APPLICATIONS OF IOT IN AGRICULTURE USING ML

Sparsh

School of Engineering and Technology

Department of Computer Science and Applications

Sharda University, Greater Noida, UP, India

sparsh28091999@gmail.com

Somya Bhardwaj

School of Engineering and Technology

Department of Computer Science and Applications

Sharda University, Greater Noida, UP, India

somyabhardwaj338@gmail.com

Akanksha Kumari

School of Engineering and Technology

Department of Computer Science and Applications

Sharda University, Greater Noida, UP, India

kumariakanksha648@gmail.com

Dr. Gaurav Kumar

School of Engineering and Technology

Department of Computer Science and Applications

Sharda University, Greater Noida, UP, India

gaurav.kumar9@sharda.ac.in

Abstract

The research presented highlights how the integration of the Internet of Things (IoT) and Machine Learning (ML) is transforming agricultural practices. Precision farming, an outcome of this integration, leverages technology to collect meaningful environmental data, which is further analyzed for superior accuracy, resulting in optimized crop yields and resource usage. Our research explores the applications of IoT and ML in agriculture and provides insights into their benefits. With real-time data collection and processing, we highlight how these technologies contribute to the advancement of smart farming practices by enhancing soil analysis, crop health monitoring, and predictive output analytics. Furthermore, the scalability of these solutions accommodates diverse farming sizes - from backyard gardens to industrial agriculture. A special focus is given to the potential of these technologies in transforming agriculture in India and their implications globally. Additionally, we underscore the economic benefits of smart farming for farmers and emphasize the potential of mobile technologies in making the advancements accessible globally. The research concludes with a future-focused outlook that encourages continual exploration of IoT and ML for their potential to guide us towards a more efficient and sustainable future in agriculture.

***Keywords* -** Precision farming, IoT and ML integration, Smart farming practices, Crop optimization, Agricultural transformation.

1. Introduction

In 1995, Bill Gates first used the term "thing to thing," while EPC Global first presented the idea of the Internet of Things (IoT) in 1999. Interactions between people and their devices, as well as between machines and other people, are made easier by the Internet of Things. Establishing a vast network through the integration of many linked devices is its main goal. Within a system, the Internet of Things focuses on cost-effectiveness, automation, and communication. IoT enables people to simplify daily tasks by utilising the internet, which boosts productivity and reduces expenses.

IoT makes it easier to sense and operate devices remotely using current network models. IoT is very useful in environmental monitoring since it can be used to track the presence of animals in fields, monitor soil conditions, and evaluate the quality of the air and water. Furthermore, IoT is essential to precision farming since it maximises agricultural methods to increase total productivity. IoT's capacity to facilitate real-time data collection and analysis in agriculture highlights how revolutionary it may be in terms of modernising and enhancing many facets of our everyday life.

2. Literature Review

The adoption of Internet of Things (IoT) technology in agriculture has revolutionized multiple aspects of the industry, extending from cultivation to sales. With the proliferation of accessible sensors, specialized applications such as soil monitoring have become feasible. These sensors can monitor parameters such as leaf wetness, humidity, solar radiation, rainfall, wind speed, and ultraviolet radiation across different agricultural settings including fields, greenhouses, cold storages, seed banks, machinery, transportation networks, and livestock facilities. The data gathered from these sensors can be stored and analyzed in cloud infrastructure, allowing researchers to optimize resource allocation and address disparities between supply and demand in agricultural markets. However, managing and deriving insights from the vast amount of sensor data pose significant challenges in IoT systems. M. Lee et al. proposed an IoT-based agricultural production system that correlates crop statistics with agricultural practices to improve analysis and forecast future harvests. Integrating disparate IT systems on farms further complicates data management and interpretation.

Wireless sensor networks (WSNs) have emerged as a solution for real-time monitoring and control of farming conditions to enhance crop quality and yield. Banu developed WSNs using Zigbee-based wireless transceiver modules to monitor environmental factors like humidity, temperature, and water level in farming environments. The system, employing sensors, analog to digital conversion, and ATMEGA8535 and ICS8817 BS processors, aims to achieve optimal greenhouse climates while reducing energy consumption and operational costs.

Haule and Ofrim et al. explored the automation of irrigation systems using WSNs to optimize water usage and enhance crop yield. By analyzing soil moisture levels and environmental conditions, these systems adjust irrigation schedules to ensure efficient water utilization and superior crop quality. However, challenges such as communication instability, power consumption, and technological limitations still persist in WSN implementations, necessitating further research and development.

In conclusion, IoT-enabled agricultural systems hold immense potential for enhancing productivity, sustainability, and resource efficiency in farming practices. Harnessing advanced technologies like WSNs enables real-time monitoring, precise control, and data-driven decision-making, ultimately contributing to the advancement of smart agriculture.

3. Methodology

A. Existing System

The backbone of our country is agriculture. Back then, farmers would make assumptions about what kind of crop to cultivate based on their best estimate of the soil's fertility. They were ignorant of factors like moisture content, water level, and severe weather that could be even more detrimental to farmers. Based on certain assumptions, they apply pesticides, which, if incorrect, could have a major negative impact on the crop. The productivity of the crop, upon which the farmer relies, is determined by its final stage. One limitation of the current system is the variability in whether productivity will be higher or lower. Another is that we are unable to predict the weather because pollution is steadily rising.

B. Proposed System

Our technology that assesses crop quality and provides recommendations must be used to increase crop productivity in order to benefit the country and farmers. A wireless sensor network collects data on crop status and environmental changes using a variety of sensors. The data is then sent via the network to a farmer or gadget that can take corrective action. Technology advancements that reduce energy consumption and improve user interface usability are necessary to mitigate some communication-related drawbacks.

Developing a smart agriculture system to track crop growth is the primary goal of this project. The main parts of the system are an LCD display, a Raspberry Pi microprocessor, a Pi camera, and sensors for temperature, wetness, humidity, and water level. Prior to being sent to the server, the system gathers all the crop-related data and shows it on an LCD display. Similarly, using a Pi camera, the system anticipates and analyses any animal trespass.

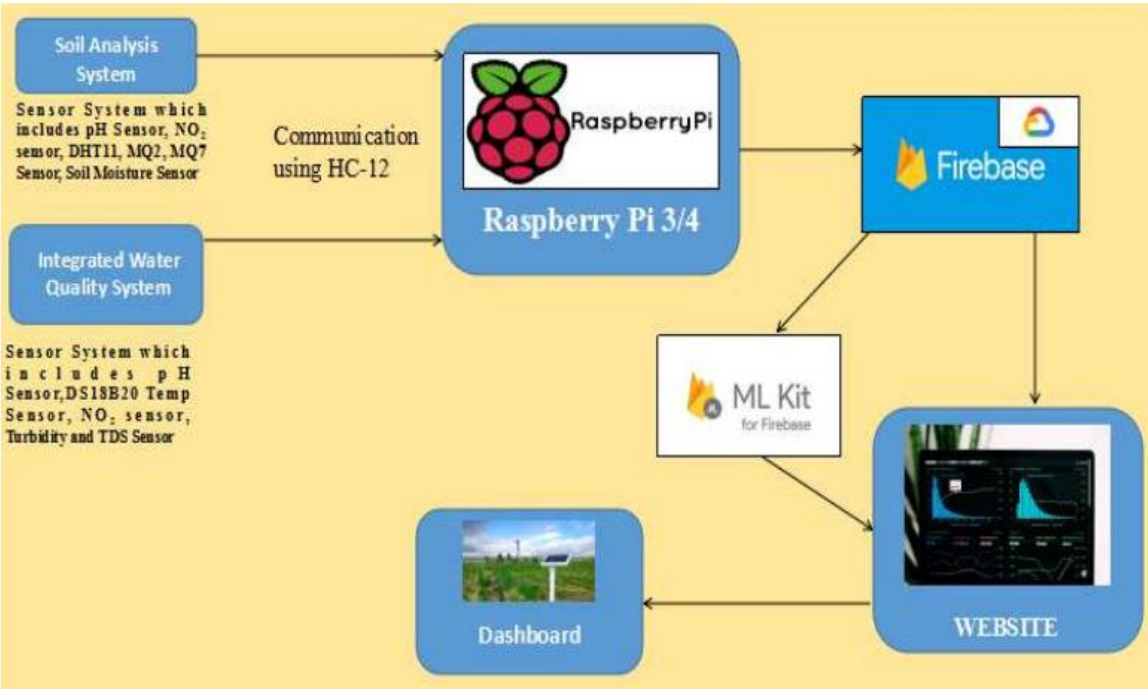

Fig 1: Flow of Smart Agriculture Monitoring System

4. Technical Requirements

A) Hardware Requirement

i) Raspberry Pi Microcontroller

The Raspberry Pi Foundation, based in the UK, created a mini computer the size of a credit card to teach students and tech enthusiasts about computer hardware, coding, and DIY projects. This computer comes in three different board versions produced under licensing agreements with Newark Element 14 (Premier Farnell), RS Components, and Egoman. These companies handle online sales of the Raspberry Pi. A special edition in red, manufactured by Egoman for the Chinese and Taiwanese markets, lacks the FCC/CE markings found on other versions. Despite the various manufacturers, the hardware specifications stay consistent. The Raspberry Pi originally includes 256 megabytes of RAM and features an ARM1176JZF-S processor running at 700 MHz contained in a Broadcom BCM2835 system-on-a-chip (SoC). Upgrades to 512 MB of RAM are available for the Model B and Model B+ versions, alongside a Video Core IV GPU. Different variants may have internal storage or solid-state drives, while the Model B+ requires a MicroSD card for booting and storage. The Foundation offers ARM versions of Debian and Arch Linux, with support for programming languages like Python, C, Java, Perl, and BBC BASIC via tools like Brandy Basic or the RISC OS image on Linux.

Fig 2: Raspberry Pi Microcontroller

ii)Energy Supply

A micro-USB source with +5 volts is used to power the Raspberry Pi 3.

iii) Pi Camera

To satisfy the growing demand for camera modules compatible with the Raspberry Pi. A Pi revision C add-on camera module that is entirely compatible with the official one has been released by the ArduCAM project. It offers the user a considerably crisper and more defined image than the earlier Pi cameras by optimizing the optical performance. Additionally, it offers the STROBE and FREX signals, which, when combined with the appropriate camera driver, can be used to synchronize capture from many cameras. The specific CSI interface, created for the purpose of integrating with cameras, is utilized by this interface. Pixel data is the only information carried by the CSI bus, which has very high data speeds. Raspbian, with the most recent update, supports the camera.

iv) Sensors

- Moisture Sensor

Soil moisture sensors are used to determine the soil's water content. A soil moisture probe is constructed by integrating several soil moisture sensors. In commercial settings, a commonly employed soil moisture sensor shares similarities with a capacitance sensor and operates based on principles within the frequency domain. For farmers to better control their irrigation systems, soil moisture measurement is crucial. Improved management of soil moisture throughout important plant growth phases allows farmers to not only grow crops with generally lower water requirements but also to improve crop quality and yields.

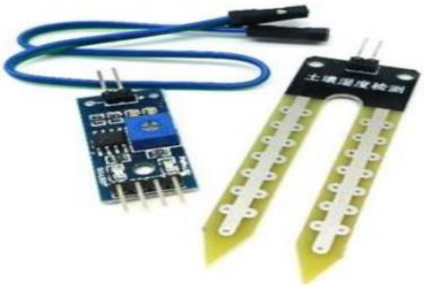

Fig 3: Soil/moisture Sensor

• Temperature and Humidity Sensor

A thermistor may not offer the same level of precision in temperature measurement as you might require. Its electronic components are enclosed, ensuring protection against oxidation or other potential issues. In comparison to thermocouples, the LM35 generates a higher output voltage, potentially eliminating the need for an amplifier.

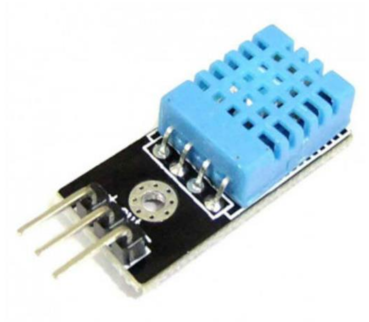

Fig 4: Temperature and Humidity Sensor Module

• Water level Sensor

Water level sensors determine the maximum amount of chemicals that can flow. It acts as an indicator for the ideal water level.

Fig 5: Water level Sensor

B) Software Requirement

i) Raspbian OS

Derived from Debian and specifically designed for 32-bit architecture. Raspberry Pi, comes in multiple iterations like Raspbian Stretch and Raspbian Jessie. While not intended to mimic a full-fledged desktop experience, Raspbian does provide users with an LXDE desktop environment. Despite Raspberry Pi's modest processing power and memory capacity, it can effectively handle LXDE and lightweight applications like the Epiphany web browser, among others.

ii) Arduino Software

The Arduino Integrated Development Environment (IDE) is a versatile application that works on multiple operating systems like Windows, macOS, and Linux. It is coded using functions derived from both C and C++. Arduino, an open-source electronics platform, comprises user-friendly hardware and software components. The software facilitates the development and uploading of programs not just onto Arduino-compatible boards, but also onto other vendor development boards, with support from third-party libraries. Adhering to specific code structuring guidelines, the Arduino IDE supports programming languages like C and C++. The avrdude program is used to convert executable code into a hexadecimal-encoded text file, which is subsequently transferred to the Arduino board through a loader program embedded in the board's firmware. By receiving inputs from sensors, Arduino can perceive its environment and interact with it through various actions and actuators. The Arduino IDE is responsible for compiling and uploading the necessary code to operate the UNO board.

iii) The Apache Web Server

A product of the Apache Software Foundation, is a free, open-source web server software widely used across different platforms. Renowned for its speed, stability, and security, it commands a substantial share, serving approximately 40% of websites globally. Its flexibility allows for deep customization to meet the specific needs of diverse environments through branches and modules. In the context of this project, the Apache server plays a critical role in monitoring received data and executing necessary tasks post data processing. With a Raspberry Pi serving as the server, it specifically manages crop health monitoring and regulates an automatic watering system.

iv) Firebase

The Realtime Database, hosted in the cloud, stores data in JSON format and guarantees smooth synchronization among all connected clients. With Firebase's iOS, Android, and JavaScript SDKs, cross-platform app development becomes seamless, with clients sharing a single Realtime Database instance and receiving updates instantly. This database empowers the creation of collaborative applications by offering secure client-side access. Even offline, data persistence ensures continuous real-time events, providing users with a seamless experience. The Realtime Database automatically resolves conflicts by syncing local data modifications with remote updates upon reconnecting.

5. Conclusion

• Enhancing **Agricultural Productivity**

The integration of Internet of Things (IoT) with Machine Learning (ML) has emerged as a transformative approach for modern agriculture, enhancing productivity and sustainability.

Systems equipped with IoT technologies collect critical environmental data such as temperature, moisture, weather, and soil fertility, enabling precise agriculture practices.

• Pioneering **Smart Farming Practices**

Implementing smart farming practices using IoT and ML has led to improved soil analyses, optimized water usage, and accurate crop yield predictions, vital for India's agriculture.

Advanced sensor networks and machine learning algorithms have brought about a shift from traditional to smart farming, fostering efficient resource management.

• **Real-Time Monitoring for Informed Decision-Making**

Real-time monitoring facilitated by IoT devices, coupled with the predictive power of ML algorithms, enables farmers to make accurate, data-driven decisions for their crops.

Strategic use of IoT and ML enhances decision-making capabilities, allowing farmers to minimize costs and improve crop management practices.

• Scaling **Up and Resource Optimization**

IoT and ML solutions are scalable, adapting to different scales of farming and various crop types, thereby optimizing the use of resources such as water, fertilizers, and energy.

High-performance computing and intelligent analytics result in an ecosystem that is not only efficient but also cost-effective and eco-friendly.

• Global **Impact and Accessibility**

The research concludes that the technology holds promise for worldwide application, providing farmers across the globe with advanced tools for monitoring and automation.

Through the mobile app functionality, farmers can stay updated on soil and crop conditions, contributing to a more connected, informed agricultural community.

Continuing advancement and innovation in IoT and ML technologies promise even greater efficiency gains and sustainability for the future of agriculture.

This research underlines the pivotal role of IoT and ML in revolutionizing agriculture, leading to smarter farm management and enhanced production. Through the synergy of real-time data collection, predictive analytics, and automated processes, the agricultural sector is poised to overcome challenges and capitalize on new opportunities in the years ahead.

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