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Reshaping of the Future Farming: From Industry 4.0 Toward Agriculture 4.0

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Abstract: Contemporary agriculture faces many challenges, most notably the large and continuous increase in population numbers, which requires the greater provision of agricultural products to meet people's need for food. There are also other challenges such as global climate change, which has recently increased inefficiency due to droughts, desertification, irrigation water decreasing, increased soil contamination, plant diseases, heat waves, floods, and water salinity, causing many agricultural problems. The agricultural industry needs to invest in new techniques and infrastructure that enable it to transform into a smart industry capable of responding to these challenges through lean operations supported by industrial digital technologies (IDTs) to maintain efficiency, sustainability, and quality. The industry 4.0 strategy has been widely adopted by the manufacturing industry, enabling the manufacturing sector to achieve the enhanced optimization, efficiency, responsiveness, and autonomy premises of the digitalization strategy. This paper discusses the digitization of agriculture "from industry 4.0 towards agriculture 4.0," which relies on Internet of Things (IoT) technologies, artificial neural networks (ANN), AI, and fuzzy logic to make a quantum leap, in the future of agriculture sector. Internet of Things devices collect data from the devices or sensors, analyse, process, and transfer it, in addition to making the right decisions, without human intervention. IOT also provides the basic communications infrastructure that is used to connect smart devices, sensors, and UAVs to mobile devices by using the Internet. These processes will lead to many services, such as collecting and analysing the information, pattern recognition, and independent decision-making based on artificial intelligence added to the current agricultural automation. These technologies will lead to a revolution in the field of agriculture, which is probably one of the most inefficient sectors today.

Keywords: Smart Farming, Agriculture 4.0, Industry 4.0, Artificial Intelligence, Fuzzy Control, Internet of Things (IOT), Unmanned Aerial Vehicles (UAV)

1. Introduction

The World Food Organization (FAO) estimates that the world population will reach 9.15 billion by 2050, with an increase of another 2 billion, while the area that can be added to arable land will only be 4% [15]. According to a paper published in 2018 by the World Government Summit, "Population growth = more food." According to the same paper, the world's population will reach 10 billion people in 2050, with 70% of food produced by farmers and expanding urban consumption matching a pattern of 45.3 kg of processed meat from dietary meat per capita annual meat consumption by 2030 [7, 1].

In such circumstances, it is not possible to achieve agricultural practises with the required efficiency except by using the latest technological solutions, relying on modern agricultural techniques to improve resources and increase consumer demand, as well as high quality such as food safety, security, and traceability. Agricultural production requires many activities, such as soil monitoring, temperature, relative humidity, vegetation conditions, carbon dioxide levels, pest control, supply management, and infrastructure. IoT-based technology can add value in terms of quality, sustainability, and production increase as it performs a range of operations and helps with decision-making [7]. Using fuzzy logic, artificial intelligence, and the Internet of Things in agriculture has many advantages for helping and developing agriculture, and it will also facilitate farms in reducing manufacturing costs and thus increasing profitability and sustainability [3]. Five emerging technologies around the main applications of Agriculture 4.0 and their research challenges are discussed below. This paper presents a rationalisation of the benefits and useful information about Industry 4.0 as well as the obstacles related to the implementation of the latest technological solutions in smart agriculture.

2. Previous Research

The use of wireless communication has changed communication standards, and this will raise the standards of agriculture automation. Many different IEEE standards describe sensor networks; standards like IEEE 802.15.1 PAN/Bluetooth, IEEE 802.15.4 ZigBee, and many more are necessary to know while planning their applications. There is currently a debate about using the IPV6 Internet Protocol for wireless communication and a lot of hardware to establish a WSN. By using WSN, it is possible to achieve precision farming and create optimal strategies. In parallel, the IoT concept has enabled the establishment of an intelligent sensor network with the capability to cover wide areas in real time. In [26], the authors Sridevi Navulur et al. have bifurcated the IOT gateway into different nodes such as actuators, sensors, interfaces, and wireless links that facilitate communication between them. In [20], Kodali et, presented the use of the Losant platform for monitoring agricultural farmland and informing the farmer via SMS or email if any anomalies are observed by the system [20, 21]. Losant is a simple, IoT-based based most powerful cloud platformIt offers real-time data observation stored in it irrespective of the position of the field [20, 21, 17]. Gutiérrez-Rodríguez et al. came up with an automated irrigation system that uses the GPRS module as a communication device [10]. The system has been programmed into a microprocessor-based gateway that controls the water quantity. It has been proved that water savings were 90% more than the conventional irrigation system. Kim et al. used a distributed wireless network for sensing and controlling irrigation processes from a remote location [36]. To improve efficiency, productivity, and the global market and to reduce human intervention, time, and cost, there is a need to divert towards a new technology called the Internet of Things. IoT is the network of devices that transfer information without human involvement. Hence, to gain high productivity, IoT works in synergy with agriculture to obtain smart farming [25]. In [23], Malavade et al. focused on the role of IoT in agriculture that leads to smart framing. Kumar et al. used a fertility and pH metre to take out the percentage of ingredients in the soil and developed a wireless sensor-based drip irrigation system [18]. In [21], Roopaei et al. discussed the use of a cloud-based thermal imaging system that helps with irrigation by incorporating the performance of the equipment and determining the area of the field that requires the most water. The absence of uniformity will hamper crop growth, and thermal imaging can help to consolidate this loss.

Artificial neural networks (ANN) have been integrated into the agriculture sector in the past decades due to their advantages over traditional control systems. Artificial neural networks can predict the system's behaviour through the training process [11]. Gliever and Slaughter used ANN to distinguish weeds from crops. The authors, Maier et al., used ANN to predict water resource variables [22]. Song & He et al, combined expert systems and artificial neural networks to predict the level of crop nutrition, and Ravichandran & Koteshwari suggested using ANN algorithms for crop prediction on smartphones, where the prediction model consists of three layers [11, 23]. The efficiency of the model was dependent on the number of hidden layers, and they are also proposing an expert farming system using IoT to send data to the server so that domain operators would be able to make appropriate decisions [30]. Two ANN models were developed to estimate soil moisture in Badi fields using decidedly less meteorological data. Both models were validated by studying the observed and estimated soil moisture values. It resulted in an accurate and reliable estimation of soil moisture in rice fields using less meteorological data and with lower labour and time consumption [2]. Hinnell et al. discuss drip irrigation systems, where ANNs have been developed to predict the spatial distribution of subsurface water [12].

Fuzzy logic is an efficient way to represent informal knowledge through the membership function of each system variable [13, 14]. In [17], "fuzzy modelling of land settlement" was carried out by Si et al. They used fuzzy control theory to obtain an accuracy-dependent result. Sannakki et al. developed an innovative leaf disease classification system with segmentation of the image, where the set of k means is used to isolate the healthy portion of the leaf from the diseased portion [29]. The fuzzy inference system (FIS) was developed by Tremblay et al. to determine the optimal N fertiliser rates based on field and crop characteristics [32]. A FIS was carried out to estimate stem water potential [33]. IF-based fuzzy inference system... The condition type was developed by Tilva et al. [37]. The model predicted plant diseases based on weather data. The system was developed to avoid diseases in the plant in advance as the disease occurs within a certain range of temperature and humidity in the atmosphere. Wall and King devised an intelligent system that controls sprinkler valves with the help of field temperature and humidity sensors [17]; Miranda et al., 2003, came up with a distributed irrigation system that measures soil water [3, 15]; and Greenhouse developed a multivariable fuzzy controller for the Greenhouse system. The developed fuzzy inference engine integrates the correlation of input variables and incorporates informal knowledge from field experts [14].

3. Definition of Industry 4.0

A paper was proposed in 2011 titled "Industry 4.0: Intelligent Manufacturing of the Future." Industry 4.0 is defined as "the name of the current trend of automation and data exchange in manufacturing technologies, including smart factory construction, the Internet of Things, cloud computing, cognitive computing, and electronic physical systems" [12, 36]. Industry 4.0 refers to the technological evolution from embedded systems to electronic physical systems [31]. Note that there are many definitions for "industry 4.0," and not all the definitions are the same, but "industry 4.0" is also known as the Fourth Industrial Revolution [1]. Decentralized intelligence helps create intelligent networks and manage autonomous operations, with the interaction of the real and virtual worlds representing a new and important aspect of the manufacturing and production process. The first industrial revolution began in the late eighteenth century in Britain, enabling the mass production of water and steam power rather than human and animal power. A century after the first Industrial Revolution, Industrial 2.0 began, introducing assembly lines and the use of oil, gas, and electric power as important energy sources in the industry, along with more advanced communications by telephone and telegraph and a certain degree of automation of manufacturing processes. [35] The third industrial revolution began in the mid-twentieth century, contributing to the manufacture of computers, advanced communications, and data analysis [31]. In addition, the digitization of factories has started with the integration of control units (PLCs) into machines to automate certain processes and collect and exchange data. The world is currently experiencing the fourth industrial revolution, which is the latest transformation in the industrial sector. The fourth industrial revolution is known as "Industry 4.0." Thanks to increasing automation and the use of smart machines and smart factories, this data helps produce more efficient and productive goods. Flexibility is improved so that manufacturers can meet customer demands with mass customization; in pursuit of efficiency, by collecting more data from the factory floor and combining it with other enterprise operational data, a smart factory can achieve information transparency and better decision-making. The Fifth Industrial Revolution is expected to bring humans back to the centre of operations through a human-electronic-physical system of value creation. Tables in figures 1 and 2 show the development roadmap of industrial and agricultural revolutions from the 18th century up to date:

Table 1. *Industrial revolutions history From Steam to Sensor [34].*

Industrial Revolutions	Industry 1.0 (Mechanization)	Industry 2.0 (Electricity)	Industry 3.0 (Electronics)	Industry 4.0 (Intelligence)
From 18th century up Today	*18th century Steam engine. Waterpower*	*20th century used electricity to create Mass productions Electrical energy*	*Late 20th century, digital revolutions, used computers to automate production Automation Information technology*	*Today AI IOT Big dana*

Table 2. *Agriculture revolutions history [34].*

Agriculture Revolutions	Agriculture 1.0	Agriculture 2.0	Agriculture 3.0	Agriculture 4.0
From 18th century up Today	*18th century. From period between 1884 and around 1870 Farmers using animal power. Indigenous tool Manual work*	*20th century, Green Revolutions Tractor Fertilizer Pesticide*	*late 20th to 21st, Precision agriculture Yeild monitoring Guidence system Viraible rate application*	*Today – Agriculture 4.0 Autonomous farming Trustworthy food supply Ubquitous agriculture sensor*

Table 3. *Industry 4.0 technology and agriculture 4.0 technology.*

Smart Industry technology	Smart Agriculture technology
IOT senser	IOT senser
Big data	AI
Analytics	Machine Learning
Cloud Computing	Fuzzy Logic
Robotics…. etc.	UAVs… etc.

4. Agriculture (4.0) and Food Industry

Despite the big evolution in the agricultural field, there are still many issues and challenges that need to be addressed, such as environmental issues, a lack of digitalization, and the issue of food safety. Industry 4.0 was marked by the synthesis of all emerging technologies, bringing together the Internet of Things (IoT), robotics, big data, and blockchain technology. [7], System Integration (SI), Cloud Computing (CC), Simulation and Autonomy Robotic Systems (ARS), Wireless Sensor Networks (WSN), Cyber Physical Systems (CPS), the digital twin (DT), and Additive Manufacturing (AM), to enable the digitization of industry. The integration of Industry 4.0 and agriculture provides the opportunity to transform industrial agriculture into Agriculture 4.0, or the "next generation,", also called "digital agriculture." Agriculture 4.0 can be achieved by collecting precise variables in real-time as well as processing and analysing data related to the agricultural industry from food production, processing, and distribution for consumer use [1]. Such a smart industrial agroecosystem would greatly improve productivity, agricultural food supply chain efficiency, food safety, and the use of natural resources [7, 19]. Sensors are used to detect crop stages, recommend timely inputs and treatments, and control the level of irrigation. The food industry needs more research on food security, transparency, and the required documentation. Smart sensors are used as a tracking system in addition to collecting human and product data. Agriculture 4.0 means a transformation of the production infrastructure: it contributes to the creation of connected farms, new production equipment, and connected tractors and machinery, enabling increased productivity, quality, and environmental protection [19].

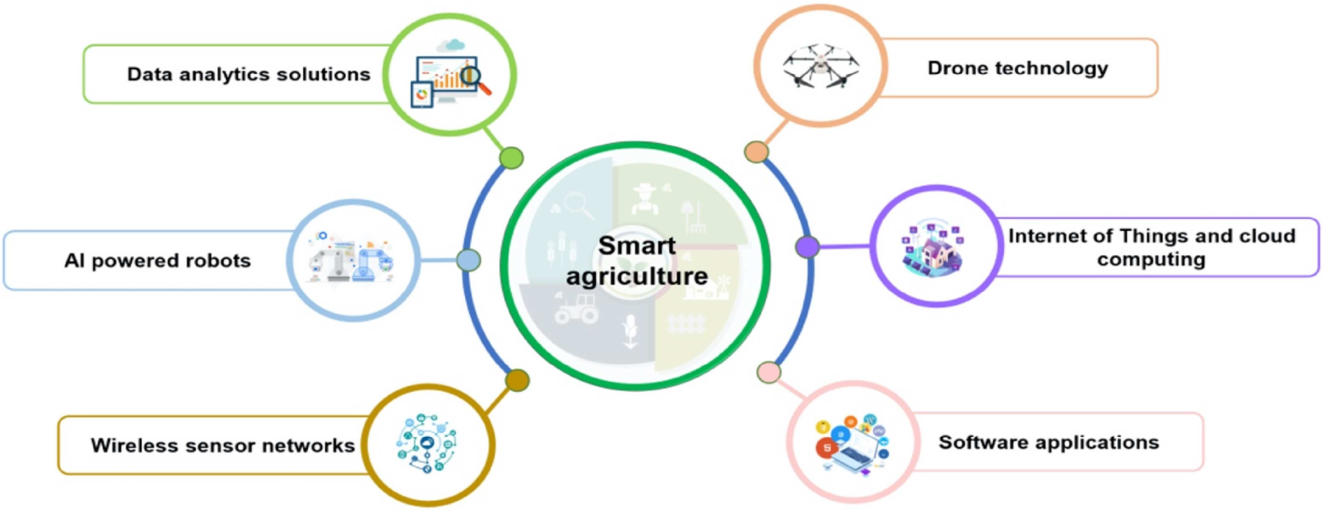

Figure 1. *Smart Agriculture Concept. [1].*

5. From Industry 4.0 Toward Agriculture 4.0

The methodology behind this study is to develop a smart farm prototype using digital technologies—implementing the industry 4.0 strategy in the agricultural industry. Also, the study deals with identifying and reviewing open challenges, application areas, and architectures for the Internet of Things in the agricultural industry. This study will develop an integrated digital tool based on Internet of Things (IoT) and Artificial Neural Networks (ANN) technologies that will enable the agricultural industry to collect, process, and transmit data and to make autonomous decisions and actions based on incorporated informal knowledge obtained through using fuzzy logic without the need for human intervention [10]. IoT provides the basic communications infrastructure (used to connect smart devices, from sensors, vehicles, and unmanned aerial vehicles (UAVs) to user- mobile devices using the Internet) [5]. This research study presents the detailed work of eminent researchers and computer architecture designs that can be applied in agriculture for smart agriculture. This research study also highlights many of the challenges exposed to contemporary agriculture, including the continually increasing demand for quality food, shortages of labour, and arable land. Contemporary agriculture is facing numerous challenges, including a continually increasing demand for quality food, shortages of labour and arable land, irrigation water reduction, increased soil contamination, and loss of yields due to plant diseases and pests. [7]. These are besides the challenges currently the agricultural industry faces due to the global climate changes, which have added to the inefficiencies of the agricultural industry as a sector. In such circumstances, to maintain efficiency and sustainably produce quality and ecologically healthy food, the agricultural industry needs to invest in new techniques and infrastructure that enable it to transform into a smart industry constituted of smart farms capable of responding to challenges through lean operations supported by industrial digital technologies (IDTs), irrigation water reduction, increased soil contamination, and loss of yields due to plant diseases and pests. The Internet of Things in agriculture [10, 4]. Implications: This study can be useful to farmers, researchers, and professionals working in agricultural enterprises for smart farming. Newness/originality of the study: Several prominent researchers have made efforts for smart agriculture using IoT concepts in agriculture. But a set of revealed challenges remain in the queue for effective resolution. This study makes some effort to discuss previous research and open challenges in IoT-based agriculture, AI, ANN, and fuzzy logic to develop smart farming. However, using IoT and AI in smart farming will give farmers and agriculture companies many benefits:

1) Using IoT can make it easily manageable to collect and control large amounts of data from sensors and integrate them in real-time from anywhere, allowing all process participants to connect.
2) By using the fuzzy logic technique, the research will enable the incorporation of human informal knowledge into the control strategy, hence developing human-like control of the parameters of the farm entities (greenhouses).
3) With the combined use of AI and IoT, they will facilitate the achievement of an enhanced level of efficiency in the utilisation of water, fertilizers, pesticides, energy sources, etc. on the farm.
4) IoT applications will lead to environmental protection.
5) With the combined use of fuzzy logic and AI techniques the research enables farms to lead to adopting more effective environmental protection strategies.

6) The Internet of Things is a key component of smart farming. By using precision sensors and intelligent equipment, farmers can increase food production by more than 70% by 2050.

The structure of the system is shown in Figure 1. The central unit receives data from autonomous measuring stations, local weather forecasts, expert knowledge from local agronomists, pre-processed images obtained from multispectral crop cameras using unmanned aerial vehicles, and data obtained from mobile applications. Based on the data collected, previously processed, and stored, the central unit generates control actions towards the actuators. This system is applicable for both outdoor and protected agriculture (in greenhouses and indoors). According to the type of plant being controlled, appropriate actions are taken. In the case of protected cultivation, the system controls the internal temperature, relative humidity, carbon dioxide enrichment, irrigation, and fertilization. In the case of outdoor cultivation, the system controls irrigation and fertilisation and calculates the severity index for early prediction of infestation. In addition, AI-based technologies will be used to optimise resource utilization.

6. Technology Driven Agriculture

Industry 4.0 revolutionised the industrial sector and provided numerous benefits in all fields, particularly agriculture. Farmers are now using Industry 4.0 technology in the agricultural sector by using modern devices such as agriculture robots, drones, sensors, and IoT.

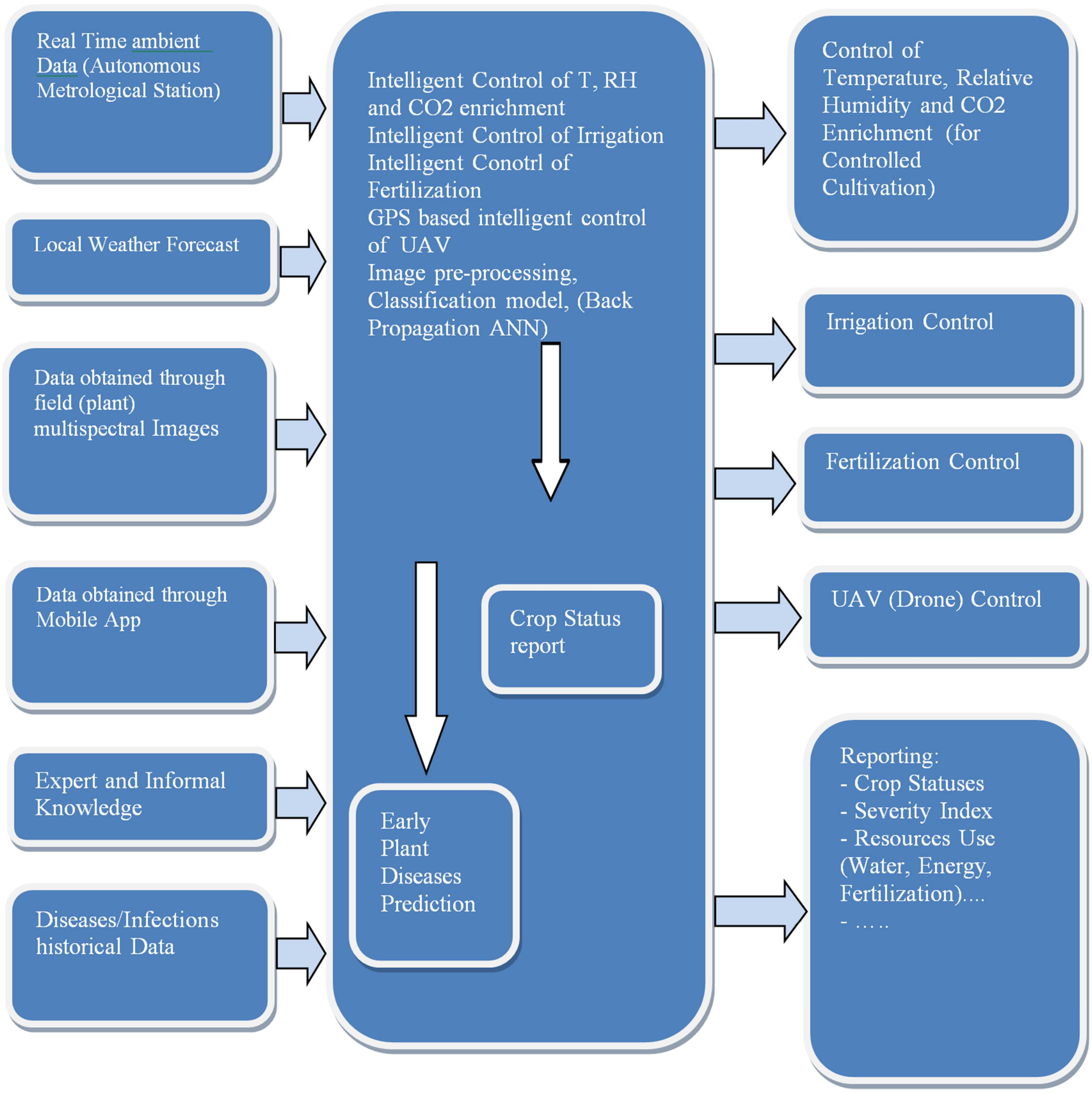

Figure 2. *The structure of the proposed system.*

6.1. Internet of Things (IOT) in Agriculture

Most of the research papers highlighted the impact of IoT devices in system automation, from determining soil texture and irrigation systems to sensing environmental changes, such as temperature and humidity, detecting pests and weeds, and the damages that occur to the soil. Agriculture 4.0 contributed to the development of the agricultural sector. Farmers are now using modern means in agriculture by linking agriculture with satellites to increase the benefits of the Internet of Things project in smart agriculture. [5]. The data connection varies. First, the sensors collect the details, share them with the IoT gateway, connect through Wi-Fi or Bluetooth to the database, and store the data in the cloud. Then the user finally gets the processed data (or information) and uses it to make smarter decisions. Wireless Sensor Network (WNS) helps make the right decisions in relevant situations, and thus WNS supports decision-making to find solutions to problems related to agriculture. [1, 34]. Despite technological development, many challenges must be faced when using modern technologies in smart agriculture. Among those challenges, most people are ignorant of how to use technology in the agriculture sector due to a lack of knowledge about dealing with mobile devices and a lack of reading and comprehension knowledge. There are also other factors, such as a lack of energy supply, changes in weather or climatic conditions, and funding sources. [1]. But the development of the agricultural field using modern technologies has helped to overcome obstacles and solve many problems in modern agriculture. Drones (UAVs), soil and water quality, crop irrigation, precision agriculture (remote sensing, humidity, and temperature), and autonomous greenhouses are the common uses of IoT in the Agriculture 4.0 sector. [34, 8].

6.2. Wireless Sensor Networks in Agriculture

Wireless sensor network (WSN) technology is used on the Internet of Things. (WSN) It is defined as a set of spatially distributed sensors to monitor environmental conditions, cache collected data, and transmit collected information to a central location [1]. WSN for smart farming consists of multiple sensor nodes connected by a wireless communication module. These nodes have a variety of capabilities (e.g., processing, transmission, and acquisition) that allow them to self-organize, self-configure, and self-diagnose [24]. There are different types of WSNs, categorised according to the environment in which they are found. These include terrestrial wireless sensor networks (TWSN), underground wireless sensor networks (WUSN), underwater wireless sensor networks (UWSN), multimedia wireless sensor networks (WMSN), and mobile wireless sensor networks (MWSNs) [1, 20]. For agricultural applications, TWSN and UWSN sensor networks are widely used. TWSN nodes are deployed above the earth's surface and consist of sensors to collect surrounding data. A second alternative to WSNs is their underground counterpart, WUSNs. Nodes are implanted inside the soil, and they perform low-frequency functions easily in soil, while higher-frequency functions are very weak. Therefore, it requires large numbers of knots to cover a large area. Several research articles have been addressed in the literature discussing the use of WSNs for various farm applications, such as irrigation management, water quality assessment, and environmental monitoring. Also, there are various factors associated with WSNs that need more attention, such as maintenance, robust and fault-tolerant architecture, and interoperability. [5, 1].

6.3. Artefactual Intelligence in Agriculture 4.0

The agriculture sector is experiencing the rapid customization of both artificial intelligence (AI) and machine learning (ML) in seasonal agricultural outcomes and field farming techniques. Artificial intelligence (AI) involves the development of computer systems capable of performing tasks that require human intelligence, such as sensory perception and decision-making [25]. Combined with CC, IoT, and big data, AI is seen as one of the main drivers behind the digitization of the agriculture industry 4.0 Many smart farming systems that use ML and DL algorithms have been developed to determine various parameters such as crop and soil control, diagnosing plant diseases, detecting weeds, intelligent spraying, aerial surveys, and photography that are also used to enhance crop production and improve real-time monitoring, harvesting, processing, and marketing. [17] Learning and responding to special situations (based on learning) to increase efficiency [1]. Providing some of these options to farmers as a service, such as Chabot or different conversation principles, will assist them in properly supporting the pace of technological improvements, such as identifying similarities in everyday farming. Agricultural robotics organisations recognise the value of robots that depend on and manipulate themselves to handle key agricultural services such as assembly plants on a more prominent scale, at a faster pace, and with more proactivity than personal workers [19].

6.4. Advance Robotic

Agricultural robots have been developed to perform precision farming operations and to replace humans in certain tasks. In recent years, advanced robots have been used for purposes such as cultivation and harvesting, water supply, targeted spraying, and environmental control. Robots equipped with lasers and cameras are used to identify and remove weeds without human intervention. These robots autonomously navigate through rows of crops, ultimately increasing yields when labour decreases [9]. It can also be used in the fields to complete certain farming tasks. Recently, robots for plant growth and fruit picking have emerged to bring new levels of efficiency to traditional methods. Stationary robots are usually the most popular alternative in industrial applications [29]. However, in the context of agriculture, mobile robots may offer greater utility, as they can traverse different types of terrain that are not otherwise easily accessible, cover large fields, and automate agricultural tasks. Mobile robots are widely used in the agricultural sector to improve farm management, increase farm efficiency, and reduce the need for labor, especially in harsh environments inaccessible to humans [19]. These robots perform a variety of agricultural tasks, such as field cultivation, soil sampling, irrigation management, precision spraying, mechanical weeding, and harvesting. [9].

6.5. Machine Learning in Agriculture

Machine learning (ML) techniques are classified into three categories: 1) Supervised Learning (Regression Trees, Linear Regression, Nonlinear Regression, Bayesian Linear Regression, Polynomial Logistic, and Vector Regression Support), 2) Unsupervised Learning (K-Group Means, Hierarchical Grouping, Anomaly Detection, Neural Networks (NN), Principal Component Analysis, Independent Component Analysis, Prior Algorithm, and Singular Value Decomposition (SVD), and 3) Re-Informational Learning (Markov Decision Process (MDP) and Q Learning)) [24, 1]. Technologies and algorithms implement machine learning in agriculture. Crop yield forecasting by sector, diseases, weed detection, and weather forecasting (precipitation), estimation of soil properties (type, moisture content, pH, temperature, etc.), as well as water management, determination of the turf-timing amount of fertilizer, and livestock production and management Rhithms are used for various agricultural applications. From the analysis, "crop yield prediction" is a widely explored area. Linear regression, neural networks (NN), random forests (RF), and support vector machines (SVM) are the most widely used ML technologies to enable intelligent agriculture. The presented use cases are still in the research phase, with no commercial use reported at this time. Moreover, it is also found that AI and machine learning techniques are sparsely explored in greenhouses and indoor vertical farming systems, especially hydroponics, aquaponics, and aeroponics [24]. ML technologies are used. Given the cybersecurity and data privacy challenges of digital transformation, new approaches such as federated learning and privacy-preserving methods are being developed to enable digital farming. And thus, mitigate security issues. [1].

6.6. UAVs in Agriculture 4.0 (Drones Technology in Agri 4.0)

UAVs, or unmanned aerial vehicles, also known as drones or aerial robots, are widely used by farmers to monitor crop growth, and combat hunger, and adverse environmental impacts. It is called "unmanned" because there is no human pilot on board [1]. Unmanned aerial vehicles are used efficiently to take pictures, spray water and pesticides, consider rugged terrain, etc. It has proven its worth not only in terms of spray speed but accuracy as well. When compared to conventional machines for the same purpose, UAV technology can be used for gathering information that helps farmers make decisions. With recent developments in drone technology, groups of drones equipped with 3D cameras and heterogeneous sensors can work together to provide farmers with comprehensive capabilities and tasks to manage their lands and farms. [5]. By using these drones in agriculture, farmers can set their eyes on the sky. However, using drones in agriculture can carry out large and difficult tasks and reach remote and rugged places with the necessary speed and time, but there are still many challenges that must be addressed to benefit from this technology, especially the integration with other technologies and how to use them in bad weather conditions [21]. UAVs, drones, and radio-controlled model aircraft can be flown at lower altitudes for increased spatial resolution, possibly at a lower cost [19]. The advantage of the image using drones for agriculture is their accuracy (very high pixels), compared to other traditional methods. [6].” Drone images are used in many things, including mapping grass types, measuring shrub biomass, mapping crop strength, monitoring crop water stress, recording crop biomass, and evaluating nitrogen treatments. On crops [21]. In addition, the UAV is also used as a geo-fence to repel animal attacks by alerting the owner in a timely and safe manner [19].

7. The Benefits of Industry 4.0 in Agriculture

Using modern technologies in the agriculture sector has many advantages related to the economic, social, and environmental fields. This paper will briefly cover all the fields mentioned above. First, the environmental field: These technologies contributed to reducing pollutants (such as agricultural chemicals and various fertilizers), which led to the sustainability [3, 1]” or increase of soil quality, reduced water pollution, reduced carbon dioxide and nitrogen, and reduced air pollution. Secondly, economically, it has many advantages, including operational efficiency, maximising resources, and providing high-quality product results, such as increased yields, improved soil quality, and high selling prices of raw materials. Smart farming systems also enable accurate management of demand forecasts and timely delivery of goods to market to reduce waste. In addition to the various benefits in terms of efficiency, there are lower costs involved, less water consumption, less use of technical inputs, and lower overall costs. In terms of social benefits, it reduces time and effort (reducing physical labor) and increases quality, as well as reducing worker stress and improving their well-being and safety at work. Overall, Agriculture 4.0 helps reduce costs and improve product quality, quantity, and sustainability [34].

8. Challenges Facing Agriculture 4.0

To introduce the new technology (industry 4.0 to agriculture 4.0) in a specific environment, there are many challenges and obstacles, such as technical and technological challenges related to the implementation of agriculture 4.0, technical problems related to modern equipment, weather problems, rugged lands in some areas, and a lack of knowledge for some farmers about how to use the modern techniques in agriculture. [8, 4]. Agriculture 4.0 requires great economic effort; financing sources consider it most important to farmers. However, funding sources are one of the most important challenges in some developing countries. Implementation challenges: Using Agri4.0 in the agriculture sector requires skills. Cultural and organisational challenges: Due to the introduction of digitalization in agriculture, Agriculture Revolution 4.0 will require skills related to introducing digital solutions in companies [34]. However, weather conditions, energy sources, and financing, the ruggedness of some areas, and the lack of sufficient knowledge to use modern technologies for some farmers are considered the most important challenges facing smart agriculture. Moreover, for a successful implementation of artificial neural networks, fuzzy control systems, and other AI engines, a huge amount of data is needed to train AI models in the agricultural sector [4].

9. Discussions and Results

Smart farming depends on advanced technology systems in management, analysis, processing, data collection, decision-making, etc. to reduce costs and make farming more productive, profitable, sustainable, and environmentally friendly. Smart agriculture plays an important role in meeting the food needs of the world's population [1]. The study aims to highlight the importance of using new technologies in agriculture. The use of Industry 4.0 in agriculture makes agriculture smart and available, as well as contributes to solving many problems facing agriculture. We have clarified part of these challenges and solutions in this paper, which shows the importance of resorting to farmers, agricultural companies, and researchers to contribute to the development of this important sector. It is not as required. There are still many issues and challenges that must be addressed in industrial agriculture, such as environmental problems, a lack of digitization, the issue of food safety, sources of financing and support, a lack of resources, and the lack of knowledge of many farmers on how to use new technologies in their farms, which is considered one of the most important challenges facing smart agriculture in developing countries. (Industry 4.0) was distinguished by doing a lot of things and tasks with less effort and in a short amount of time. Industry 4.0 spawned all the emerging technologies, bringing together BDMM, Internet of Things (IoT) technologies, robotics, big data, and blockchain technology [7, 8, 34, 19] are making production and supply processes smarter and now more autonomous. The integration of Industry 4.0 and agriculture 4.0 offers the opportunity to transform industrial agriculture into the next generation. Smart Agriculture can be achieved by collecting precise variables in real-time, in addition to processing and analysing data related to the agricultural industry from food production, processing, and distribution for consumer use, using AI, the Internet of Things, unmanned aerial vehicles, etc. Such a smart agro-ecosystem would dramatically improve productivity, agri-food supply chain efficiency, food safety, and natural resource utilization. Industry 4.0 towards Agriculture 4.0 means a shift in production infrastructure: it contributes to the creation of connected farms, new production equipment, tractors, and tying machines, enabling increased productivity, quality, and environmental protection [34, 35]. The design above in figure 2 demonstrate that the approach allows for the incorporation of expert human knowledge into control strategies using fuzzy logic to facilitate integrated control in protected agriculture.

10. Conclusions

This paper provides an overview and valuable information on the applications of Industry 4.0 towards Agriculture 4.0, through which it highlights the importance of using modern technologies in agriculture to contribute to those interested in developing and knowing the places of imbalance in the agriculture sector, as well as identifying the challenges facing smart agriculture instead of traditional methods to find solutions and innovate new ways, contribute to opening research and innovation issues, and therefore be useful in identifying prospects and knowledge of the gaps in Agriculture 4.0. The study's goal is to respond effectively to global climatic changes, fluctuations in the global economy and environmental fields, a lack of resources, and an increase in the global population, all of which affect agricultural development and prevent us from achieving food self-sufficiency. However, the technologies provided by Industry 4.0 in the agricultural field refer to many creative solutions that can be used to develop this sector. This paper dealt with the role of new technologies in agriculture, especially artificial intelligence (AI) and the Internet of Things (IoT) in agriculture 4.0, in addition to using drones in agriculture. The paper highlighted the challenges facing farmers and presented objective solutions to make agriculture smarter and more efficient to meet future expectations. In this context, wireless sensors, drones, cloud computing, micro-communication technologies, artificial intelligence, and the Internet of Things are all discussed. The paper presents our current research in the field of applications of artificial intelligence, IoT, ANN, fuzzy logic, and plant diseases in Agriculture 4.0. The use of ANN as a non-linear classifier and fuzzy logical engines as a representative of informal expert knowledge, as well as the concept of the Internet of Things for intelligent communication in data collection, processing, and analysis, are powerful tools to which, agricultural management, farmers, and researchers should pay close attention to move this sector to a new qualitative level. It will also provide an ecological approach to protecting the human environment, although a lot of research remains to be done. The research and design above demonstrate that the approach allows for the incorporation of expert human knowledge into control strategies using fuzzy logic to facilitate integrated control in protected agriculture. Moreover, some different expert-based strategies can be simulated, analysed, and compared [13]" In conclusion, humans can, in formal knowledge, use fuzzy logic to facilitate integrated control of protected agriculture.

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