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"IOT-BASED SMART AGRICULTURAL MANAGEMENT AND RECOMMENDATION SYSTEM FOR WEATHER FORECASTING, NPK AND ANIMAL DETECTION"

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Abstract

The rapid advancements in Internet of Things (IoT) technology have revolutionized various industries, and agriculture is no exception. This system is designed to automate and remotely monitor agricultural land. The system consists of a soil moisture sensor, an Arduino board, a pump, humidity and NPK sensors, an ESP8266 Wi-Fi module, a Raspberry Pi, a buzzer, and a mobile app. The soil moisture sensor measures the moisture level in the soil and sends data to the Arduino board, which processes the data and sends a signal to the pump to actuate. The humidity and NPK sensors measure the humidity and nutrient levels in the soil and send data to the ESP8266 Wi-Fi module, which in turn sends the data to the cloud. The Raspberry Pi detects animals in the agricultural land, and it turns on a buzzer and sends a signal to the IoT cloud platform. The IoT cloud platform stores the data and allows farmer to access it from anywhere through the mobile app. Farmer can get know about the moisture, humidity, and nutrient levels in the soil and receive alerts when an animal is detected in the agricultural land. This system makes it easier for farmers to maintain healthy plants and keep pests away.

Keywords: Agriculture, Internet of Things, Arduino board, NPK sensors, ESP8266 Wi-Fi module, Raspberry Pi

I. Introduction

The agriculture sector plays a crucial role in global food security and sustainability, making it imperative to harness technological advancements for improved productivity and resource management. This paper presents an innovative IoT-based Smart Agricultural Management and Recommendation System (IoT-SAMRS) designed to address key challenges in modern farming, including weather forecasting, nutrient management (NPK), and animal detection.

The IoT-driven smart agricultural management and recommendation system has been meticulously crafted to empower farmers with precise, up-to-the-minute data, thereby enhancing crop yields and mitigating crop damage risks. This system harnesses an array of IoT sensors, devices, and advanced technologies to meticulously gather and analyze data pertaining to weather patterns, soil nutrient levels, animal behavior, and crop growth conditions. It boasts four pivotal components, namely the weather forecasting module, NPK recommendation module, animal detection module, and crop yield prediction module, each contributing indispensably to the system's comprehensive functionality.

The weather forecasting module harnesses IoT sensors and external weather forecasting services to gather live weather data. This data is subsequently scrutinized to furnish farmers with precise weather forecasts and valuable insights concerning weather patterns that may impact crop development. The module relies on various sensors, including temperature and humidity sensors, wind speed sensors, and rainfall sensors, to obtain this crucial information.

The NPK recommendation module assesses soil nutrient levels through IoT soil sensors and offers farmers guidance on the ideal quantities of nitrogen, phosphorus, and potassium needed for robust crop growth. This module relies on specialized sensors, including soil nutrient sensors, pH sensors, and moisture sensors, to precisely determine the soil's nutrient composition and conditions.

The animal detection module plays a crucial role in identifying potential crop-damaging animals, including deer, rabbits, and other wildlife. This module employs advanced image recognition techniques and cameras to detect the presence of these animals within the farm premises. Upon detecting an animal, the module can promptly send real-time alerts to farmers, enabling swift action to prevent crop damage. Its key components encompass cameras, sophisticated image recognition algorithms, and a responsive alert system.

II. Literature Studies

Sudhir Yadav et al., [1] in their paper they have worked on a system which has been developed for continuous monitoring and control of moisture levels in various plants. This system employs sensors to detect the moisture content in the soil surrounding the plants, providing real-time data for analysis. The system then compares this data to the specific moisture requirements for each plant.

Mohammad Sadegh Norouzzadeha et al., [2] a novel approach is proposed for safeguarding crops against animal incursions by utilizing camera trap images and advanced deep learning techniques. The system strategically deploys camera traps across agricultural fields to capture images of potential animal intruders. Subsequently, these images undergo processing through deep learning algorithms, which have been trained to identify and categorize various types of animals. By analyzing the camera trap images, the system swiftly discerns instances of animal intrusion and effectively distinguishes between harmless wildlife and potential threats to crops.

Laxmi C. Gavaded et al.,[3] in their work a system has been developed for the comprehensive detection of nitrogen (N), phosphorus (P), potassium (K) content, and soil humidity in agricultural fields. This system integrates Programmable Intelligent Computer Controller (PICC) sensors and advanced monitoring technology. The PICC sensors are strategically embedded in the soil to gather data regarding nutrient levels and soil moisture. These sensors employ sophisticated algorithms and analytical models to precisely measure the concentrations of N, P, and K in the soil. Additionally, they continuously monitor soil humidity levels to gauge moisture content accurately. The collected data is transmitted to a central computer controller, which processes this information and delivers real-time feedback on the nutrient and moisture conditions within the agricultural field.

B.S. Panda et al., in their work the objective was to predict the weather for the following day based on various weather parameters, including Maximum Temperature, Minimum Temperature, Evaporation, Humidity, and Wind speed. To achieve this, both linear regression (LR) and a deep neural network regressor (DNN) were employed. These models were trained using historical weather data to discern the intricate relationships between the input parameters and the corresponding weather outcomes.

III. Motivation

The driving force behind the development of the IoT-based smart agricultural management and recommendation system is to confront the challenges that farmers encounter in their quest to maximize crop yields while safeguarding against crop damage. Conventional farming practices often rely on manual labor and guesswork, resulting in inefficiencies, diminished crop productivity, and elevated expenses. Moreover, the unpredictability of weather patterns and the influence of animal activity can further compound the complexities of farming operations.

By harnessing IoT sensors, devices, and machine learning algorithms, this system endeavors to furnish farmers with precise, real-time data encompassing weather conditions, soil nutrient levels, animal behaviors, and crop growth statuses. This data empowers farmers to make well-informed decisions and take proactive steps to optimize the growth environment for their crops, mitigate the risk of crop damage, and curtail labor-related costs. In essence, the system's overarching aim is to enhance farming efficiency, bolster sustainability, and bolster profitability, thereby delivering benefits to both farmers and consumers alike.

IV. Problem Definition

Farmers in agriculture grapple with a multitude of challenges, ranging from wild animal incursions and insufficient weather information to incorrect fertilizer application and uncertainty in crop selection and timing. The influence of climate change in India has only intensified these issues, resulting in a notable decline in agricultural crop productivity over the last two decades.

In response to these pressing concerns, there arises a crucial requirement for a holistic solution that incorporates predictive capabilities for crop yields. Such a solution would empower policymakers and farmers alike to make well-informed decisions concerning marketing and storage. Furthermore, the escalating instances of animal attacks in India present a substantial threat to rural communities and their agricultural produce.

A. Objectives

- To protect the crop against animal attacks.
- To prevent the crop from improper fertilizer usage and ensure proper soil moisture and
- NPK condition of the soil.
- To notify whether the farmer should switch on the motor or not.

- To inform the farmer about climate change, animal attacks, and soil moisture content in
- the agricultural field.

B. Methodology

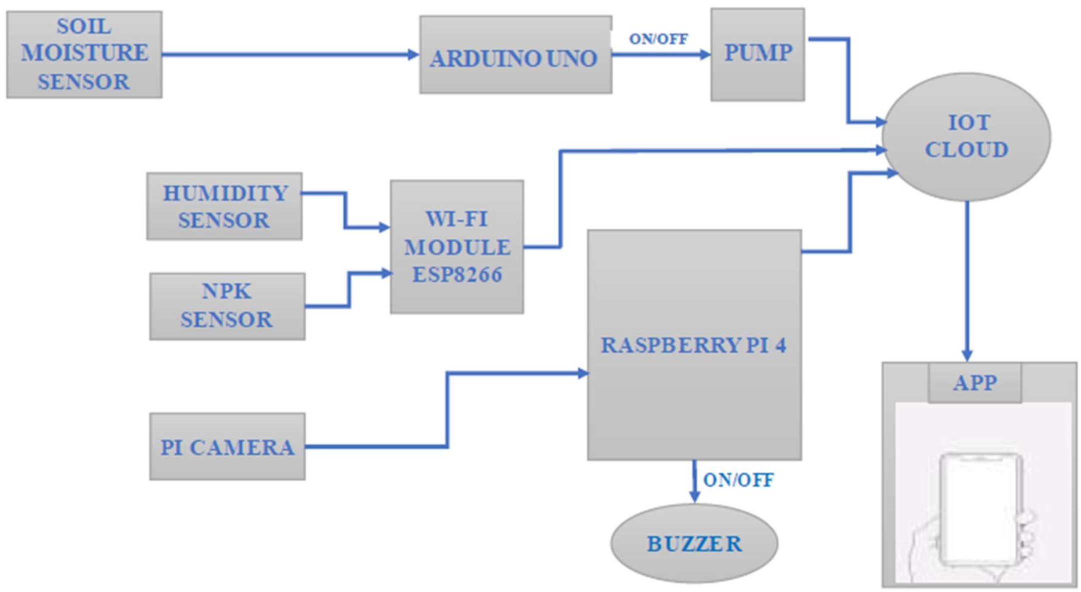

Fig: 1 Block diagram of the system

Soil Moisture Sensor: The soil moisture sensor measures the amount of water in the soil. It is connected to an Arduino board, which receives the data from the sensor. If the moisture level in the soil is too low, the pump is turned on to water the plants. If the moisture level is too high, the pump is turned off to prevent overwatering.

Arduino Board: The Arduino board receives data from the soil moisture sensor and sends a signal to the pump. It also controls other devices in the system, such as the Raspberry Pi and the buzzer.

Humidity and NPK Sensor: The humidity and NPK sensors measure the humidity level and nutrient levels in the soil. They are connected to an ESP8266 WIFI module, which receives the data from the sensors.

ESP8266 WIFI Module: The module receives data from the humidity and NPK sensors and sends it to an IoT cloud platform. The data is sent over WIFI, so the system does not need any wired connections.

Raspberry Pi: The Raspberry Pi receives data from a camera that detects animals in the agricultural land. If an animal is detected, the Raspberry Pi turns on a buzzer and sends a signal to the IoT cloud platform.

IoT Cloud Platform: The platform receives data from the ESP8266 WIFI module and the Raspberry Pi. It stores the data and allows users to access it from anywhere in the world through an internet connection.

App Application: The mobile app is a user interface that allows users to view the data from the IoT cloud platform. Users can monitor the moisture, humidity, and nutrient levels in the soil, as well as receive alerts when an animal is detected in the garden. The app can be downloaded on a smartphone or tablet, making it easy to access the data from anywhere.

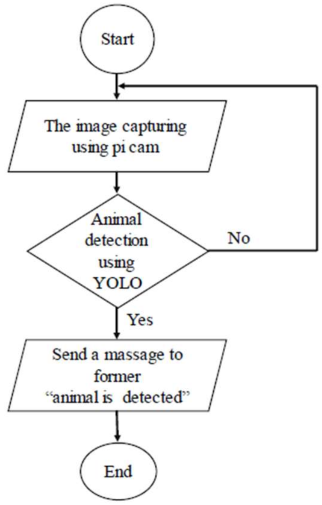

Fig:2 A flow chart representation of the system

Arduino IDE (Integrated Development Environment) is an open-source software platform used to develop and program microcontroller-based systems. It is primarily designed to support the Arduino hardware platform but can also be used with other microcontroller boards. The IDE provides a simple and user-friendly interface for writing, compiling, and uploading code to an Arduino board. It includes a text editor, a code library, a serial monitor, and a variety of tools for managing code and uploading it to the board.

V. Problem Solving

A. Hardware Connections

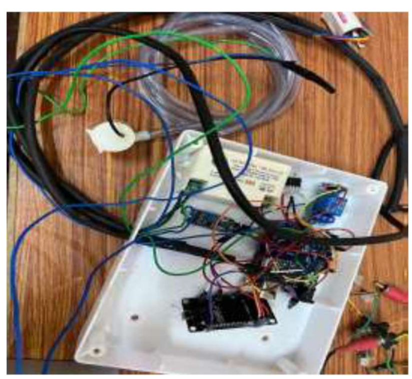

Fig 3 Hardware connection

The Arduino board is connected to a moisture sensor, which measures the level of moisture in the soil. The Arduino reads the sensor data and based on the predefined threshold; it triggers a connected pump.
ESP8266 microcontroller is connected to both a moisture sensor and an NPK (nitrogen,

phosphorus, and potassium) sensor. The moisture sensor measures the soil moisture level similar to the setup with Arduino. The NPK sensor, on the other hand, measures the levels of nitrogen, phosphorus, and potassium in the soil. The ESP8266 reads the sensor data from both sensors and can perform actions based on the readings, such as adjusting the watering schedule or adding appropriate nutrients to the soil.

The Raspberry Pi is connected to a Pi camera and a buzzer. The Pi camera is used to capture images or videos, providing visual information for various applications. It can be used for surveillance, image recognition, or any other purpose that requires visual data. The buzzer is connected to the Raspberry Pi to generate audible alerts or notifications based on certain events or conditions detected by the system.

B. Animal detection

The below figures on the Raspberry Pi3 screen show the results of animal detection using the system. The accuracy of detecting monkeys is measured at 75%, indicating that the system correctly identifies monkeys in images with a high level of accuracy. Similarly, the accuracy of detecting elephants is measured at 65%, indicating that the system successfully identifies elephants in images, albeit with a slightly lower accuracy compared to monkeys. These accuracy percentages serve as performance indicators for the animal detection capabilities of the system, providing insights into its effectiveness in identifying specific animal species.

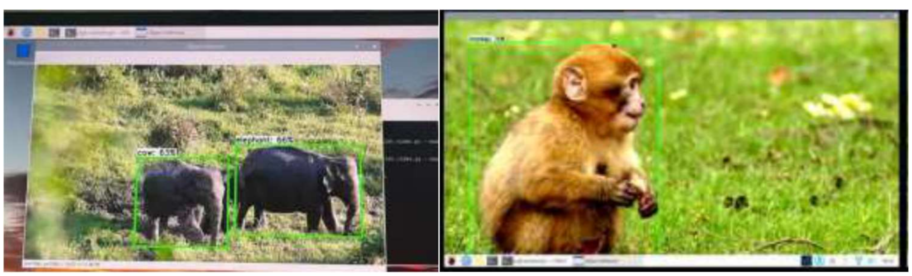

Fig 4: Animal Detection using Raspberry Pi 3

c. Mobile Application

The application in Figure 5 is the first page of the application. When the user clicks the "Start" button, they are redirected to Figure 5. This page shows the temperature, humidity, moisture of the field and the nitrogen, phosphorus, and potassium levels of the soil. The farmer can access this information from anywhere, at any time.

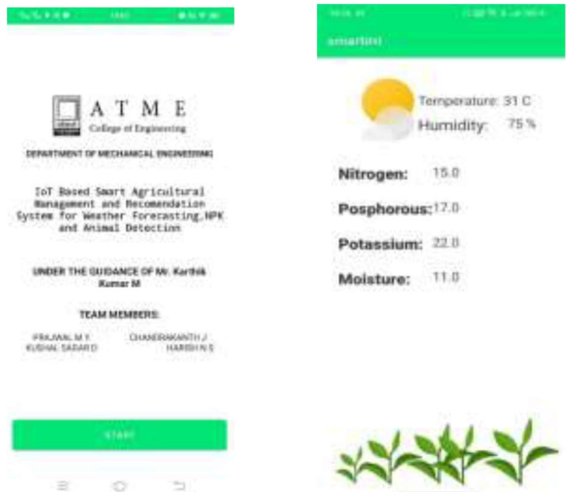

Fig 5 : Front page of the application **&** Second page of the application

d. Alert Message

If an animal is detected in the agricultural land by the animal detection system, an alert message is immediately sent to the registered mobile phone of the farmer. This alert serves as a notification to the farmer about the presence of an animal, allowing them to take prompt action to prevent or minimize crop damage. This proactive alert system enables farmers to mitigate the risks posed by animal intrusion and ensure timely interventions for crop preservation

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Fig 6: This text message snapshot received by the farmer when the animal is detected in the field.

VI CONCLUSION

In conclusion, an IoT-based smart agricultural management and recommendation system can be a game-changer for the agricultural industry. This system can help farmers make informed decisions about their crops by providing real-time insights and recommendations based on data collected from sensors and IoT devices. By monitoring weather patterns, soil moisture levels, and nutrient levels, the system can provide recommendations on the optimal time to plant crops, the optimal amount of water and fertilizer to use, and the best time to harvest crops. Moreover, incorporating animal detection capabilities into the system can help farmers protect their crops from being damaged by animals, thus preventing losses and increasing profits.

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