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AI Robotics in Agriculture

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ABSTRACT: Due to the increasing global population and the growing demand for food worldwide as well as changes in weather conditions and the availability of water, artificial intelligence (AI) such as expert systems, natural language processing, speech recognition, and machine vision have changed not only the quantity but also the quality of work in the agricultural sector. Researchers and scientists are now moving toward the utilization of new IoT technologies in smart farming to help farmers use AI technology in the development of improved seeds, crop protection, and fertilizers. This will improve farmers profitability and the overall economy of the country. AI is emerging in three major categories in agriculture, namely soil and crop monitoring, predictive analytics, and agricultural robotics. In this regard, farmers are increasingly adopting the use of sensors and soil sampling to gather data to be used by farm management systems for further investigations and analyses.

Keywords: Artificial Intelligence Application, Agriculture, Smart Farming, Internet of Things, Sensors, Machine Learning, Deep Learning.

INTRODUCTION:

Smart farming applies information technologies for the optimization of complex farming systems. It incorporates information and communication technologies to improve agriculture production system. The agricultural sector is one of the most important production sectors. It is concerned with all aspects of agricultural activities and is divided into the four major subsectors of . Artificial intelligence (AI) encompasses a broad range of applications in the Field of computer science related to the possibility of building smart machines, robots, or sensors that are capable of simulating human actions to achieve tasks on behalf of humans to serve society intelligently. These actions are controlled by application programs using information technology devices. Combining AI approaches and traditional agricultural methods, smart agriculture is being used to improve national economies by monitoring crop growth using the principles of precision farming. Smart irrigation is another new technique in agriculture to help farmers in automating irrigation processes by collecting data using smart devices such as Raspberry Pi. The collected data are then analyzed to select the best technique for switching the ow of water on the farm to the ON or OFF state. Therefore, smart irrigation system provides the agriculture sector and farmers with many benefits such as:

- Cost savings due to minimized water waste
- Reduced human efforts
- A unified view of soil characteristics, including moisture and nutrient contents

Systematic Review Methodology

Agriculture and food industries are considered among the most critical fields around the world. This sector can take advantage of AI and its sub fields such as machine learning, computer vision, and image processing to solve many emerging problems. In these processes, IoT equipment can be used to collect helpful information from raw data on farms regard ing agriculture and irrigation, while AI techniques can be utilized during preproduction (crop yield and nding irrigation leaks), production (disease detection and weather prediction), processing (product estimation), and distribution (storage and consumer analysis). In a systematic literature review, authors should search, understand, and classify the current research works in the area of interest and then perform analysis and draw conclusions based on their ndings. For the present literature review, we searched journal papers, conference papers, and bookchapters addressing AI and IoTapplications in agriculture. We focused on high-quality papers indexed by IEEE Xplore, Clarivate, and Scopus. Figure 1. Systematic literature review phases show the review process followed for this paper.

Machine Learning in the Agriculture Sector

Machine learning is a part of AI technology and it con tributes to the agricultural sector by monitoring and control ling agricultural activities, there by increasing productivity and improving the quality of the crops that are cultivated. Machine learning algorithms play essential roles in precision agriculture by detecting objects in agricultural fields. Treboux and Genoud showed 94.27% accuracy with machine learning algorithms in detecting specific objects, clearly reflecting the immense impact of these applications in smart farming. Machine learning algorithms allow machines to learn about particular agricultural lands, the geographical structure of farming areas, and plants and crops using supervised and unsupervised learning methods. Datasets are organized and predefined in the former case, where as datasets are not classified in the latter. Once the machine has learned about agricultural activities, it can perform actions such as monitoring and predicting temperature and humidity, soil moisture, crop yield, and plant diseases.

INTERNET OF THINGS IN SMART FARMING

In this section, we provide an overview of categories of sensors, IoT sensor types used in smart farming, wireless sensor networks, and IoT protocols used in smart farming.

Primitive Sensors VS. Smart Srnsors

A sensor is defined as any device that can detect and measure different types of physical properties and quantities, such as wind speed and direction, air pressure, light, humidity, heat, and many other physical variables. The input value read by the sensor results in an electrical signal that is usually transmitted to a microcontroller and then makes its way to a network interface for further processing. The evolution from primitive to smart sensors allowed a leap in how data are collected from the environment, processed, and used in making decisions for further investigations. IoT smart sensors can connect huge numbers of smart systems that help us develop smart solutions for emerging problems. which basically senses a physical attribute, and then the resulting signals are manipulated for further processing and sent out as an analog current. Technological advancements have improved modern sensors in terms of
how they convert the physically sensed data; signals are conditioned and converted to digital format, becoming input for an algorithm for processing and then being sent to the transceiver unit as illustrated. A smart sensor usually consists of the following:

 A sensing device that measures a physical attribute (heat, humidity, etc.).

 Signal conditioning to translate the sensed signal into data.

 A connected processing unit with memory and a user interface. This unit is loaded with an algorithm to process digital data.

 A transceiver unit to exchange information with the gateway/sink sensor node Sensors Types For

Smart Farming

Innovation is rapidly improving traditional farming practices. Technologies such as satellite imaging, unmanned aerial vehicles (UAVs), and sensor technologies are revolutionizing the agricultural industry. Smart farming applies information technologies for the optimization of complex farming systems. The objective of smart farming is to access and use data collected to solve a problem or optimize a solution. The main goal is to find a way to use the collected information in a smart way. Smart farming embraces almost all operations of a farm [16]. Farmers can use portable devices such as smartphones and tablets to monitor real-time data (irrigation, climate, fertilization, etc.) that will aid farmers in reacting to situations based on the collected data and making informed decisions supported by smart algorithms. There are many types of sensors that can be used to read and process agricultural data

List the most common sensors used in smart farming and their specifications.

- Water Content Sensors.
- pH Sensors.
- Weed Seeker Sensors
- Temperature Sensors.
- Wind Speed Sensors.

Expert Systems In Agriculture

AI is now regarded as a well-established and important technology that has contributed to many fields, such as commerce, medicine, electronics, games, manufacturing, and many more. In the domain of agriculture, AI technology has been used to create computer programs that can perform tasks that require human skills. There are a wide range of AI technologies that have been used successfully in agriculture, including expert systems and artificial neural networks. Expert systems are computer programs that can perform tasks that normally require the abilities of a skilled human. These tasks are usually decision-making tasks rather than physical activities, such as predicting or forecasting weather condition. Expert systems are used in agriculture to change farming practices and replace human labor. In expert systems, intel ligence means understanding and analyzing a pattern in the data to replicate human behavior for decision-making and problem-solving. The first application of AI techniques in the management of crops occurred in 1985.

Challenges Of Adopting AI In Agriculture

AI has provided great opportunities to the agricultural sector; however, there are still many challenges faced by researchers in this area, such as collecting the required data for building the knowledge base. In addition to external factors, challenges from sowing to harvesting have led researchers to improve and create AI techniques such as artificial neural networks, fuzzy systems, expert systems, and agricultural robots. These systems are widely used in many farming applications such as crop and soil monitoring, weed management, pest management, disease detection, yield prediction, and general efforts to overcome challenges. Environmental sustainability is a key factor in farming, as climate change will cause decreases in water supplies and increased costs of production. Crop management systems provide interfaces that cover many features of the management of crops. This approach was first introduced by McKinion and Lemmon. The designing of such systems is important for guarding crops from many different kinds of damage. Another challenge in farming is crop pests and the selection of measures to control them. Drone technologies were developed by different companies to help farmers virtually visit all their crops and provide full monitoring systems, which can be used to discover dead soil, diseases, irregular crops, and pests, in addition to recommending solutions to these issues. Plant diseases caused by pests have a significant effect on the global economy as 35% of crops are destroyed by different diseases. Thus, monitoring systems are needed to diagnose diseases and pests in addition to providing solutions. Such solutions can be based on past experiences. Soil quality is another factor to be considered for crop growth. It is known that many plants require specific soil characteristics to achieve maximum yield and profit.

Cloud Computing Services

Cloud computing services can be used in smart farming applications for the purpose of collecting and storing the data transmitted by remote sensors. On the other hand, cloud computing can be used for processing the data and generating results for the users. Data processing consists of data analysis, visualization, and decision-making. Cloud services can be classified into three connected layers, namely Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS), which correspond to the internet applications offered for end users, the tools used to implment a wide range of applications, and physical resources, respectively.

ARTIFICIAL INTELLIGENCE

The main concept or idea behind Artificial Intelligence (**AI**) is to understand intelligent entities. Many definitions address AI in different terminologies and frameworks. In 1990, Kurzweil defined AI as ‘‘the art of creating machines that perform functions that require intelligence when performed by people’’. The other idea of AI was proposed by Winston in 1992, who defined AI as ‘‘the Study of the compilations that make it possible to perceive reason and act

AI IN AGRICULTURE

Agriculture has a significant role in the sustained viability of any economy. It is signi cant for long-term economic growth and structural transformation, and it has evolved in terms of the processing, production, and conveyance of crops and domesticated animals. Currently, the agricultural sector is being influenced by new innovative IoT technologies,wireless communications, machine learning, and AI. Thanks to these technologies, the collection and analysis of data such as temperature, weather, soil properties, and historical crop performance provide predictive information that helps solve agricultural

problems such as crop dis eases, pesticide control, weed management, lack of irri gation, and water management. At the same time, intelligent robots that operate in dynamic and unstructured situations and interact with humans have sparked increased interest and expanded applications in all elds, including agriculture. Significant advances have occurred in the field of agricul ture from 1980 to the present day. For example, Jha etallisted more than 50 technological advances in sub fields of agriculture, including the use of artificial neural networks and expert systems, machine learning and fuzzy logic systems, automation, and IoT techniques to solve agricultural problems. Artificial neural networks that predict and forecast based on parallel reasoning were incorporated into the agricultural sector by Robinson and Mort, who proposed one of the first models to be fed with raw meteorological data like humidity, temperature, precipitation, and wind direction to predict the occurrence of frost.

ROBOTICS IN AGRICULTURE

The literature has reported various ideas regarding the abilibity of robots to assist in agricultural activities. Indeed, the mechanization and automatization of agricultural tasks are an essential step to addressing population growth. Khadatkar et al. emphasized the available robotic systems for various farm operations for field crops and horticulture and they discussed the following approaches and technologies presented in the literature for undertaking various agricultural operations:

 Transplanting: Robotic transplanters use computer graphics or machine vision systems for transplanting operations . Most robotic transplanters consist of a robotic arm for seedling pick-up, a path manipulator, and an end-effector.

 Intercultural operations: Intercultural operations such as weeding are done to kill weeds by mechanical weeders or chemical spraying. Robotic weeders use vision-based systems for weed detection, guiding weed ers, and uprooting weeds mechanically. Gonzalez-de-Soto et al. developed a robotic patch spraying system for the precise application of herbicides.

 Harvesting: Fruit selection and detachment are among the essential tasks for efficient harvesting. Most robotic harvesters have been developed for fruits and operate by grasping the fruit with grippers and then detaching it based on shape, size, color, and texture.

Rahmadian et al.explored three important developments of autonomous robotics in agriculture: navigation (incorporating GPS technology and vision-based sensor navigation to direct robots through agricultural elds), harvesting systems (incorporating sensors for harvesting and actuators to control harvesting devices), and soil analysis systems (giving information about the state of the farms soil). However, agricultural conditions present many difficulties for robotic

ABNORMAL ACTIVITIES

The first step in anomaly detection is defining the normal patterns as a standard reference point for the data analysis and processing phase. In general, an anomaly is defined as an abnormal state of the data that does not fit with the standard normal flow of systematic data behavior.

For the performance evaluation of the detection model, some anomalies were inserted into the data during the process of data collection from the sensors. The model was able to detect anomalies from different sensors successfully. The implemented autoencoder model in that study [145] was considered as one of the most well-recognized neural network techniques classi fied as an unsupervised learning method, where the encoder has to learn the ways of compressing, encoding, and reconstructing the data. Basically, after the input data are acknowledged, the autoencoder starts the encoding process, utilizing the bottleneck layer in order to shrink the input data size. In the decoding phase, the autoencoder is trained to ignore non-vital data in the process of reconstructing the original data. By ignoring non-vital data such as moisture too low, light too high, or humidity too low in the decoding process, the autoencoder will be able to process large numbers of features with as little loss of normal data aspossible and maximization of the loss of the anomalies contained within the testing dataset.

IRRIGATION LEAKAGE

Water is scarce and it is one of the most essential resources in the agricultural sector. A large amount of water is wasted as a result of the improper management of irrigation systems. As per the United Nations World Water Development Report, more than 50% of the worlds population will be facing high levels of water scarcity by 2050. The main reason for water wastage in farming is leakage in water distribution systems (WDSs). In an unmonitored irrigation system, small leaks in the WDS often go unnoticed, resulting in critical problems such as ruptures or bursts in the pipelines. The leakages in water pipelines are mainly due to excessive pressure on the pipelines, which causes distortion and further leads to the bursting of pipes when water flows through them.

Leakage detection in these pipelines by using a proper irrigation leakage monitoring system can help reduce water wastage and improve the ef ciency of irrigation systems. A considerable number of studies have been conducted on leakage detection in WDSs. Researchers have developed dif ferent approaches for leakage detection and localization, such as the use of ow sensors and methodologies to analyze inputs from the sensors.

CONCLUSION

Smart farming is a concept that involves handling and controlling farms using new technologies such as the IoT, robotics, drones, and AI to increase the quantity and quality of products while reducing the human labor required for production. These benefits will have positive effects on the profitability and the growth of the economy as population sizes are dramatically increasing worldwide. Therefore, researchers and scientists are moving toward the utilization of recently introduced IoT technologies in smart farming to help farmers use AI technology in the development of improved seeds, crop protection, and fertilizers. AI in agriculture is emerging in the three major areas of soil and crop monitoring, predictive analytics, and agricultural robotics. In this regard, farmers are rapidly beginning to use sensors and soil sampling to gather data to be used by farm management systems for further investigation and analysis.

In this survey, we have studied many AI applications in the agricultural sector to investigate the various developments and solutions to improve the productivity of farms and solve some environmental problems encountered during the pro duction of different types of products in agriculture. The AI models for farms help countries to maintain sustainability in this sector.

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