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IoT-Driven Smart Agriculture: Machine Learning for Precision Farming

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Abstract—The paper highlights the application of smart farming in the agricultural sector, leveraging the capabilities of machine learning (ML) and the Internet of Things (IoT). The paper proposes the use of ML and computer vision techniques to classify different sets of crop photographs. This technology aids in monitoring crop quality and evaluating yield by analyzing metrics such as crop health, disease detection, and growth patterns. The main challenges faced by the agricultural sector include identifying leaf diseases in affected areas and rapidly improving both crop output and quality. The IoT plays a crucial role in modernizing agriculture by providing farmers with a diverse range of technological tools for gathering information on external factors that impact crop growth, such as weather conditions, soil fertility, moisture levels, and temperature. This data helps farmers make informed decisions about irrigation, fertilization, and pest control. Additionally, automated systems incorporating microcontrollers and wireless sensor networks are employed to monitor and control agricultural processes, optimizing efficiency and reducing manual labor. The paper emphasizes the potential of ML, computer vision, and IoT technologies in smart farming to address agricultural challenges, increase productivity, and optimize crop management practices. By leveraging these advancements, farmers can make data-driven decisions and improve the quality and quantity of their agricultural output.

Keywords— ***Smart farming, IoT, Animal intrusion***

I. INTRODUCTION

Machine Learning and Internet of Things have the potential to save over 815 million people from hunger, especially in Africa, where agriculture plays a significant role in the economy and employment. The major applications of AI in agriculture include agricultural robots, crop and soil monitoring, and predictive analytics. IoT finds application in various sectors such as industry, smart cities, smart homes, smart energy, connected cars, and smart agriculture, among others. The number of IoT device installations in the agriculture sector is expected to increase from 30 million in 2015 to 75 million by 2020.

Smart agriculture enabled by IoT and AI is expected to deliver high operational efficiency and yield. Nature Sweet, a US-based tomato producer, increased its harvest by four percent using AI monitoring. App developers in Africa are creating solutions to improve agricultural output and prevent crop failures. AI is helping with supply chain tracking and market positioning, as seen in the coffee traceability solution in Ethiopia, which improves fair trade and organic certification. AI and IoT offer the potential for machines to solve agricultural problems through physical interactions, leading to improved soil management and resilience against droughts.

The use of IoT and AI in Africa holds promise for addressing food security challenges and enhancing the productivity of the agricultural sector continent-wide. By implementing the most recent sensing and IoT technology in farming methods, every aspect of conventional farming can be impacted. Smart use of wireless sensors and the Internet of Things (IoT) in agriculture can progress it to previously envisioned levels. IoT can contribute to the improvement of many traditional farming problems, such as drought response and yield enhancement. In precision farming, IoT-based smart sensors are placed on agricultural land to gather information on the topsoil nutrients, fertilizer, and water demand. The sensor data is analyzed and used as training data for the machine, which would then learn the pattern or cycle to improve farming techniques. The main difficulty facing the agriculture sector is locating the leaf disease in affected areas as well as enhancing output and output quality.

In the past, an informed person would recognize ailments. Contacting experts in remote areas is extremely difficult for farmers to do. Climate change is one of the major contributors to plant diseases. If the disease is not discovered when it should be, there is a huge loss in agricultural productivity on large farms. Although the service department can't clearly see the farmer's problem, they might give farmers bad advice regarding plant diseases. This has the potential to seriously harm the crop. To help farmers, it is essential to identify different plant diseases in their early stages. The illnesses' characteristics are remarkably similar. Farmers find it very difficult to identify plant diseases with their naked eyes since they cannot fully comprehend the severity of the ailment, which occasionally results in incorrect disease diagnosis. Certain grains and vegetable leaves can harbor bacteria, fungus, and virus-based diseases. Anthracnose, Bacterial Blight, Cercospora Leaf Spot, Powdery Mildew, Black Mold, Downy Mildew, and Rust are some of the most prevalent plant diseases. When a disease affects a plant, the texture, color, shape, and size of its leaves reveal the infection. Due to the limitations of human vision, most symptoms make illness detection impossible. Overall, it emphasizes the positive impact of AI and IoT in revolutionizing agriculture, increasing productivity, and addressing food security issues. It showcases examples of successful implementations and highlights the potential for further advancements in the future.

II. RELATED WORKS

Rahul et al., [1] fully enclosed steel building used for controlled cultivation to increase harvest production. If more water than necessary streams through the line, a water volume sensor device that keeps track of the flow makes a difference on the server and ultimately plays out the crucial actions. The client can view the obtained data and use anticipated synthetics to maintain the proper PH once soil PH detects the PH of the dirt and sends it to the server. Muhammad Ayaz et al., [2] remotely located sensors Drones, distributed computing, and correspondence developments are all covered in detail. To find patterns in the data, AI and inspection are used. Different sensors are used, including FPGA, acoustic sensors, electromagnetic, optical-ultrasonic and telematic sensors. The data obtained from remote sensors is transmitted without a clear relationship.

Anneketh et al., [3] would provide a more precise and affordable solution for the ranch's demands. using several microcontrollers, such as the Raspberry Pi, Arduino Uno, and Arduino Mega. These chips regulate soil temperature, moisture, and maturity in conjunction with these sensors, transducers, and actuator screens. Jinyu Chen et al., [4] developed framework for IOT-based smart agriculture has been developed to use sensors to screen the fields. The IOT edge processing, 5G, block chain, artificial intelligence, AI, mechanical technology, robots, and other advancements are among those causing the smart farming upheaval. Jiun Horng et al., [5] used a harvester, grass cutter, or sickle on a regular basis, procuring is the act of cutting grain or heartbeat for gathering. There are numerous types of neural network models for item recognition currently. Ahmad et al., [6] used several different sensors available that provide greenhouse observation applications with a fully developed detecting innovation. The nursery framework plan is divided into three important phases, the first of which is temperature checking. The crucial temperature alluded signal is produced by the second stage of the plan architecture.

Dahane et al., [7] developed the model based on the design and research of a clever cultivating considering a clever stage which boosts the expecting capacities using computer-based intelligence processes. For air mugginess expectations, LTSM (long transient memory intermittent organizations) based models outperform GRU-based models. Yu Han et al., [8] framework of a smart water system consists of a water system hub, an organizer, a remote server, and an observational focus. With the terminal of the checking center, clients can access the server and recognize ongoing observation. To achieve closed-loop stable water system stream or soil dampness management goals, PID control technique is used in water system control. Sai Pratyush et al., [9] The framework was changed to use all the observed data from the temperature, moisture, and dirt dampness sensors to generate the dataset that was provided. Chakraborty et al., [10] design can accommodate large picture sizes and can be applied in a variety of contexts. The main idea is to effectively leverage application-explicit domain knowledge when working under duress. The Enchanting structure is demonstrated to be adjustable throughout a broad range of pressure/quality and can pack past the typical quality component cut-off thresholds of both JPEG 2000 and Web. Showkat et., [11] embracing smart programming and utilizing specialized hardware, accuracy is being cultivated. On this field's soil testing, crop examination, and information gathering are complete. Somali et al., [12] with the integration of Web of Things (IoT)-based innovations, computerized horticulture offers the ability to control a framework at various levels (individual, neighborhood, local, and global) and creates tools that take further developed independent direction and higher efficiency into consideration. Mahmoud et al., [13] many AI algorithms have been applied to focus on bugs, their variety, population, and rural conditions in terms of soil and environment for crops like guava. SVM, Decision trees, arbitrary backwoods, slope-helping calculations, k-implies, and self-sorting out maps for grouping are a few ML techniques.

Saleh et al., [14] sensors in the Raspberry Pi use a basic to automated converter to measure the temperature and soil moisture (ADC). Due to this, a dataset-ready calculation for credulous bayes learning has been done on a Raspberry Pi. The Python Sci-unit Learn package was used to work with the Guileless Bayes Classifier AI model. Maddikunta et al., [15] UAVs are one type of aircraft that can fly autonomously without the assistance of a pilot, and the movement of the aircraft is managed remotely by an administrator. A remote system called Bluetooth Savvy or Bluetooth Low Energy (BLE) is used to make specific progress in the fields of medicine, the environment, health, and energy. Rayner et al., [16] In general, smart farming is anticipated to be impacted by big data, machine learning, and the internet of things (IoT), notably to produce rice. These three elements (for example, BD, ML, and IoT) have been heavily used to work on all aspects of rice creation processes in horticulture, changing traditional rice cultivation practices into a new era of rice shrewd cultivation or rice accuracy agribusiness.

III. PROPOSED METHODOLOGY

The hardware combination serves to implement the system. During the implementation phase, all hardware components are connected. The developed system's circuit schematic is shown. Using true pins, every one of the sensors is linked to the Node MCU. The common GND and Vcc for all the sensors correspond to the GND and Vcc pins on the Node MCU, respectively.

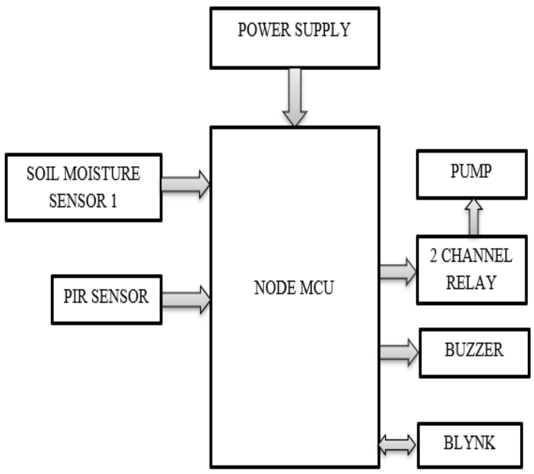

Fig 1. Methodology of the system

Using a Node MCU, the suggested method monitors multiple conditions such as soil moisture and PIR sensor. Our recommended system's primary controller is a Node MCU. Once the project is linked to the Blynk application, all the sensors constantly check the data. If the soil moisture drops, the user receives a notification through the Blynk application, and the pump goes on immediately. The area around the electric fence is monitored using PIR sensors; if the PIR sensor notices any motion, it notifies the user, and if the electric fence is disturbed, an automatic buzzer system is activated. The three layers used in the development of IoT applications are sensing, transport, and application.

1. In the detecting layer, measure the conditions such as PIR sensor (moment detection) and Soil moisture sensor.
2. In the transport layer, the results will be transported from sensors to Node MCU.
3. At the Application layer, if the reading is out of the threshold immediately a message will be sent using Wi-Fi Technology.

Power supply: An electrical device referred to as an electrical power supply unit is used to convert electric current from a type of source into an appropriate current, voltage, and frequency required for operating a load.

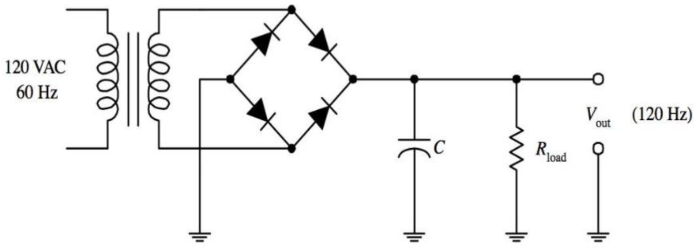

Fig 2. Power Supply

The power supply consists of transformers, full wave bridge rectifiers, filters, and voltage regulators to convert AC to DC, regulate voltage, and protect against overcurrent.

Node MCU: The ESP8266 is the name of a micro controller designed by Espress Systems. The ESP8266 itself is a self-contained WiFi networking solution offering as a bridge from existing micro controller to WiFi and is also capable of running self-contained applications.

Soil Moisture Sensor

The two large, exposed pads function as probes for the sensor, together acting as a variable resistor. FC-28 soil moisture sensor is a simple breakout for measuring the moisture in soil and similar materials.

PIR Sensor

PIR sensor, also known as a passive infrared sensor, denotes that it does not produce or emit any energy for detection.

Relay

It regulates how an electrical circuit's circuit connections open and close. The relay is not energized with the open contact when the relay contact is open (NO).

Pump

Micro Submersible Pump DC 3-6V: Mini water pump for a water feature in the garden. This compact, inexpensive submersible pump motor can be powered by a 3 to 6V power source. It has a maximum flow rate of 120 liters per hour and uses relatively little electricity (220mA).

Buzzer

Buzzers and beepers are frequently used as alarm clocks, timers, train horns, and to validate human input such a mouse click or keyboard.

Arduino IDE

A Java-based cross-platform application for Windows, macOS, and Linux is called the Arduino IDE. A code editor with features like text editing, compiling, and application uploading to an Arduino board has been included. It comes with a software library from the Wiring project and is compliant with C and C++ programming languages.

IDE

It has programming software from the Wiring project and enables C and C++ programming.

Sketch

The fundamental parts of an Arduino sketch, these two activities are essential for running the board and performing various tasks.

SOFTWARE METHODS

Blynk Application
Blynk was developed for use with the Internet of Things. It can store data, show sensor data, visualize data, control equipment remotely, among many other fascinating things.

NUMPY
The main Python module used for scientific computing is called NumPy. A multidimensional array object, many derivative objects (including masked arrays and matrices), and several functions for quick operations on arrays are all provided by this Python module.

SCIKIT LEARN
Scikit-learn provides a range of supervised and unsupervised learning algorithms via a standardized Python interface. A freeware machine learning toolbox for the Python programming language is called Scikit-learn.

PANDAS
With the aid of the Pandas software module for the Python programming language, data processing and analysis are simplified. It offers techniques and data structures for working with time series and mathematical tables.

KERAS
To connect with Python and be user-friendly, modular, and easy to modify, Keras was created.

IV. RESULTS AND DISCUSSION

The system was tested on different elements and conditions for the heartbeat, ECG, body temperature, and SPO2 sensors, and error rates were measured. The results showed that the system is efficient and user-friendly and can help examine patients without the presence of a doctor. The expected outcomes were achieved as the system accurately indicated according to the patient's vital readings. SpO2, Heartbeat, ECG, and Temperature are the variables that are captured by the sensors that interact with the Arduino board. If the measured values are not within the expected range, the GSM module responds and sends a message to the emergency contact.

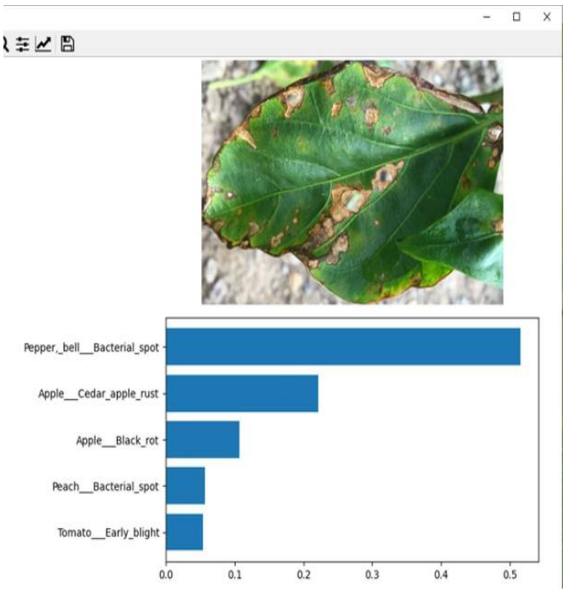

Figure 3: Blood Saturation measured using the device

When a finger is kept on the sensor it senses the blood oxygen level and displays the percentage of oxygen present in the blood and hence determines the sates of the patient's condition

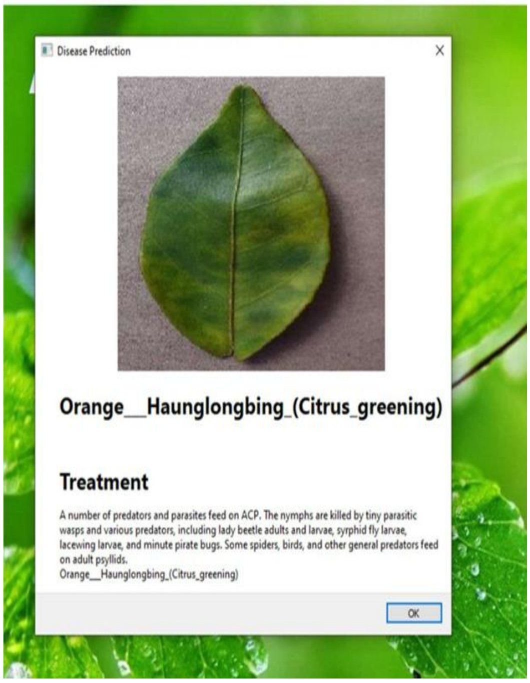

Figure 4: Heartbeat measured using the device

The finger is inserted in the heartbeat sensor where heartbeat is measured based on optical power variation as light scattered or absorbed during its path through the blood as the heartbeat changes as shown in figure 4.

Figure 5: ECG measured using the device

V. CONCLUSION

The use of various sensors, such as heartbeat, ECG, body temperature, and SPO2 sensors, enables continuous and accurate monitoring of patients' vital signs. This data can be transmitted in real-time to healthcare providers, who can remotely assess the patients' health status and intervene if necessary. Early detection of health issues through continuous monitoring can lead to timely medical interventions and improved patient outcomes. Integration with IoT devices and the ability to share patient data among multiple healthcare providers can further enhance the system's effectiveness. This interoperability allows for better coordination of care, seamless transfer of patient information, and improved continuity of care across different healthcare settings. The patient health monitoring system has the potential to revolutionize patient care by enabling remote monitoring, early detection of health issues, and efficient sharing of patient data. It not only helps to mitigate the risks associated with pandemics but also offers long-term benefits in terms of improving healthcare delivery and patient outcomes.

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