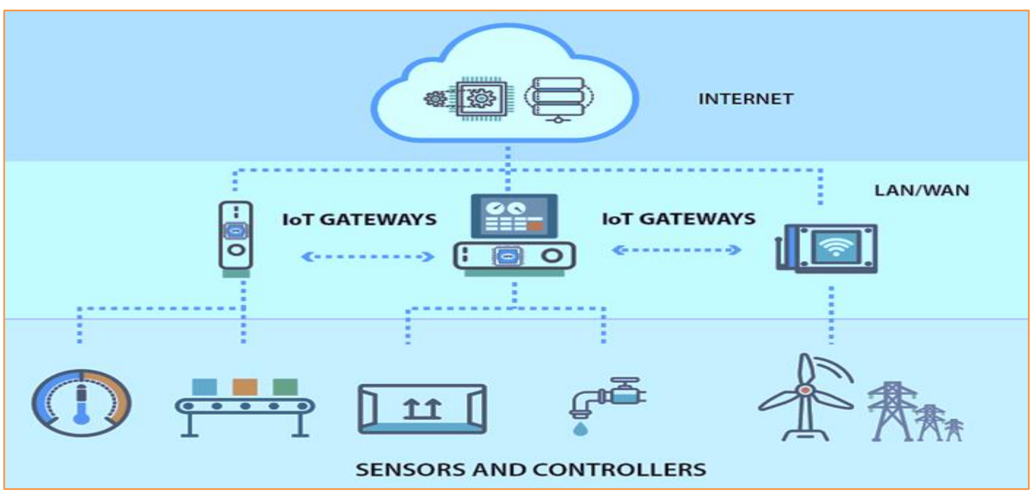

Fig. (2). General architecture of IoT [1].

Industrial Revolution 4.0 includes the Industrial Internet of Things (IIoT), which is an implementation of IoT in the industry sector. The IIoT, which integrates the strong points of the mature industry with the internet, emphasizes the notion of

CHAPTER 10

Explainable Artificial Intelligence (XAI) for IoT

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Abstract: Artificial Intelligence and Machine Learning are the latest topics across industries. A lot of concentration has been given to these areas and still the adoption has been challenged by users and experts in this field in the search for some kind of solution to be provided that the output can be trusted by all. The purpose of this paper is to focus on the sensor data coming from various IoT devices and how the data can be interpreted by various available algorithms. The ML algorithm is considered a black box with a focus on providing the required output without finding the causes behind the decision and working mechanism provided by that model. In this chapter, we tried to explain various common techniques/models available for eXplainable Artificial Intelligence (XAI) and how those can be used for IoT data.

Keywords: Artificial intelligence, Explainable artificial intelligence (XAI), Machine learning (ML), The internet of things (IoT).

1. INTRODUCTION

Recently, the influence of advanced and sophisticated techniques such as explainable artificial intelligence (XAI), machine learning (ML), and deep learning (DL) on the Internet of Things (IoT) is increasingly intensified. With the increase in the number of connected devices , the IoT usage needs some kind of trust among the users and hence, Explainable Artificial Intelligence (XAI) is an intriguing modern conversation topic [1]. XAI provides a comprehensive analysis of the predicted outputs due to which it is regarded as one of the most prominent techniques in recent times [1]. Regardless of understanding the issue, studies have stated the necessity of understanding the model's process and its predicted output. It is expected that the investigation of XAI and ML models will experience an exponential increase in coming years [2]. It is also anticipated that XAI will overcome the technical difficulties associated with conventional ML techniques.

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According to Samke *et al*. (2017) [3] Explainable AI is a collection of tools and frameworks that facilitate understanding and analysis of the predictions made by traditional machine learning models. AI is often defined as the capacity of a model to perform a task that has historically been performed by people using a number of learning techniques. As opposed to this, explainable AI, often referred to as interpretable AI, is artificial intelligence in which the result of the solution is understandable to humans. In contrast, the "black box" concept in machine learning prevents even the designers from explaining why AI made a certain decision.

The Internet of Things (IoT) has significantly impacted people's lives in recent years on the commercial, economic, and social levels, claim Koppula and Muthukuru (2016) [4]. A distributed, interconnected network of embedded systems that communicate with one another across wired and wireless networks is referred to as the [5] Internet of Things (IoT). The development of smart products has substantially modernized modern society's lifestyle and way of life. Because it makes energy automation possible and enhances people's quality of existence, IoT is significant in the modern world (De Luca & Chen, 2021). Despite the fact that IoT networks are vulnerable to threats due to their resource restrictions and ad hoc nature, continuous monitoring and analysis can be used to secure IoT systems, enabling the application of preventive actions, the reduction of possible hazards, and the protection of private data. IoT is essential for the creation of intelligent applications, including smart cities. IoT technology could be used to collect, process, and store data. Also possible are service visualization, monitoring, and device management. However, the security and complexity of IoT have considerably expanded as a result of the ability to share information between devices scattered throughout the globe (Al Hammadi *et al*., 2021) [6]. Furthermore, a number of security issues have grown as a result of the exchange of extremely sensitive information *via* an IoT platform. Therefore, it is crucial to combine more sophisticated and cutting-edge methodologies, such as AI and ML, with IoT to achieve better performance.

One of the fast-expanding subfields of artificial intelligence (AI) is eXplainable AI (XAI). It refers to techniques that produce accurate and comprehensible models that are transparent, interpretable, and understandable so that people can comprehend the results that are presented (Adadi, & Berrada, 2018) [7]. The purpose of XAI is to offer a means of identifying the origin of the produced output. A younger generation of AI techniques might develop using XAI. In essence, XAI creates a connection between model attributes and results. Explainable models are introduced by XAI's artificial intelligence algorithms, which also guarantee a strong level of learning feedback. It ensures the confidence, security, and privacy of AI partners. XAI employs two distinct modules: an explanation systematically identifies an informative module, in contrast to conventional machine learning techniques. There is a trade-off between explainability and accuracy. Existing models are more precise and efficient, but they are also more complex to comprehend. The implementation of the XAI has the potential to offer the maximum degree of accuracy, efficacy, and explicability. Some of the pioneers in Explainable Artificial Intelligence platforms are IBM, Google, Darwin AI, Flow cast, Imandra, Kyndi, and Factmata [8]. And over 70% of company directors, according to a PwC survey released in 2017, think AI will be beneficial for their companies. It also asserts that by 2030, artificial intelligence would increase the global GDP by up to $15 trillion. As a result, in order to keep up with demand, AI technology needs to become more responsible and reliable, and XAI might be the greatest solution for the AI industry.

Explainable AI is a developing field in artificial intelligence and machine learning. Building public confidence in AI model decisions is crucial. It won't be possible unless the opaqueness of AI algorithms is made more apparent. Explainable AI frameworks are tools that generate reports on model performance and attempt to explain it. LIME and SHAP are the two techniques that we primarily use. In the next subsections, each method is explained in depth.

LIME-Local Interpretable Model-Agnostic Explanations: LIME [9, 10] is one of the most commonly used methods for the interpretation of ML models' predictions. One of the key advantages of LIME is that it is a model agnostics method and could be used for the explanation/interpretation of any model. For the explanation of an ML model, LIME perturbs the input samples and analyzes the changes in the prediction of the model [11]. This simple working mechanism makes it a preferable choice for model interpretation compared to model-specific methods, which require a deeper understanding of the underlying models.

LIME provides local interpretation, which means the model's behavior is described by analyzing the response of a 4 model to changes in a single data sample. Here the intuition is to analyze the cause behind a particular prediction by answering questions like" why was this prediction made?" or" which features caused the prediction?". It produces results in the form of a list of explanations highlighting the contribution of the individual feature as detailed in upcoming sections. We note that the idea and working mechanism of LIME are different from a related concept of" feature importance", which is generally carried out over the entire datasets.

SHAP-Shapley Additive Explanations: Our second explanation approach is based on another state-of-the-art technique namely, SHAPE. The method was

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CHAPTER 11

Explainable AI (XAI) for Agriculture

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Abstract: In most nations, agriculture is the main industry providing employment. Agricultural activities used to be restricted to the cultivation of food and crops, but they have expanded over time to include the processing, production, marketing, and distribution of crops and livestock products. Agriculture related approaches or practices must be continuously reviewed with the goal of presenting innovative approaches to sustaining and improving agricultural activities. Currently, agricultural activities serve as the primary source of livelihood, increasing GDP, being one of the sources of national trade, reducing unemployment, and providing raw materials for production in other industries.

Inadequate soil treatment, disease and pest infestation, among other issues, are only a few of the difficulties this industry must overcome in order to maximize productivity. There have been some difficulties with the increased use of technology in this industry, including the need for large amounts of data, low output, and the most obvious difficulty, the knowledge gap between farmers and technology.

When compared to earlier more conventional methods, agricultural practices, and activities have significantly improved since technology entered the field. Technologies like the Internet of Things (IoT) and Artificial Intelligence (AI) have been a few of the technologies that are widely used in these sectors with projects for improving crop production, disease prediction, continuous monitoring, efficient supply chain management, water waste and operational efficiency just to name a few but, this of this project will focus more on AI, more specifically on Explainable Artificial Intelligence (ExAI or XAI).

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Keywords: Artificial Intelligence , Explainable Artificial Intelligence (XAI) , SHapley Additive exPlanations (SHAP), Local Interpretable Model-agnostic Explanations (LIME).

1. INTRODUCTION

Since it feeds the entire population, agriculture is a crucial component of any nation's economy. If a nation's agricultural base is relatively substantial, that nation is deemed to be socially and economically affluent. The majority of countries rely heavily on agriculture as their main industry. Agriculture used to be solely concerned with growing food and crops, but over time, it has expanded to include the processing, production, marketing, and distribution of crops and livestock products. Currently, agricultural activities serve as a primary means of subsistence, increasing GDP, contributing to national trade, lowering unemployment, and developing the economy as a whole [1]. However, as the world's population continues to grow geometrically, agricultural approaches and practices must be continually reviewed in order to introduce new ideas for sustaining and enhancing agricultural activities.

To maximize productivity, this industry must overcome various obstacles, including poor soil management, pest and disease infestation, and others. There have been significant issues with the increased use of technology in this industry, including enormous data requirements, low yield, and—most notably—the knowledge gap between farmers and these technologies.

Farming entails a great deal of choices and uncertainties, and from season to season the price of farming materials fluctuates, the soil degrades, crops are not viable, weeds suffocate crops, pests damage crops and climate changes occur. Although agricultural practices are broad, farmers must learn to cope up with these uncertainties.

With the introduction of technology in the agriculture domain, there has been great improvements in how agriculture practices and activities are exercised compared to old traditional ways. With projects to improve crop production, disease prediction, continuous monitoring, efficient supply chain management, water waste, and operational efficiency, to name a few, technologies like the IoT and AI have been some of the technologies that have been widely used in these sectors [2 - 6]. However, for the purpose of this project, the focus will be more on ExAI or XAI.

AI, also known as a synthetic version of the human brain that is capable of learning natural language and planning, perceiving, and processing it, has been applied to agriculture with the main objective of creating standards, dependable product quality, control procedures, and the exploration of new avenues for better-serving society at low costs. By enhancing the user experience of a product or service and fostering end users' confidence in the AI's judgment, the purpose of XAI is to clarify what has been done, what is being done now, what will be done next, and to expose the data on which the actions are based.

2. NEED FOR AI IN AGRICULTURE

Plant and animal cultivation is the practice of agriculture. And agriculture was the main factor in the rise of human civilization. Agriculture has a very long history. Agriculture or farming began with the collection of wild crops and the domestication of pigs, sheep, and cattle. Foods, fibers, fuels, and raw materials can be used to categorize the principal agricultural products. Agriculture employs more than one-third of all people on the planet. A tremendous rise in food yield has been achieved by industrial agriculture, mechanization, contemporary agronomy, plant, and animal breeding, agrochemicals like pesticides and fertilizers, and some technological advancements, however, these practices have been inflicting ecological and environmental harm. Aquifer depletion, deforestation, antibiotic resistance, and the use of growth hormones in industrial meat production are a few examples of environmental problems. A drop in crop productivity can result from the agriculture's role in environmental degradation, which includes biodiversity loss, desertification, soil degradation, and global warming.

With the continuous rise in global population and the increased demand for food, traditional ways and the previous advancement in this sector will not be enough to meet the demands of the entire population and also the negative impact that they have on the environment. New ways have been found which promise to deliver good quality while having a lower or no impact on the environment and also maintaining low costs. Amongst these new ways, AI has become so popular in this sector and the positive impact it has, revolutionizing the ways agricultural activities are practiced, to name a few, boosting agricultural productivity, predicting diseases, ongoing surveillance, effective supply chain management, reducing water waste, and operational efficiency.

3. ROLE OF AI IN AGRICULTURE

Over the years, technology has redefined agriculture, and it has revolutionized the agriculture industry in many different ways. Due to the fact that agriculture is a major source of employment in many nations around the world and that only 4% more land will be cultivated by 2050 due to population growth (which the UN

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