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Live Monitoring of Agricultural Land with an Internet of Things (IoT) Based Smart Farming Approach: Case Study of Corn Field

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Abstract. Technological innovations in the agricultural sector result in rapid progress, causing conventional farming systems to be no longer used. Agricultural technology innovations help improve the quality of agricultural production and produce superior agricultural products. Technological innovation in agriculture can be referred to as "Smart Farming." Recently, Smart Agriculture has been proposed in various studies to increase food production. Smart Farming System introduces various information technology models such as the Internet of Things (IoT), artificial intelligence, and cloud computing. Internet of Things (IoT) and artificial intelligence are two core techniques for building Intelligent Farming Systems. IoT is utilized to automatically collect agricultural data and transmit the collected data to the data centre. In contrast, artificial intelligence techniques such as Artificial Neural Networks (ANN) are used to analyze agricultural data in decision making. This study aims to identify the Deep Learning Convolutional Neural Network method in improving the quality and quantity of corn. The data is obtained in the form of sensor data for soil pH and humidity values. Then the process uses the Deep learning Convolutional Neural Network (DL-CNN) algorithm that brings about output in the form of Data Tables and Graphs.

26 July 2023 14:22:59

INTRODUCTION

Conventional farming systems are agricultural systems that aim to obtain maximum agricultural production by utilizing modern technology such as high doses of synthetic chemical fertilizers and pesticides without or little input of organic fertilizers [1]. Farmers mostly practice this farming system in all regions. However, the weakness of conventional farming systems is that it is one of the applications of agricultural systems that have the potential to reduce soil organic-C levels, encourage the destruction of soil structure, reduce soil fertility, and lose fertilizers and other chemical elements due to erosion and leaching [2]. In the long term, this impact can reduce soil quality and productivity due to soil degradation.

Technological innovations in the agricultural sector result in extremely rapid progress, causing conventional farming systems to be no longer used. Agricultural technology innovations help improve the quality of agricultural production and produce superior agricultural products. Technological innovation in agriculture can be referred to as "Smart Farming." Smart Farming is a conceptual idea about cultivating agricultural land using the latest technology and earning more income than conventional farming [3].

Smart Farming is also known as precision farming, in which farming is managed by software and monitored by sensors. Smart Farming is increasingly important because it is a combination of a growing global population, increasing demand for higher yields, the need to use natural resources more efficiently, the increasing use and sophistication of information and communication technologies, as well as the increasing demand for "Climate-Smart Agriculture" [4].

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Monitoring environmental parameters and weather conditions play an important role in the production phase of the crop. Monitoring such as sunshine, rainfall, and humidity guides optimal water use for crop irrigation scheduling and planning. Recently, Smart Agriculture has been proposed in various studies to increase food production. Smart Farming System introduces various information technology models such as the Internet of Things (IoT), artificial intelligence, and cloud computing. Internet of Things (IoT) and artificial intelligence are two core techniques for building Intelligent Farming Systems [5]. IoT is used to automatically collect agricultural data and transmit the collected data to the data centre. In contrast, artificial intelligence techniques such as Artificial Neural Networks (ANN) are used to analyze agricultural data in decision making. The basic concepts of a smart farming system are shown in Fig. 1 below.

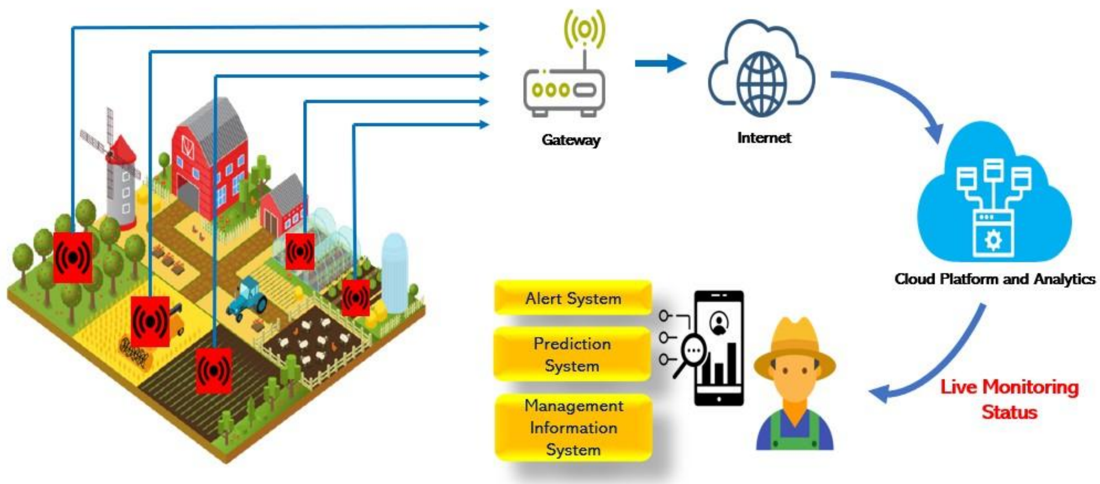

FIGURE 1. Basic Concepts of Smart Farming System

Smart Farming can be considered a modern farming system to produce a better quantity and quality of agricultural products, particularly for the researched products. This study aims to identify how IoT is used in Smart Farming by (i) presenting the main components of IoT-based Smart Farming with relevant technologies, (ii) identifying the most used hardware and platforms, (iii) evaluating the use of various analytical techniques in IoT, such as artificial intelligence, and (iv) reviewing the challenges of using IoT technology in the agricultural sector, corn farming case studies. Introduction This paper describes previous studies on how conventional farming systems turn into Smart Farming, a technological innovation in agriculture widely adopted by developed countries to create more effective and efficient agriculture.

The remainder of this paper is structured as follows: Section II describes smart farming in the cornfield to produce ethanol energy, Section III discusses IoT technology-based smart farming. Next, Section IV reviews the data and methodology that are going to be used in the study. Section V discusses and emphasizes the important takeaways through conclusions.

SMART FARMING IN CORNFIELD FOR ETHANOL ENERGY PRODUCTION

Corn is one of the strategic agricultural commodities in Indonesia [6]. Corn is also considered one of the staple foods in some parts of the country [7], such as East Java, East Nusa Tenggara, North Sulawesi, Southeast Sulawesi, and Papua [8]. Besides being a staple food, corn is also used as animal food [9] and raw material for renewable bioenergy [10]. The need for corn will potentially continue to increase along with the increase in population and the diversification of the use of corn to support community needs [11].

One factor affecting the gap between the yield and the potential of corn plants is the abiotic factor [12]. Abiotic factor in the form of climate change brings about irregular rainfall, and it affects the availability of groundwater and decreases maize production [13]. In general, maize plants absorb water easily if the groundwater does not fall from 60 cm below the plant root system [14]. On the other hand, maize is difficult to adapt to areas with high rainfall intensity [15]. Corn planting is more optimally carried out on dry land with land that has a high water storage capacity

26 July 2023 14:22:59

[16]. The condition exists because excessive water intensity in maize cultivation results in the reduction in leaf area and production, and it can, as a result, cause plant death [17]. In addition, the intensity of water from irrigation sources affects the growth and the characteristics of maize [18]. Therefore, it is important to monitor soil moisture to obtain optimal corn production. Monitoring soil moisture can be used as a climate model and an indicator of flood and drought conditions that impact corn production.

One of the advantages of the Smart Farming system is that it can produce a better quality of agricultural products compared to other systems. For example, with the Smart Farming system, corn and wheat are grown and used as food and animal food, but they can also be used as raw materials for renewable ethanol fuels. Corn ethanol is the ethanol produced from corn biomass, and it is mixed into more than 98% of gasoline to reduce air pollution [19]. Corn ethanol reduces well-to-wheel greenhouse gas emissions by up to 101 through 115% [20]. The type of corn used for ethanol is called “No.2 Yellow”. The USDA Corn Grades provides a reference, and ethanol plant operators accept USDA Grade #2 Yellow Corn as the minimum quality grade for ethanol production [21]. It is hoped that this monitoring can increase corn production and productivity following ethanol renewable energy production standards.

IOT TECHNOLOGY BASED UPON SMART FARMING

IoT-based smart agriculture consists of four main components [22], [23], as shown in Fig. 2. The four main components are 1) IoT devices, 2) communication and connection technology, 3) data processing, and 4) data analysis.

IoT systems are based on devices that provide sensing, actuating, controlling, and activity monitoring [24]. These IoT devices are sometimes also referred to as IoT sensors. IoT devices can exchange and collect data with other connected devices and applications via the internet. The sensor output in an electrical signal transmitted to the microcontroller is sent through the network for further processing. In agriculture, IoT tools provide useful information regarding various environmental parameters that can improve the quality and quantity of agricultural products [25]. The imagery of the Key Component of IoT-based Smart Agriculture is shown in Fig. 2 below.

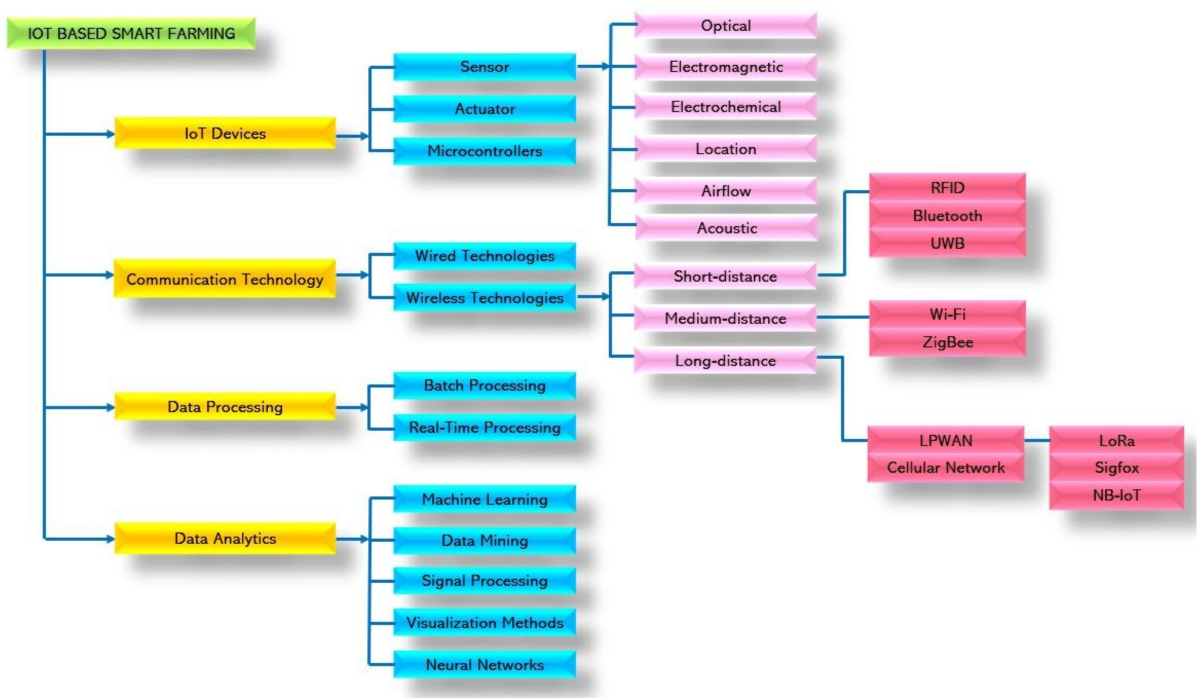

FIGURE 2. Key Components of IoT-based Smart Agriculture

Wireless communication technology has an important role in the successful implementation of IoT systems. The technology can be categorized based on spectrum, transmission distance, and application scenarios. Various studies have been proposed to overcome problems in IoT communication technology used in smart agriculture, such as reducing energy consumption [26], increasing resiliency and scalability [27], propagation losses [28], integrating

26 July 2023 14:22:59

various network protocols, and reducing latency problems [29]. The selection of communication technology following the circumstances and the area of agricultural land must also be well planned. Zigbee, LTE, CDMA, GSM, Wi-Fi, LoRa, NFC, and RIFD are communication technologies used for agricultural purposes [30]. Various protocols like HTTP, WWW, and SMTP serve as efficient communication in agricultural scenarios.

Several IoT technologies have been developed and classified based on data processing concepts, batch processing technology, and real-time processing technology [31]. The batch processing technology is more suitable for high throughput data processing. The principle used is to store data first and then process it. Meanwhile, real-time processing technology processes data that is moving or happening to get valuable information as quickly as possible. Real-time data processing must operate with high data rates and low latency.

The main constituent of IoT applications is choosing an efficient data analysis method based on the characteristics of the data generated by the IoT system [32]. Data analysis means analyzing each data segment to identify trends, extract hidden information, and extract valuable information. Data models such as neural networks, cluster classification methods, machine learning are widely used in research for data analysis in IoT applications.

DATA AND METHODOLOGY

The imagery data come from a variety of sources. The bulk of the data is collected in a cornfield demonstration plot for this research. Data retrieval uses a soil pH sensor and humidity sensor. Data from the sensor is then sent to Arduino by using the ADC port that is calibrated so that it gets an accurate soil pH and humidity value. The calibration data on Arduino is sent to Visual Studio C# using the Serial port for processing by using the DL-CNN (Deep Learning Convolutional Neural Network) algorithm that produces output in the form of data tables and indicator graphs, as shown in Fig. 3 below.

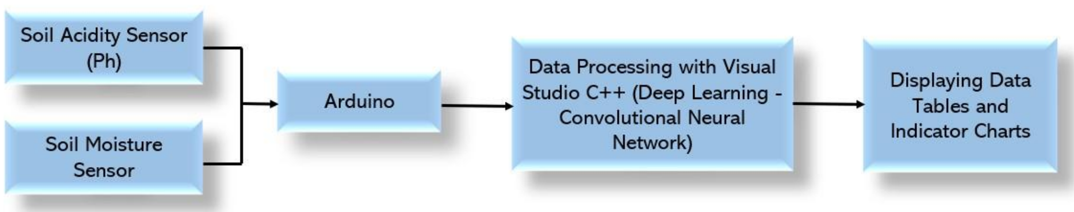

FIGURE 3. Data Processing

The approach for determining live monitoring status for cornfield demonstration plots is a type of Deep Learning called Convolutional Neural Network (CNN). The data is obtained in the form of sensor data for soil pH and humidity values. Then the process uses the Deep learning Convolutional Neural Network (DL-CNN) algorithm that brings about output in the form of Data Tables and Graphs. One of the previous studies examined crop disease detection by using DL-CNN. The overall modelling process requires several steps for effective data preparation for the CNN model to achieve a good result. Fig. 4 below illustrates the detailed set of steps involved [33].

FIGURE 4. Model Pipeline

CONCLUSION

This article shows that several cases used the Deep Learning Convolutional Neural Network technique in several previous studies, for example, examining plant disease detection using DL-CNN. Moreover, in our future research, which is applied in monitoring the status of agricultural land (case study: cornfields) in real-time, we will also use the

26 July 2023 14:22:59

Internet of Things (IoT) Based Smart Farming with a DL-CNN approach, it is expected to be able to monitor agricultural land in real-time to improve the quality and quantity of corn.

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