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DEVELOPMENT OF NEW SENSORS AND TECHNOLOGIES FOR PRECISION AGRICULTURE

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ABSTRACT

Precision agriculture is becoming increasingly important in modern agriculture as it allows farmers to optimize production and increase yields. This includes the use of sensors and technologies to collect and analyze data on soil, crops, weather, and other relevant factors. However, existing technology still has limitations such as accuracy and coverage over large areas. In order to solve this, new sensors and technologies are being developed, especially those based on artificial intelligence and machine learning, which allow for greater accuracy in data collection. In addition, new technologies such as drones and satellite imagery are being used to map crops and optimize agricultural production. This paper analyzes some of the latest developments in precision agriculture, providing insight into the future development and application of this technology. This work is particularly relevant to farmers, researchers, and companies involved in the development of sensors and technologies for precision agriculture.

Keywords: Technology, sensors, machine learning, artificial intelligence, agriculture.

INTRODUCTION

With the rapid advancement of technology and the decreasing size of sensors, their use is now expanding into almost all areas of life. One such domain is agriculture, where sensors and their networks are effectively used to achieve numerous benefits (Rehman, Abbasi, Islam, & Shaikh, 2014). Precision agriculture or PA is a concept that involves the use of information technology to improve production and crop quality (Milićević, Zdravković, Jović, & Jagličić, 2022). One technology that plays an important role in this area is a wireless sensor network or WSN. This technology is used to collect and analyze data from agricultural fields, enabling more accurate and efficient monitoring of various factors such as pest and disease control, crop strength, and animal monitoring (Kumar, & Ilango, 2017). Using WSNs can improve crop productivity while maintaining high-quality standards. This paper explores the importance of sensors in precision agriculture and the critical role that WSN technologies play in remote monitoring in various agricultural applications. In addition, drones are being considered for crop observation as well as yield optimization management (Shaikh, Rasool, & Lone, 2022).

THE IMPORTANCE OF SENSORS AND TECHNOLOGY IN PRECISION AGRICULTURE

The term precision agriculture is known worldwide as a significant factor in the improvement of crop production technology. However, its practical application is limited to large farms. This state-of-the-art technology relies on an innovative systems approach and combines several core technologies such as Geographic Information System (GIS), Global Positioning System (GPS), computer modeling, ground/aerial/satellite remote sensing, variable speed technology, and advanced information processing. These elements facilitate timely crop management within and between seasons (Liaghat, & Balasundram, 2010).

Sensors and technologies play a key role in precision agriculture, as they enable more precise and efficient management of agricultural resources. By collecting and analyzing data on various factors such as soil moisture, temperature, and nutrient levels, sensors can provide valuable insights into crop health and growth. This information can then be used to optimize irrigation and fertilization schedules, reduce waste and increase crop yields.

In addition to sensors, other technologies such as drones, GPS systems, and machine learning algorithms are used in precision agriculture. Drones can provide high-resolution images of crops, enabling early detection of pest and disease infestations. GPS systems can be used to map fields and track equipment in real-time, optimizing resource use and reducing costs.

Machine learning algorithms can be trained on large data sets to predict crop yields and identify patterns that can be used to improve management practices. Overall, the importance of sensors and technologies in precision agriculture cannot be overstated. They enable farmers to make informed decisions, optimize resource use and ultimately increase profitability and sustainability.

Figure 1. Connection of GIS tools in precision agriculture (Digital Agro, 2022)

DEVELOPMENT OF NEW SENSORS FOR PRECISION AGRICULTURE

Precision agriculture has emerged as an innovative solution to solving current challenges in agriculture. Precision agricultural sensors are an important tool in modern agriculture because they allow farmers to collect data about their crops and livestock in an efficient way. These sensors help farmers monitor and improve the quality of their produce, and stay abreast of changes in the field and environment.

Intelligent agricultural sensors are used to identify animals, monitor their health and detect heat. This facilitates the isolation and treatment of sick animals, as well as the monitoring of the entire herd. Smart sensors can also be used to monitor crops and their effectiveness remotely, solve pest problems and protect crops from potential environmental risks. Overall, precision

agricultural sensors represent a very useful technology that can improve the quality of food production, save time and money for farmers, and at the same time contribute to the preservation of the environment.

Overview of current sensor technologies for precision agriculture

There are a variety of sensors currently in use in precision agriculture, each with its own advantages and limitations. One type of sensor commonly used in precision agriculture is the soil moisture sensor, which measures the amount of moisture in the soil. This information is used to determine when and how much to irrigate crops.

Other sensors used for soil analysis include pH sensors, nutrient sensors, and electrical conductivity sensors. Weather sensors are also important in precision agriculture as they provide information on temperature, humidity, wind speed, and precipitation. This data is used to optimize crop growth and reduce the risk of damage caused by extreme weather conditions.

Remote control technologies such as satellites and drones are also used in precision agriculture. They provide a bird's-eye view of fields and can be used to gather information on crop health, yield, and other important factors. In addition to these sensors, there are also specialized sensors for monitoring plant growth, detecting pests and diseases, and even monitoring the movement of livestock.

These sensors can provide valuable data that can be used to optimize crop yields, reduce the use of pesticides and other chemicals, and improve animal welfare. Overall, the use of sensor technologies in precision agriculture is rapidly evolving, and new sensors and technologies are constantly being developed and refined to meet the ever-changing needs of farmers and agricultural professionals. Some examples of these sensors are GPS sensors, agricultural temperature sensors, property monitoring, and accelerometer sensor (GeoPard Agriculture, 2022)

New sensors based on artificial intelligence and machine learning

The information technology of the agricultural sector is currently considered a problem to deal with the many difficulties that arise in this area. The development of efficient and more profitable agricultural systems and instruments is increasing rapidly with environmental monitoring and remote control in agriculture.

Wireless sensor technology based on artificial intelligence improves the efficient functioning of all sectors and solves the problems faced by many sectors in the agricultural industry, such as crop harvesting, irrigation, and soil content sensitivity. AI technology enables the diagnosis of plant diseases, pests, and malnutrition on farms, and AI sensors can monitor and control agricultural parameters (Murugamani et al., 2022). This cutting-edge technology, driven by machine learning (ML), enables machines to learn without explicit programming. ML, along with the Internet of Things (IoT)-enabled agricultural machinery, is a key component of the agricultural revolution.

One application of ML in precision agriculture is through computer vision to classify different crop images for crop quality monitoring and yield estimation. This approach can also be integrated for improved livestock production by predicting fertility patterns, diagnosing nutritional disorders, and monitoring animal behavior using ML models based on data collected by collar sensors.

Intelligent irrigation, such as drip irrigation, and intelligent harvesting techniques are also being developed and revised, significantly reducing the need for human labor. This technology offers great potential for improving agricultural efficiency and sustainability in the future. New products, practices, and new technologies are in demand in the agricultural industry. To meet these diverse needs, farmers must use precision agriculture.

Figure 2 (a) and (b) presents a pictorial representation of the farm management system enabled by traditional agriculture and technology.

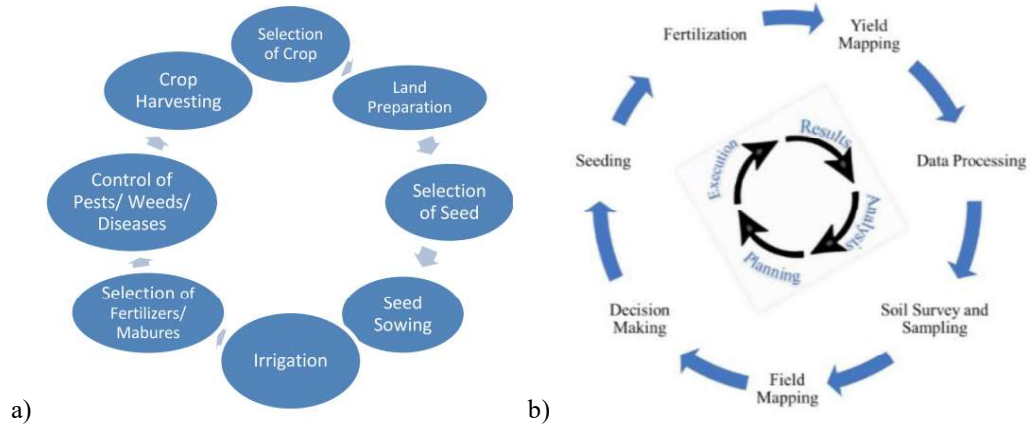

Figure 2. (a) Traditional agricultural cycle, (b) Precision agriculture cycle (Sharma, Jain, Gupta, & Chowdary, 2020)

USE OF DRONES AND SATELLITE IMAGES FOR OPTIMIZATION OF AGRICULTURAL PRODUCTION

In recent years, smart sensors, big data and machine learning, non-invasive technologies, and information technologies have been combined to derive reliable plant physiological parameters with increasing throughput for precision agriculture (Qiao, Valente, Zhang, Su, & He, 2022). Recently, drones have been increasingly used in agriculture. Drones, equipped with various cameras and sensors, can be used for terrain mapping, nutrition monitoring, plant health monitoring, detection of harmful organisms, and localized application of biological plant protection agents.

Satellite and drone data offer a new perspective on previously overlooked fields - a bird's eye view. This unique aspect of precision agriculture allows farmers to identify problems that were once difficult to detect. Drones and satellites can provide valuable information about crop pests and diseases, nutritional status, yield forecasting, and more.

The process of working with a drone involves collecting data, usually through multispectral imaging fields, although RGB images are increasingly used. The next step is to process the data using specialized software such as Pix4dFields, which can be done in the field without an internet connection. This creates the basis for more detailed vegetation indices.

After the data has been recorded and processed, the next step is to generate and interpret the index. This includes clearly marking the edge areas to be cultivated and identifying areas that are subject to flooding, erosion, or other features such as ground elevation. Multispectral images can reveal irregularities such as pests, diseases, or nutrient deficiencies, which enables the planning of further activities based on multispectral analysis.

Application maps can be created to apply irrigation resources or techniques precisely to marked areas of fields with water or nutrient deficiencies. In the end, the created application maps are performed by inputting them into a machine equipped for precision agriculture, such as a tractor with GPS guidance and a console, or an agricultural drone like the AGRAS T30, designed specifically for precision agriculture. Figure 3 shows the use of drones in precision agriculture (Elashmawy & Uysal, 2023).

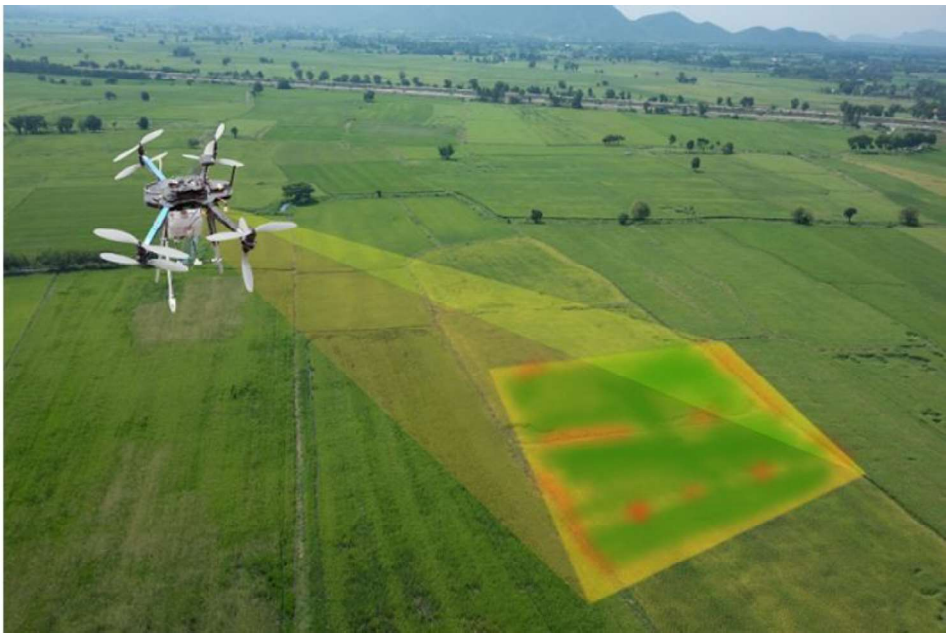

Figure 3. Use of drones in precision agriculture (Sela, 2022)

CONCLUSION

In the world of big data, where sensor networks have become ubiquitous, artificial intelligence (AI) and machine learning (ML) are creating significant opportunities in multidisciplinary fields such as healthcare, financial services, and precision agriculture. In conclusion, precision agriculture is a rapidly developing field that relies heavily on advances in sensors and technology. Wireless sensor networks, drones, GPS systems, and machine learning algorithms play a key role in collecting and analyzing data on various factors such as soil moisture, temperature, and nutrient levels to optimize crop management.

Despite existing sensor technologies, precision agriculture still faces limitations in terms of accuracy and coverage of large areas. In order to solve this, new sensors based on artificial intelligence and machine learning are being developed, which enable greater precision in data collection. In addition, drones and satellite imagery are used to map crops and optimize agricultural production. Overall, precision agriculture provides numerous benefits, including increased crop productivity, reduced resource wastage, and increased profitability and sustainability. The continuous development and improvement of sensors and technologies in precision agriculture are of crucial importance to meet the ever-changing needs of farmers and agricultural experts.

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