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Artificial Intelligence for Smart Sustainable Agriculture

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Abstract:

Artificial intelligence is proving itself day after day as an important solution towards improving agricultural productivity. Since artificial intelligence is the mainstay of robots, there is an increase in dependence on robots in the agricultural sector for better crop productivity and the increased consumer power is expected to drive the market to more dependence on robots. The gradual shift of farmers towards robots, smart sensors, drones and the increasing trends of precision farming have stimulated market movement. The increasing demand due to the increase in the population, the adoption of advanced technology and the information management system for crop productivity and government initiatives to adopt modern agricultural technologies are potential causes to stimulate movement, the market and moreover, the application of machine learning can find more solutions and predictive analysis in different agricultural practices. This use increases significantly. The application of Artificial Intelligence (AI) has been evident in the agricultural sector recently. The sector faces numerous challenges in order to maximize its yield including improper soil treatment, disease and pest infestation, big data requirements, low output, and knowledge gap between farmers and technology. The main concept of AI in agriculture is its flexibility, high performance, accuracy, and cost-effectiveness. This paper presents a review of the applications of AI in soil management, crop management, weed management and disease management.

Keywords:

Artificial Intelligence, Disease Management, Smart Agriculture, Internet of Things(IoT), Smart Sustainable Agriculture Solutions

1. Introduction

The agriculture industry nowadays is experiencing rapid growth and adopting advanced technologies in order to bolster the overall yield of the all crops. Accessibility of a huge number of equipment's and state of the art technologies like intelligent monitoring system, drones, and robots, among others has totally revolutionized this important sector.

Artificial Intelligence is one of the most important technologies in today's digital agriculture that is being implemented and deployed on a large scale for more sustainable use of available resources.

Actually, by leveraging AI, farm enterprises and farmers will be able to enhance agriculture production to meet the food demands in need of the hour. Since humans work hard and can only perform for some hours, indeed, machines have no fixed time to work. Every person's mind has not strong decision-making abilities that can lead the inadequate and indecorous decisions. On the contrary, AI-powered machines better learn the situations or environment and make strong decisions.

Advanced technologies such as remote sensing technology accompanied by the 3D laser scanning are helpful and can provide crop metrics across thousands of acres of farming land. It can bring revolutionary changes from the perspective of time and efforts are monitored by the farmers. With the help of emerging solutions, farmers and farm enterprises can make better decisions during the farming as well as can assess a variety of things like weather conditions, temperature, water usage, or soil conditions in real-time.

With the help of computer vision technology and drone-based data collected, farmers can take immediate actions in real-time in order to generate the alert to speed up precision farming. This is one of the significant areas in today's farming. Computer vision technologies are very important and useful and can be deployed in areas including disease detection, crop readiness and identification, field management, and soil survey and mapping.

Precision Farming: In this process, farmers can detect pests, diseases in plants, and poor plant nutrition of farms with the help of AI. Also, AI sensors can identify and target weeds and then decide which weed killers or herbicides to apply within the right zone. It assists to thwart over application of herbicides and excessive toxins that find their way in today's daily food.

2. Challenging and growing factors of AI in Agriculture

Despite a huge number of opportunities for applications in agriculture, there is still a lack of familiarity with the latest technology across most of the world. Also, the high initial cost associated with the deployment of AI in agriculture can be a restraining factor towards digitalization of the agriculture sector.

Rising investments in and adoption of AI and robotics are majorly accelerating the growth of the global AI in the agriculture market. AI applications in agriculture comprise agriculture robots, autonomous tractors, agricultural drones, crop health monitoring, facial recognition, and automated irrigation systems.

Agricultural robots will save time, money, increase yields, reduce energy usage and improve quality of crops. Furthermore, a robot can help farmers pick and pack their crops, technology can help farmers maximize their resources, it is likely to result in increased agricultural productivity and returns to investment & improved environmental sustainability.

2.1. Applications of AI in Agriculture

Artificial Intelligence (AI) is used in many different industries, from manufacturing to automotive; one of the most interesting industries that AI is breaking into is agriculture. Moreover, Agriculture is a major industry and a huge part of the

foundation of our economy, as climates are changing and populations are increasing, AI is becoming a technological innovation that is improving & protecting crop yield.

The most popular applications of Artificial Intelligence in agriculture industry are three major categories which are Agricultural Robots, Predictive Analytics, Crop & Soil Monitoring, Computer vision & deep-learning algorithms are used to process data captured by drones and/or software-based technology to monitor crop & soil health, equipment's learning models are used to track & predict various environmental impacts on crop yield such as climate changes.

The use of artificial intelligence in the agricultural market has been divided according to technology and application:

Based on technology, the market is separated into predictive analysis, computer vision and machine learning. The applications sector includes drone data analysis, livestock control, precision agriculture and robotic agriculture. The rapid use of computer vision technology, including the identification of plant images, the increasing demand for crop health analyzes and the continuous monitoring of all data are among the main factors contributing to the growth of this sector. The drone market is also expected to grow as a result of the widespread application of these drones. This enables them to make decisions in real time as well as to diagnose and monitor crop health. Moreover, it is expected that government rules and regulations for drones will change to facilitate procedures for their actual use in the agricultural sector as a result of increased reliance on them.

The use of artificial intelligence in the agricultural market has been divided according to technology and application.

This technology can save human time and effort to ensure crop safety, and it will add benefit to agricultural crops produced at broad commercial levels, opening up an opportunity to commonly employ artificial intelligence in our lives.

Some tomato growers install a network of cameras in the greenhouse roofs to monitor plant growth and identify any urgent problems, and some farmers have piloted drones as a way to automatically monitor their crops.

Artificial intelligence is used to monitor climatic conditions to know the most appropriate times for cultivation, as well as know the state of the soil to determine the types that can be grown and research ways to improve the quality of crops and increase their productivity.

2.2. The Internet of Things (IoT) and Artificial Intelligence (AI)

The Internet of Things (IoT) and Artificial Intelligence (AI) have been employed in agriculture over a long period of time, alongside other advanced computing technologies. However, increased attention is currently being paid to the use of such smart technologies. Agriculture has provided an important source of food for human beings over many thousands of years, including the development of appropriate farming methods for different types of crops. The emergence of new advanced IoT technologies has the potential to monitor the agricultural environment to ensure high-quality products. However, there remains a lack of research and development in relation to Smart Sustainable Agriculture (SSA), accompanied by complex obstacles arising from the fragmentation of agricultural processes, i.e. the control and operation of IoT/AI machines; data sharing and management; interoperability; and large amounts of data analysis and storage. This study firstly, explores existing IoT/AI

technologies adopted for SSA and secondly, identifies IoT/AI technical architecture capable of underpinning the development of SSA platforms. As well as contributing to the current body of knowledge, this research reviews research and development within SSA and provides an IoT/AI architecture to establish a Smart, Sustainable Agriculture platform as a solution.

Agriculture is the bedrock of sustainability of any economy [1]. It plays a key part in long term economic growth and structural transformation [2] though, may vary by countries [3]. In the past, agricultural activities were limited to food and crop production. But in the last two decades, it has evolved to processing, production, marketing, and distribution of crops and livestock products. Currently, agricultural activities serve as the basic source of livelihood, improving GDP [4].

The introduction of AI to agriculture will be enabled by other technological advances, including big data analytics, robotics, the internet of things, the availability of cheap sensors and cameras, drone technology, and even wide-scale internet coverage on geographically dispersed fields. By analyzing soil management data sources such as temperature, weather, soil analysis, moisture, and historic crop performance, AI systems will be able to provide predictive insights into which crop to plant in a given year and when the optimal dates to sow and harvest are in a specific area, thus improving crop yields and decrease the use of water, fertilizers and pesticides.

2.3. Disease Management

To have an optimal yield in agricultural harvest, disease control is necessary. Plant and animal diseases are a major limiting factor regarding the increase of yield. Several factors play role in the incubation of these diseases which attack plants and animals, which include genetic, soil type, rain, dry weather, wind, temperature, etc. Due to these factors and the unsteady nature of some diseases causative influence, managing the effects is a big challenge, especially in large scale farming. To effectively control diseases and minimize losses, a farmer should adopt an integrated disease control and management model that includes physical, chemical and biological measure [5]. To achieve these is time consuming and not at all that cost effective, hence the need for application of AI approaches for disease control and management. Explanation block (EB) gives a clear view of the logic followed by the kernel of the expert system [6]. A novel approach of rule promotion based on fuzzy logic is used in the system for drawing intelligent inferences for crop disease management. A text-to-speech (TTS) converter is used for providing capability of text-to-talking user interface. It provides highly-effective interactive user interface on web for live interactions [7] . A rule based and forward chaining inference engine has been used for the development of the system that helps in detecting the diseases and provides treatment suggestion in [8].

Smart Agricultural is a global initiative to preserve resources and maintain sustainable agriculture [9]. Recently, researchers have adopted the Internet of Things (IoT) [10], with a number of studies emphasizing the adoption and implementation of IoT in agriculture, farming, and irrigation [11]. Around the globe, many private companies and organizations are now focusing on investigating new technologies to create a smarter agriculture environment. These include mechanical and economic aspects, engineering, food retailers and computing. However, agricultural processes are fragmented, resulting in a number of issues, i.e. difficulties in operating and managing smart machines, data sharing and management, data analysis and storage

[12]. It is therefore important to facilitate cooperation when developing standards for smart agriculture, while also enhancing interoperability among different stakeholders, systems and technologies [13].

The use of IoT and AI technologies has the potential to result in a positive transformation of traditional agriculture [14], including: (1) improved use of data collected from smart agriculture sensors; (2) managing and governing the internal processes within the smart agriculture environment (including the management of the harvesting and storage of crops); (3) waste reduction and cost saving; (4) increasing business efficiency by means of automating traditional processes; and (5) improving the quality and volume of products . A major challenge is to provide farmers with the required information in a rapid manner [15]. AI therefore has significant potential to address the urgent challenges faced by traditional agriculture. There has, over previous decades, been considerable research and application of AI, including in: smart agriculture; robotics; agricultural optimization management; automation; agricultural expert systems; agricultural knowledge-based systems; and decision support systems [16].

2.4. Farm Management Systems (FMS)

Farm Management Systems (FMS) can assist farmers with a variety of collected information, by managing and controlling various tracking devices and sensors. The collected information is analysed for the undertaking of complex decision-making tasks before being placed in a storage medium. This enables the use of the most effective agricultural data analysis practices [17]. Soil Monitoring Systems help to track and improve the quality of soil through the monitoring of its physical, chemical, and biological properties. Livestock monitoring systems provide real-time assessment of the productivity, health and welfare of livestock, to promote the health of animals [18]. The IoT/AI SSA platform Cloud offers real-time information to farmers to facilitate decision-making and reduce operational costs, while at the same time enhancing productivity. Following a review of a considerable amount of research, we define SSA as the utilization process of IoT/AI technologies to establish, monitor, manage process and analyse data generated from various agricultural resources, such as field, crops, livestock and others to ensure the sustainability and quality of agricultural products and further enrich decision-making taken by stakeholders.

Artificial Intelligence and Data Management Layer: This layer is responsible for managing processes and controlling the business logic, focusing on three main activities: (1) data analysis and processing, using data mining and intelligence statistical analysis on generated data; (2) data classification and transformation, using ontologies, and machine learning to classify and transform analyzed data; and (3) data interpretation, representing the transformed data into knowledge to make machines smarter .

2.5. Internet of Things (IoT) and Sensing Layer

This forms the first interaction layer with SSA domains. It uses and hosts various types of IoT devices (e.g. sensors), capable of collecting data from real-world objects, sharing it to provide real-time data. Many sensors in the cloud are hosted and integrated within this layer, i.e. humidity sensors, moisture sensors and weather monitoring systems. Furthermore, this layer is responsible for operating robotic and drone actuators to assist in the mobility of intelligent machines within the agricultural

area. It thus allows intelligent machines to move between locations, in order to cover a wide area .

3. Conclusion

This paper has established the importance of employing recent and advanced computing technologies in the agricultural sector, in particularly AI and IoT. Agriculture is considered central to the survival of human beings. Supporting the current practices of traditional agriculture with recent IoT/AI technologies can improve the performance, quality and volume of production. This study has reviewed the existing IoT/AI technologies discussed within the main research journals in the area of agricultural. Further, it categorized the main domains of smart, sustainable agriculture, i.e. human resources; crops; weather; soil; pests; fertilization; farming products; irrigation/water; livestock; machines; and fields. The major contribution of this paper concerns the AI/IoT technical architecture for SSA, leading to an emphasis on the research and development of a unified AI/IoT platform for SSA, to positively resolve issues resulting from the fragmentary nature of the agricultural process. Future work will include investigation of the process of implementing AI/IoT technologies for SSA by applying the proposed AI/IoT technical architecture in the form of the prototype of a unified platform on real test cases. This will identify the relevant strengthens and weaknesses for further improvement and enhancement.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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