The Ciência & Engenharia - Science & Engineering Journal
ISSN: 0103-944X
Volume 11 Issue 1, 2023
pp: 2667 – 2677

Smart Agriculture Using Iot and Machine Learning

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Abstract— In recent years, farmers have had to deal with a lot of problems. Some of these problems include scarcity of water, improper crop selection, lack of knowledge on modern farming techniques, improper irrigation control etc. Even today, a large section of the farmers are dependent on the traditional farming techniques. It involves the use of an approximation of the amount of manure, fertilisers and irrigation needed, which does not guarantee maximum harvest output. In order to address these issues and to ensure a better yield, an attempt is made to develop an application that can predict the fertiliser content and the type of crop that would be most suitable for the selected area based on the environmental factors and can also implement an automatic irrigation system remotely. To do this, the trained submodels of the main system are used to process the environmental factors that affect plant growth and the water level is considered for irrigation purposes. Smart agriculture that is enabled by the Internet of Things (IoT) allows farmers and growers to maximise productivity while minimising waste in areas such as the amount of fertiliser used, the number of trips made by farm vehicles, and the efficient use of resources such as water and electricity. IoT smart agricultural solutions are systems that track crop fields and automate irrigation systems. It makes use of various sensors, devices, software etc. which help increase the yield.

Keywords— Sensors, Smart agriculture, Irrigation system, Internet of Things, Crop prediction, Fertiliser content prediction, Blynk 2.0

Introduction

Smart agriculture refers to the use of cutting-edge technologies, such as IoT, big data, and artificial intelligence, to improve the efficiency, productivity, and sustainability of agriculture. With the world's population projected to reach nearly 10 billion by 2050, the demand for food is expected increase significantly [1]. Currently farmers are facing numerous challenges, including climate change, resource constraints, and declining soil fertility. In this context, smart agriculture offers a promising solution to help meet the growing demand for food while addressing the challenges facing the agricultural sector.

Traditional farming is a term for farming methods that have been around for a long time and are based on manual labour, simple tools, natural resources, and traditional knowledge. These methods have several issues that impact the efficiency and sustainability of the agriculture sector. The intensive use of pesticides and fertilisers, monoculture practices, and overexploitation of resources have led to soil degradation and a decline in soil fertility. These practices have also resulted in environmental pollution, which has negative effects on human health and the ecosystem. Additionally, traditional farming is often reliant on manual labour, which can be time-consuming and labour-intensive. The use of outdated techniques and lack of access to modern technologies and resources also limit the productivity and profitability of traditional farms. These challenges have led to a growing demand for innovative and sustainable agriculture practices, such as smart agriculture.

IoT-based smart agriculture refers to the use of IoT technologies to improve the efficiency, productivity, and sustainability of agriculture. It involves the use of sensors, devices, and other technologies to gather data about various aspects of agriculture, such as soil conditions, weather patterns, crop growth, disease control etc. This data is then analysed and used to make informed decisions about crop management, irrigation, fertilisation, and other aspects of agriculture. Some examples of IoT-based smart agriculture technologies include precision agriculture systems, smart irrigation systems, and animal tracking systems [2].

The benefits of using IoT and related technologies in the agricultural sector are as follows. IoT-based smart agriculture allows for increased efficiency and productivity by enabling farmers to collect and analyse data in real-time, which enables them to make informed decisions about crop management, irrigation, fertilisation, and other aspects of agriculture. This can lead to optimized use of resources, reduced waste, and increased crop yields. Secondly, it can help to improve the sustainability of the agriculture sector by reducing the use of harmful chemicals and promoting conservation practices. For example, precision agriculture systems can help farmers to use fertilisers and pesticides more efficiently, reducing their impact on the environment. Thirdly, it can help to improve the traceability of food products, allowing for better tracking of food from the farm to the consumer. This can help to ensure food safety, improve food security, and promote transparency in the agriculture sector.

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It can also help to improve the livelihoods of farmers by providing them with access to new technologies and resources, allowing them to increase their yields and income.

The Smart agriculture system helps to select more suitable crops, helps to calculate the accurate amount of fertiliser required and enables proper and remote control over irrigation system. This is achieved by collecting real time values of various soil components using sensors. Using this data the most suitable crop and the fertiliser content required for the farmland is predicted by the trained model. The system automates the irrigation based on the soil moisture content. The sensor values are displayed on the Blynk platform which also sends alerts to the farmer.

The rest of the paper is organized as follows: Section 2 provides the related works on smart agriculture and the use of IoT in agriculture. Section 3 describes the design and implementation of the proposed IoT-based smart agriculture system. This section includes a discussion of the hardware and software components of the system, as well as the architecture diagrams. Section 4 provides the implementation details a discussion of the results of field tests. Finally, the paper concludes with a summary of the main findings and recommendations for future work in the field of IoT-based smart agriculture.

Related Works

This section discusses the related works on IoT and ML based smart agriculture. With the use of IoT, key agricultural processes including soil sampling, mapping, irrigation monitoring, fertilisation, yield monitoring, forecasting and harvesting can be made much more efficient. Almost every industry has undergone a makeover as a result of IoT-based technology, including smart agriculture that shifted from statistical to quantitative methodologies.

When it comes to gathering data on crop conditions and other matters, wireless sensors are the most important and play a significant role. Using temperature sensors, humidity sensors, soil moisture and fluid level sensors, it is feasible to monitor the ambient temperature, humidity and soil moisture [3]. Standard chemical soil analysis is made easier by electrochemical sensors. Therefore, they are appropriate for detecting soil elements including macro and micro nutrients that must be taken into account at various stages of agriculture, such as crop and fertilisers selection [4].

The logic that determines how remedial action will be done in response to sensor readings must be defined by onboard processing. Three well-known microcontroller-based platforms utilised in IoT-based SAS are the ATMEGA328P, ESP8266 NodeMCU microcontroller and the 18F458 PIC microcontroller. These platforms are low-cost, power-efficient, do not need a lot of extra circuitry and have processing built in [3].

Cellular communication, Zigbee, LoRa, SigFox and other technologies can be employed for communication in agriculture. Long-range and low-power LoRa wireless technology is one of them [4]. Compared to Bluetooth, Wi-Fi, etc., it is significantly more efficient and stable. Overall, LoRa - based networks outperform other types of networks in terms of lifespan while also requiring less care and maintenance [3]. Effective smart agriculture systems can be built based on realtime data gathered by sensors, IoT devices and communication methods, leading to improvements in the agricultural sector.

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In 2019, Mr. Santosh Mahagaonkar and Devdatta A. Bondre [1] devised and implemented a technique to forecast crop production and needed fertiliser from historical data. Using ML methods like SVM and Random Forest, this was accomplished. It provides a succinct analysis of using ML approaches, crop yield prediction and fertiliser recommendations from the studies described above, it was shown that when attempting to classify soil, Random Forest outperforms Support Vector Machine, with an accuracy rate of 86.35%. The Support Vector Machine is useful for fertiliser advice and crop yield prediction. The accuracy is 99.47% as compared to the Random Forest method.

In 2019 Jayakumar R and team [2] proposed ”SMART AGRI App,” which operates on an IoT platform and covers all the concerns linked to the determination of soil fertility and irrigation. With the configuration, the data is gathered and sent to the SMART AGRI APP through the Ethernet Shield. To ensure that crops receive the best possible water resources, this project remotely measures and monitors soil moisture levels . Additionally, it automatically turns on irrigation systems to handle low soil moisture levels and stop crop loss or damage.

Priyadharshini in 2021 [3], proposed a system to help farmers choose crops by taking into account all the variables, including the planting season, soil and geographic location.

In 2018, by creating a unique NPK sensor utilising LED and a LDR Lavanya Ga, Rani Cb and Ganeshkumar Pc suggested an IoT based system [5]. The soil’s nutrient content was monitored and evaluated using the colourimetric technique. To enable quick data retrieval, the NPK sensor collected data from the chosen farmland and sent it to the Google cloud database. Based on the result reached regarding the absence of N, P and K present in the soil chosen for testing, a warning message is issued to the farmer on the amount of fertiliser to be utilised at regular intervals.

Jash Doshi, Tirthkumar Patel and Santosh Kumar Bhart [6] presented a product in 2019 that will help farmers by obtaining real-time data from the farms (Temperature, UV index, soil moisture, humidity and IR) so they can take the necessary steps to engage in smart farming, which will also help them increase crop yields and conserve resources. Temperature, humidity, soil moisture sensors, and a live data feed that can be viewed on a serial monitor and a smartphone app called Blynk are all components of the suggested device.

In a report published in 2020 by Sebastian Sadowski and Petros Spachos [7], an experimental evaluation of IoT devices with energy harvesting capabilities that utilise WiFi, Zigbee and Long Range Wireless Area Network (LoRaWAN) was conducted. The best LoRaWAN technology has a maximum Los range of 15,000 metres. Zigbee’s second-best Los range is 120 m, whereas WiFi has the shortest transmission range. According to the research, LoRaWAN is the ideal wireless technology to use in an agricultural monitoring system when network lifetime and power consumption are crucial considerations.

In 2020, R. Santhana Krishnan and his team [8] presented a smart irrigation system that uses the Global System for Mobile Communication to assist farmers in watering their agricultural lands (GSM). This system sends confirmation notifications regarding the job’s status, including such as the soil’s relative humidity, the ambient temperature and the motor’s state with the main source of power or the solar power. The motor’s state is indicated and

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controlled via a fuzzy logic controller, which computes input factors including soil moisture, temperature and humidity.

An autonomous agricultural system that monitors the environment in real-time and analyses field factors including temperature, soil moisture and humidity was developed in 2021 by S. J. Suji Prasad and team [9].The LoRa Gateway receives the sensor collected data. The Arduino sends a command to a motor to operate to raise any parameter that is below the ideal level. LoRa-based wireless sensor networks make it possible to build agricultural monitoring systems which has low power requirements and has long distance transmission capability. All the recent papers present different systems that have many limitations, like a limited dataset, less accuracy, an improper irrigation system, etc. There is no smart agriculture system which performs multiple functions like crop and fertiliser recommendation, smart irrigation, monitoring etc.

Proposed System

Agriculture is a critical sector for global food security and the livelihoods of millions of people around the world. However, traditional agriculture methods are often characterized by low productivity, limited access to resources, and environmental degradation. In recent years, there has been growing interest in the use of technology, such as the IoT, to improve the efficiency and sustainability of agriculture. The proposed IoT-based smart agriculture system aims to address these challenges and improve the overall performance of the agriculture sector.

A. Methodology

The smart agriculture system is designed to measure temperature, soil moisture, and humidity in the field as real-time values. The soil moisture sensor measures the moisture level in the field; the temperature sensor measures the temperature; and the NPK sensor measures the level of nitrogen, phosphorus, and potassium content of the soil. The WiFi module receives this data and sends it to the cloud server. This sensor-collected data will be displayed on the dashboard of the Blynk IoT mobile app. Based on this information, the best crop for the farmland and the amount of fertilizer needed will be suggested. When the soil moisture level falls below the threshold, a notification alert is sent to the mobile app to start the motor pump, and when the moisture value reaches the threshold or above, the motor will stop automatically.

B. Implementation

This section conveys the details of the implementation of the proposed system. The proposed system has two modules: one is an interface for suggesting crops and fertilisers and the other is a smart irrigation and monitoring system. Both modules are described in detail in the subsections that follow.

1) Recommendation System - Module 1: The crop and fertiliser prediction module will be the first to be implemented in the proposed system. Environmental and soil parameters must be carefully considered. The reason for this is that certain kinds of soil will be able to support a crop even if the prevailing environmental factors of the farmland will not, but the crop's yield will suffer as a result.The operation of the module as a whole is illustrated in Fig. 1.

The information gathered using the sensors includes specifications about the selection criteria for the crops, such as the amounts of phosphorus, nitrogen, and potassium present, as well as

The Ciência & Engenharia - Science & Engineering Journal
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the humidity, temperature, and soil moisture levels. These are the primary factors that determine the crop yield for a given area. In data preprocessing stage,

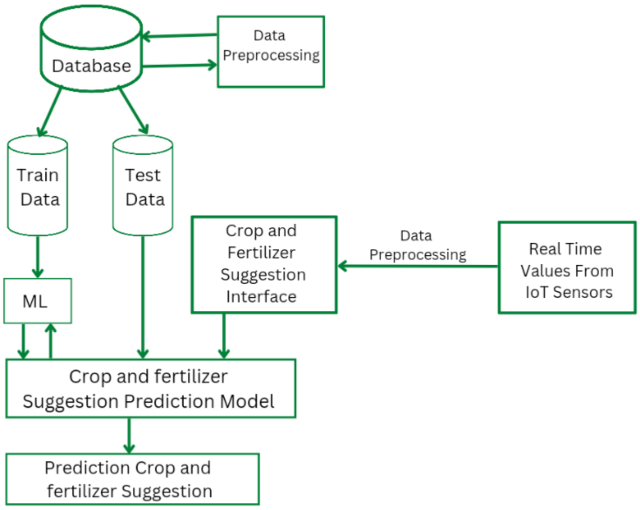

Fig. 1. Architecture Diagram of Recommendation System

the unprocessed data is converted into well-formed datasets so that data mining analytics can be applied to them. After dividing the dataset, the first portion is used in process of training the model, while the remaining data is used in testing and prediction. This dataset is fed to the ML algorithm, Multioutput Regression for the Crop and fertiliser recommendation. The real-time values gathered through the use of sensors serve as the input.

2) Smart Irrigation and Monitoring System - Module 2: The second module does the automated irrigation and realtime crop monitoring. The overall working of the module is depicted in Fig. 2.

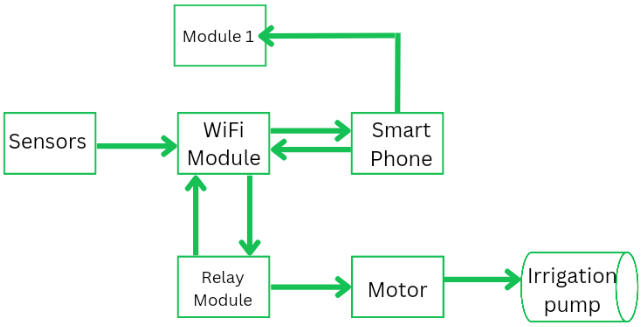

Fig. 2. Architecture Diagram of Smart Irrigation and Monitoring System

The NodeMCU ESP8266 is utilised on the sensor node. After that, the sensors are incorporated into the circuit. For instance, resistive soil moisture sensors are employed in the process of determining the amount of moisture content in the ground. The DHT11 Temperature and Humidity Sensor are utilised to determine the temperature and humidity of the air in the immediate vicinity. The NPK sensor is used to measure the levels of nitrogen, phosphorus, and potassium in the soil to determine its fertility. To create an automatic irrigation system, a 5V relay module is combined with a water pump. The WiFi Module will send the collected values of air temperature, humidity and soil nutrient contents wirelessly to

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ISSN: 0103-944X
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the cloud server. The NodeMCU ESP8266 contains a WiFi chip already integrated into its circuitry. Thus it uploads the parameters to the appropriate location on the server for the IoT. As an IoT platform, Blynk IoT 2.0 is utilised for monitoring and controlling irrigation systems. The Blynk IoT Dashboards which are accessible via the web and applications which can be downloaded to mobile devices, make the sensor-collected data available from anywhere in the world.

C. Component Required

1) ESP8266 NodeMCU
   The ESP8266 is a cheap Wi-Fi chip that has TCP/IP networking software and microcontroller built in.
2) Soil Moisture Sensor
   Soil moisture sensors are used to determine how much water is present in the ground.
3) NPK Sensor
   Using the soil NPK sensor, one can measure the levelsof nitrogen, phosphorus, and potassium in the soil to determine its fertility.
4) DHT 11 Sensor
   For measuring temperature and humidity, the DHT-11 Digital Temperature and Humidity Sensor is an easy- touse, incredibly affordable digital sensor.
5) 5V Relay Module
   A 5V relay is an automatic switch in an automatic control circuit that allows a low-current signal to control a high-current load.
6) Water Pump
   Water pumps are mechanical or electrical devices that move water through pipes or hoses by creating a pressure difference.

Results And Discussion

A sensor-based transmitter and receiver circuit was successfully implemented, as shown in Fig. 3, which marked the successful conclusion of the first stage of the project. This circuit pulls in real-time soil data and displays it on the Blynk 2.0 platform after it has been collected.

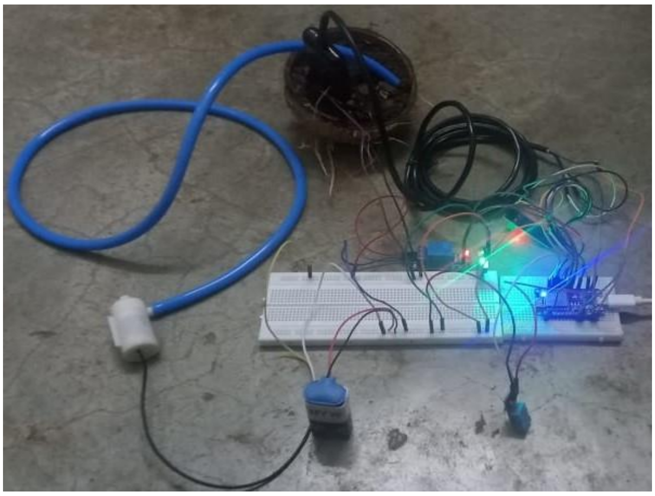

Fig. 3. Transmitter and Receiver Circuit

Initially, pinout diagram of NodeMCU ESP8266 was studied. It was decided to set up the Blynk 2.0 IoT Cloud Dashboard. This dashboard shows the values that the sensors have collected in real-time and also sends out notifications and alerts. After assembling the hardware components, the electronic circuit for the transmitter and receiver was constructed. The programming for the transmitter and receiver worked out perfectly when it was put into action.

At present, a DHT sensor is used to measure temperature and humidity, and a soil moisture sensor is used to measure the amount of water that is contained within the soil. Also NPK sensor measures the levels of nitrogen, potassium, phosphorous in the soil. The data retrieved from the soil moisture sensor is compared to a predefined threshold to notify the farmer, so as to implement the irrigation system. The implemented circuit can accurately measure the soil's parameters, and the results are shown on the Blynk 2.0 dashboard, as in Fig. 4.

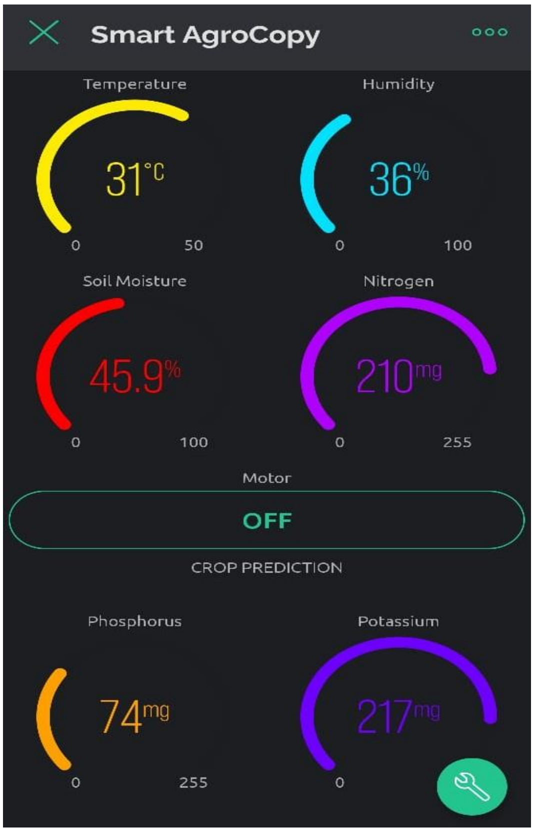

Fig. 4. Real-time Monitoring in Blynk IoT Platofrm

The second stage deals with the prediction model where the values collected from the sensors are used to predict the most suitable crop and hence and amount of nutrients to be added. The Fig. 5 shows the crop and fertiliser prediction application implemented with flask framework.

Conclusion

Therefore, the IoT-enabled intelligent agriculture will revolutionise the world of agriculture; it will increase productivity, enhance quality, and even save the lives of farmers. During the farming process, there is an urgent need for a system that simplifies and makes things easier for farmers. India's only industry is agriculture, so it must increase crop production annually

The Ciência & Engenharia - Science & Engineering Journal
ISSN: 0103-944X
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to take advantage of new technologies. When this type of technology is implemented in the agricultural sector of a country, one of the primary objectives is to protect natural resources and significantly

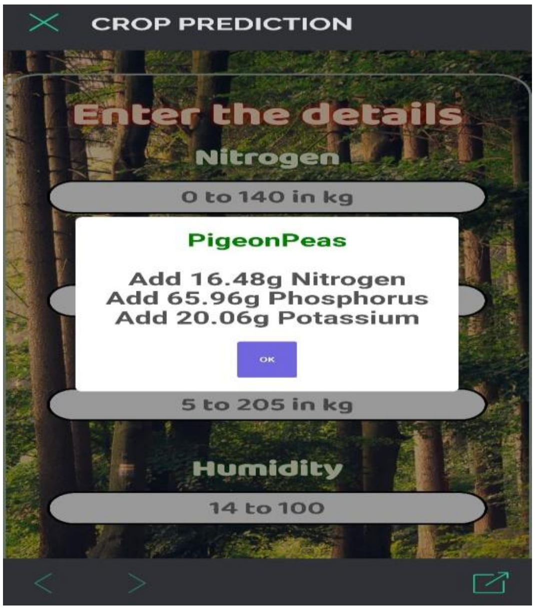

Fig. 5. Crop and Fertiliser Prediction

increase crop production. The primary objective has been to reduce the amount of labour, water, and time required of farmers.

Ultimately, we can make an effort to address the technological obstacles and challenges that will be posed by the future development of intelligent agriculture systems. The primary objectives of these potential future directions are to expand the availability of open-source, modifiable solutions for farmers, increase the number of AI-based solutions that can be brought from the core to the edge devices for real-time threat detection and immediate corrective action, and incorporate additional recommendations for fertiliser use. Also, farmers can now use farming equipment that drives itself and use data from the present to make better predictions for the future. This has the potential to help reduce crop diseases as well as pest infestations.

Currently, the system for monitoring the environment in real time is operational. The crop-fertilser prediction model and the irrigation system are also active which takes in these real-time values collected from the sensors and predicts a suitable crop and amount of nutrients as well as implements the irrigation. In the future, it is planning to expand the current system to incorporate a dosing system for automatic irrigation and fertiliser control. This will enable the system to not only monitor and predict crop and fertiliser requirements but also automatically adjust the amount of irrigation and fertiliser delivered to the crops in real-time. This will further optimize the crop yield and improve the efficiency of the system. Also, it is planned to explore and implement new machine learning algorithms to enhance the accuracy and efficiency of the system. One area of focus will be on deep learning algorithms that can handle larger and more complex datasets, including image data. Another aim is to obtain a comprehensive dataset that includes all relevant environmental factors that influence crop growth, such as sunlight, humidity, and wind speed, in addition to the existing sensor data. Overall, these future works will further enhance the capabilities and functionality of the smart agriculture system and enable it to become an even more valuable tool for the agriculture industry.

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