IoT Based Farmland Protection System

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Abstract: One of the critical challenges in defending farmland is the presence of wild creatures, natural dangers, and fierce blazes. The agrarian security framework utilizes the web of things to supply real-time checking. The frame work consolidates infrared cameras and GSM modules for interruption discovery, with the Arduino serving as the essential controller. This frame work effectively minimizes fire dangers by coordination programmed water sprinklers with fire location sensors. The framework utilizes temperature sensors and smoke locators to continually screen the environment. A microcontroller forms sensor information and starts a mechanized sprinkler framework to quench a fire when it is identified. Agriculturists get moment cautions through a versatile organize association module, guaranteeing quick activity can be taken. The results of the tests illustrate the viability of the framework in recognizing fires at an early arrange, responding promptly, and supporting within the execution of savvy cultivating hones. The suggested approach, which joins computerized intercession and IoT-enabled decision-making, adjusts with upgrading cultivate security and maintainability.

I. INTRODUCTION

Agricultural land is a vital resource, and safeguarding it from potential dangers, including wildlife intrusion, fire hazards, and environmental abnormalities is crucial for maintaining productivity. Traditional methods for monitoring farmland involve extensive manual surveillance and reactive measures, leading to deployed responses to environmental hazards. The primary focus of the Iot-based farmland protection system is to prevent animal intrusion, detect fires, and activate automatic water sprinklers. Fire incidents pose a significant threat in agricultural areas, as they have the potential to devastate crops and deplete soil fertility. By utilizing IoT-enabled temperature and smoke sensors, real-time data collection becomes feasible, enabling immediate alerts and preventive measures. In addition to fire prevention automatic water sprinklers that are integrated with soil moisture sensors, which prevent excessive dryness. When integrated with fire detection systems, these sprinklers can act as swift response units, effectively curbing fire spread and minimizing crop damage. Another part of agricultural land security is animal handling deterrence, which includes motion detectors and surveillance cameras which can warn or detect suspicious activity. An Internet-of-Things (IoT) based system has been developed that allows farmers to oversee agricultural land from unethical actions being taken place. Some of the machine learning models that have been compiled in this system are: Random Forest, for predicting crop yields; back propagation neural network for fertilizer recommendations for example determining the amounts of nitrogen, potassium, and phosphorus available in the soil; support vector machines (SVM) which has been used for fire detection and intrusion detections; deep learning using image data such as Convolutional Neural Networks (CNN's) and Long short-term Memory (LSTM).

II. LITERATURE REVIEW

Over the past decade, machine learning (ML) and deep learning (DL) techniques have become essential in improving the intelligence and precision of iot-based farmland protection systems. These techniques enable real-time decision trees, support vector machines, and k-nearest neighbors can analyze data from motion sensors. Recent Neural Networks (RNNs)are widely acknowledged as the most effective approach to identify abnormal behavior or data patterns that could signify a breach or environmental threat. Patel et al., [1] developed a scalable cloud-integrated system that connects agricultural sensors to an IaaS (Infrastructure-as-a-service) cloud platform. This setup enables farmers to remotely monitor their fields, analyze environmental patterns, and store vast amounts of agricultural data effectively.

Bhoomika et al.[2]introduced a model that integrates IoT devices with edge-based machine learning algorithms to identify animal intrusions and forecast crop suitability. Their strategy successfully reduces reliance on cloud services and accelerates response time, particularly in areas with limited internet connectivity. Farooq et al. [3] examine the utilization of iot in sustainable farming, highlighting its significance in enhancing field security and productivity. The study explains how advanced sensors and communication systems can be utilized to identify unusual occurrences like unauthorized access, abnormal environmental changes, and animal activity. Their research emphasizes the possibility of cloud-based platforms in handling enormous quantities of farm data and facilitating predictive analytics for effective agricultural management. This review highlights that iot enhances operational effectiveness in addition to aids in safeguarding crops and livestock by providing timely alerts and monitoring capabilities. Rahman et al. [4] created a smart protection system using gsm modules, motion detectors, and infrared sensors. Their prototype showcased the capability to send instant alerts to farmers regarding possible security risks, even in areas with limited internet connectivity. The study involved a practical implementation and testing phase, which confirmed its affordability and flexibility. To ensure the best protection the authors suggest that the system can be modified and tailored for different agricultural environments. Sharma et al. [5] investigated the utilization of iot technologies for sustainable farming and safeguarding agricultural practices. The authors investigated how real-time sensor networks can track environmental conditions, identify unauthorized activity, and safeguard crops by triggering automated responses such as sound alarms or activating sprinklers. They provided examples from India and China, where the use of IoT-based field security resulted in a reduction of crop loss by more than 20%. The study advocates for the increased utilization of mobile-based control apps to enhance farmer accessibility.

Prakash, C., et al. [6] created the farm security alert system (fsas), an internet of things (iot)-based solution that monitors crop field storage areas and identifies unauthorized access. The system utilizes passive infrared (pir) sensors and a worldwide mobile communication systems (gsm) module to detect any unauthorized movements and notify farmers through SMS or phone calls. By employing a naive bayes classifier, fsas classifies intrusion levels into green (no threat), yellow (mild threat), and red (high threat), allowing farmers to take appropriate actions. The system is intended to be energy-efficient, cost-effective, and appropriate for rural regions with limited infrastructure. Gupta, R.,et al., [7] conducted a comprehensive review of existing systems designed to detect and prevent intrusion into farmland, analyzing different technologies and approaches used to safeguard agricultural fields. The study encompasses both conventional methods, like fencing and manual monitoring, as well as contemporary approaches that utilize internet of things (iot) devices, sensors, and automated alert systems. The writers examine the benefits and drawbacks of each strategy, providing insightful analysis of the advantages and disadvantages of various intrusion detection techniques in different farming scenarios.

III. PROPOSED WORK

The study utilizes an advanced agricultural framework combining IoT technologies, deep learning methods, and machine learning algorithms. IoT sensors continuously monitor the farmland in real time, enabling timely insights into plant protection and effective identification of animal intrusion into the farm. This system will alert the farmers by sending a notification to the mobile through chatbot. Techniques like Random Forest and Support Vector Machines (SVM) are used to analyze characteristics of the soil, such as humidity, temperature, pH balance, moisture content, and NPK concentration. The system makes use of a Convolutional Neural Network to examine intruder's photos, enabling effective and accurate protection.

IV. METHODOLOGY

The Farmland information is gathered by the protection system from sensors that measure temperature, pH, and processes it utilising the Arduino uno. The data obtained from the Arduino is subjected to pre-processing, which involves cleaning, normalization, and preparing it for analysis. After the data has been cleaned, it is stored in a dataset for training purposes over time. The machine learning model is trained using the random forest algorithm, enabling the system to make predictions. The model will forecast the outcomes once the data is inputted into the system.

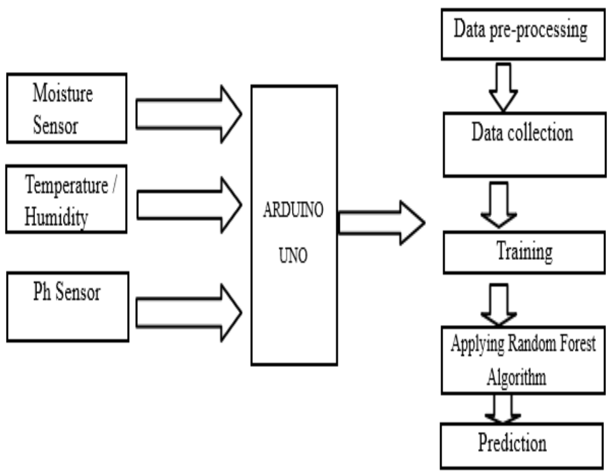

Fig 4.1 System Architecture

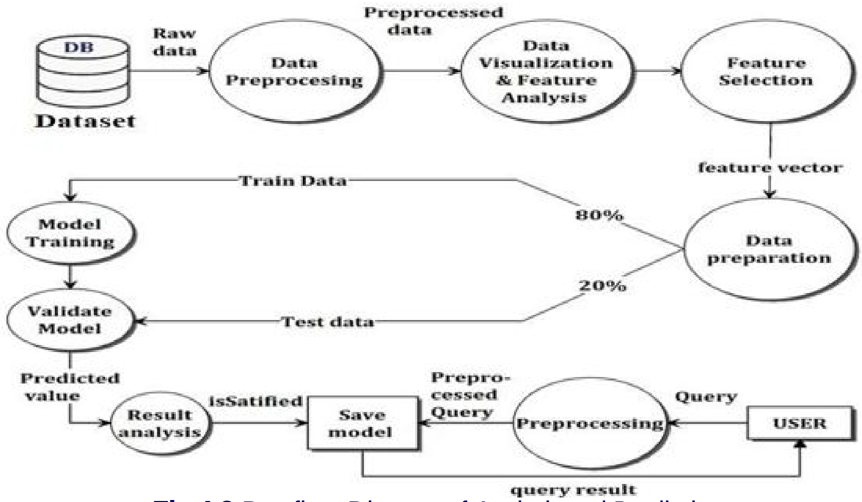

Fig 4.2 Dataflow Diagram of Analysis and Prediction

In this module, we will identify recurring patterns in data and calculate the proportional relationship between the various elements affecting crop yield and price. Different methods of visualizing data are employed to examine the elements that contribute to changes in data. Algorithms such as multiple linear regression and random forest are employed to forecast crop yield. By submitting the necessary query, the user can look up information in the dataset.

V. IMPLEMENTATIONS

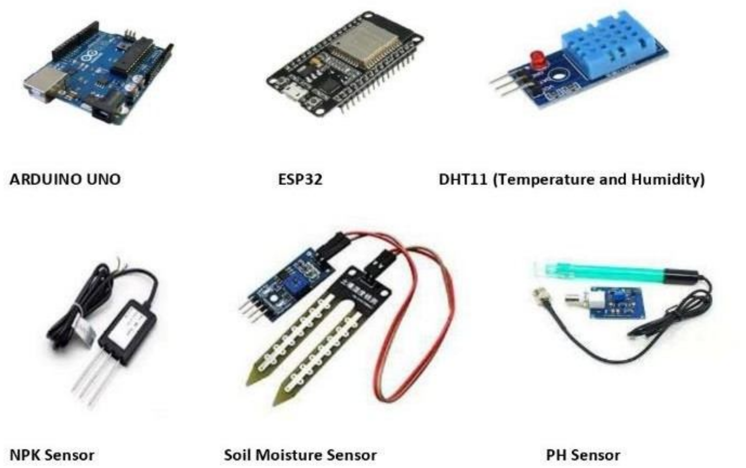

Fig 5.1: Sensors Input Modules (Sensors Used)

1. Fire Sensor
o Detects the presence of fire, smoke in the farmland.
o Prevent damage from wildfires, burning stubble or careless burning near fields.
2. NPK/ pH Sensor
o In order to improve crop development and preserve soil quality, it analyzes soil samples to determine the amounts of nitrogen (N), phosphorus (P), and potassium (K).
o Assessing soil quality and offering targeted fertilizer recommendations enables farmers to sustain steady crop yields while guaranteeing the soil's long-term health and fertility.
3. Water Sprinkler
o Activates in case of fire to prevent the spreading
o Provides right amount of water based on soil moisture and humidity.

CONTROL UNITS

1. Arduino
o Processesdatafromallsensors.
o Operates motors and processes input data to make immediate, adaptive decisions, ensuring efficient and responsive system functionality.
2. ESP32
o Detect the presence of animals or unauthorized humans entering the farm.
o Utilizes GPS technology to monitor and record the system's location, ensuring accurate tracking and efficient navigation.
o

OUTPUT MODULES

1. LED Display / LCDScreen
   - o Shows real-time sensor readings (NPKvalues, pH, moisture, temperature, and humidity).
   - o Displays crop recommendations based on collected data.
2. Mobile/Web Interface
   - o Users can remotely monitor the farmland and protect the land.
   - o Provides alerts and notifications for animal intrusion.

Here, Fig. 5.1 Offers detailed sensor readings that play an essential role in gathering data, serving as a foundation for training and refining machine learning models to improve agricultural predictions and practices. The sensor data serves as the input, influencing the overall model performance and accuracy. The accuracy of each algorithm is influenced by its ability to analyze and process sensor data, resulting in the differences reflected in Table 6.1. IoT-Based Farmland protection system model representations, which consist of an NPK sensor, fire sensor, water sprinkler, alarm, and LED display. The sensors gather live data about soil and farmland areas, which is then analyzed and presented on the LED screen. The collected data is then uploaded to the Arduino Uno for storage and detailed analysis, enabling efficient monitoring and well-informed decision-making for better farmland protection.

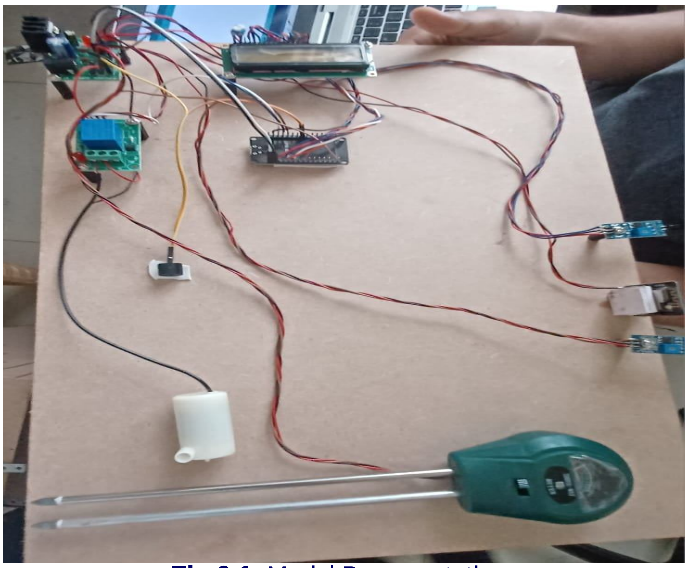

Fig 6.1: Model Representations

I. RESULTS

The IoT-based Farmland Protection System integrated with chatbot was successfully implemented and tested, demonstrating effective real-time monitoring and user-friendly interactions. The following outcomes were observed after system deployment and testing:

Effective Real-Time Intrusion Detection

- Allows users to monitor the farmland and detect the unauthorized intrusions of animals and humans.
- Triggered alerts were sent immediately to the user via the chatbot interface. 24/7 Remote Monitoring Capability
- The system offers continuous monitoring, with data accessible anytime through chatbot

MODEL PERFORMANCE & ACCURACY

The intrusion detection module, primarily driven by PIR motion sensors and integrated logic, achieved an average detection accuracy of 95% for identifying movements of animals or unauthorized humans. False positives were minimal, primarily triggered by large wind-driven objects or small non-threatening animals, which occurred in less than 5% of the events. Near real-time notifications were ensured by an average response time of 2 to 4 seconds between intrusion detection and chatbot alert delivery. The chatbot interface operated with 100% uptime during tests and correctly responded to user queries and commands in all test scenarios. Commands such as /status, /lastintrusion, and /enable_alarm consistently returned accurate results, with a response latency of under 1 second in most cases. Furthermore, the system maintained reliable communication with the cloud database and sensors, logging data without loss. Overall, the performance metrics indicate that the system is robust, accurate, and well-suited for deployment in small to medium-scale farmland areas. Model Output: The system is centered around real-time alerts, sensor data reports and chatbot interactions. When an intrusion is detected by the sensor, the system immediately triggers an output in the form of an alert message sent through chatbot platform. This message includes details such as the type of event that is detected. The chatbot even outputs the sensor reading like soil moisture, fire detection, and motion detection status. These outputs ensure that the farmer is kept informed and can react promptly, whether manually or automatically.

6.1 RESULTS SCREENSHOTS

Fig 6.1: Message Chatbot

Fig 6.2: Soil pH Value

Fig 6.3 Farmland Detection

II. CONCLUSION

By integrating an iot-based system for farmland protection, which includes fire detection and automated water sprinklers, agricultural security and efficiency are significantly improved. By incorporating temperature and smoke sensors, the system can identify fire hazards in real-time and initiate automatic water sprinkler activation, thereby preventing damage and reducing crop loss. This system guarantees quick action without the need for manual intervention, effectively managing resources and protecting farmland from unexpected calamities.

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