Undergraduate Conference on Intelligent Computing and Systems (UCICS 2025)
26-27 February, 2025; Varendra University, Rajshahi, Bangladesh

IoT-based Smart Plant Monitoring and Animal Detection with YOLOv8

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***Abstract*—This study proposes a novel system that integrates the IoT and AI into a unified framework to enable simultaneous plant monitoring and security. The proposed solution introduces an efficient IoT-based application for agricultural monitoring that, addresses critical challenges while ensuring portability and secure access. The system is designed to help farmers effectively monitor and track environmental changes. We used an ESP8266 microcontroller in conjunction with the YOLOv8, MediaPipe, and Blynk platform to monitor plant health, as well as to detect threats in the form of animals and humans. Traditional plant monitoring systems rely on manual oversight; however, this smart system automates tasks and enhances accessibility through mobile compatibility. Users can remotely monitor the plant security and ensure peace of mind. By providing real-time updates, reducing labor requirements, and optimizing water usage, the system promotes sustainable farming. It offers a cost-effective and scalable solution suitable for home gardens and large-scale agriculture, thus addressing the demand for efficient and sustainable technologies.**

***Index Terms*—Plant Monitoring, Animal Detection, Blynk smart agriculture, Yolov8, MediaPipe**

I. Introduction

The Smart Plant Monitoring System is an IoT and artificial intelligence-based system. This system is needed in today's world where we require a sustainable form of agriculture and an efficient utilization of available resources. It is an intelligent method for monitoring and maintaining plants. This system uses advanced sensors, an automated system, and real-time feedback to achieve complete growth with minimal effort [1]. In Bangladesh, more than 50% of the population is directly involved in the agricultural sector,which plays a critical role in the country's rapid economic growth. More than 70% of the country's land is used for agricultural production [2]. Despite its importance, agriculture in Bangladesh faces many problems. These include land degradation, water shortages, soil fertility decline and declining crop productivity [3]. Animal attacks from outside and intruders also cause losses in this sector. To address these difficulties, we propose a solution called "Smart Plant Monitoring System and Animal Detection." The entire system uses the ESP8266 [4] microcontroller, which measures various physical parameters such as soil moisture, temperature, and humidity. These data can be viewed on a local LCD display and transmitted to a mobile app, allowing users to receive alerts and notifications while having remote control over their plants. The agricultural pump in this system can be activated when the predefined moisture limit is crossed, simultaneously preventing both over-watering and under-watering at the same time. Thus, this study simultaneously achieves ease of use, accuracy, and sustainability. The major contributions of this study are as follows.

- We have studied the existing solutions that are currently assisting in smart plant monitoring and have provided a cost-efficient, faster response, user-friendly, and more secure solution.
- We designed and developed a system that can accurately detect humans and animals using machine learning, thereby enabling efficient classification.
- We have implemented an alert system for security threats.
- Finally, we incorporated the features of automated and manual irrigation systems.

The remainder of this paper is organized as follows. Section II reviews existing smart plant monitoring systems and highlights their components. Section III describes the proposed solution and provides an overview of the workflow of this study. Section IV presents the results and system performance, and compares the proposed solution with several existing works. Finally, Section V concludes the paper.

II. Literature Review

A smart plant monitoring system is essential because it enhances efficiency by reducing manual effort and supports improved decision-making. Numerous researchers have conducted studies and proposed various approaches for this framework. In [5], a smart plant watering and monitoring system was built using ESP8266, GSM, Ultrasonic, PIR and DHT11. The author used a WiFi module to wirelessly control the water pump, soil moisture sensor to measure the moisture level of the soil, and ultrasonic sensor for water level. This system offers low-cost automation. Although this was budget-friendly and used PIR for object detection, there was an absence of advanced feature for object detection, which created a lack of security. In [6], smart irrigation system was developed using soil moisture sensor, temperature sensor, water flow sensor, arduino uno, relay module, and motor. This framework automatically control water flow when needed. Its goal is to optimize water usage. In [1], the author introduced a system using GSM, soil moisture, IR sensors, a light sensor, and a temperature and humidity sensor for plant monitoring and watering. This scheme provides intruder detection system by using IR sensor. Monitoring is more accessible in this scheme as IP address is used to access results.

While more recent works focus on irrigation and precise data collection, they lack proper security features. Our proposed system addresses existing gaps by integrating advanced detection capabilities with YOLOv8 [7] for animal detection and MediaPipe [8] for human detection, ensuring enhanced security. In addition, the system utilizes the Blynk platform for real-time monitoring and automated irrigation, providing a user-friendly interface for seamless interaction. By incorporating both plant monitoring and security features into one device, our system offers a comprehensive solution that enhances plant care and security through smart automation and accurate detection.

III. Proposed Methodology

The system is divided into two parts:- plant monitoring [9] and security. For plant monitoring, the system uses necessary sensors to monitor the plant's environment, including temperature, humidity, soil moisture, a relay for controlling the water pump, and an I2C LCD [10] display. An ESP8266 [4] microcontroller manages all these sensors and offers easy upgrading to include additional sensors. The second part of the system focuses on security. Python OpenCV [11] and a pre-trained model for animal detection, along with MediaPipe [8] for human face detection. This program runs on a server and communicates with the ESP8266 [4] via the HTTP protocol to send status to detected animals of human presence. All data were sent over the Blynk [12] app and web dashboard for real-time monitoring. If an animal is detected, the system sends an alert to the mobile application and shows the detection status. Figure 1 illustrates the architecture of the system.

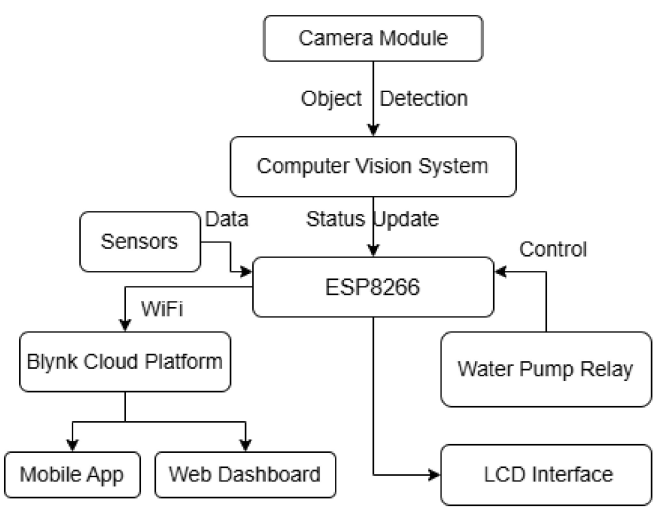

Fig. 1. System architecture

A. Components

In this section, we summarize the components of this system. The components of the system are shown in Figure 2.

1) **ESP8266 [4]:** ESP8266 is a low-cost Wi-Fi microcontroller, with built-in TCP/IP networking software and microcontroller capabilities. It can connect to a 2.4GHz network supporting 802.11 b/g/n. It will not work with 5GHz frequencies.
2) **DHT21 [13]:** DHT21 is a high-performance temperature and humidity sensor that provides accurate measurements, low power consumption, long-distance data transmission, automatic calibration, and long life. The sensor is small, making it easily integrated into the project.
3) **Soil Moisture [14]:** A device that is used to sense the moisture level in sand is called a soil moisture sensor. This sensor reminds the user to water their plants and monitor the moisture content of the soil.
4) **Relay Module [15]:** A relay module is a switching device, and control circuit that operates with low-power signals. This enables a low-power supply circuit to switch on or regulate a high-power supply circuit without integrating it with the same circuit or electrical appliance.
5) **Water Pump [16]:** This is a low-cost, small-sized Submersible Pump Motor that can be operated from a 2.5 6V power supply. It can take up to 120 L/h with a very low current consumption of 220mA.
6) **I2C LCD [10]:** This 2×16 character LCD Module with GREEN Backlight uses an I2C interface to communicate with the host microcontroller. This budget-conscious LCD is used in projects requiring the display of text, data, or ASCII characteristics of all types. Connect to Vcc, Gnd, SDA (serial data line), and SCL (serial clock line). This is a 5VDC device and will be found on the I2C bus at address 0x27 / 0x3F.

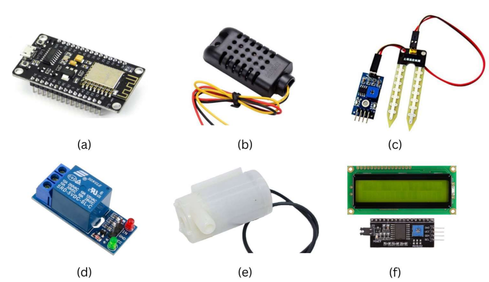

Fig. 2. : List of Components (a) ESP8266 (b) DHT21 (c) Soil Moisture (d) Relay Module (e) Water Pump (f) I2C LCD Display

B. Software Implementation

1) **Arduino IDE [17]:** The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware to upload and communicate with programs.

2) **Blynk [12]:** An IoT platform manages device connectivity and allows developers to build new mobile software applications.

C. Animal Detection System

1) **Object Detection using YOLOv8 [7]:** YOLOv8 (You Only Look Once, Version 8 is a state-of-the-art deep learning model designed for real-time object detection in computer vision applications. It is used to detect animals such as dogs and cows. This is a pre-trained medium-sized YOLOv8 model (yolov8m.pt). This model operated with a confidence threshold of 0.5.
2) **OpenCV [11]:** OpenCV-Python is a library of Python bindings designed to solve computer vision problems. the frames were captured from live video using OpenCV.
3) **MediaPipe [8]:** MediaPipe is an open-source framework for building pipelines to perform computer vision inference over arbitrary sensory data such as video or audio. It is primarily used for human detection.

D. Workflow of the System

This system combines Internet of Things (IoT) devices and AI to create a smart and intelligent plant monitoring and security system. The ESP8266 [4] microcontroller collects environmental data from sensors like DHT21 sensors and soil moisture sensors and displays these data to an LCD, blynk app, and web dashboard. YOLOv8 and MediaPipe process images from webcams to detect animals and humans, respectively. The detection status sent to the ESP8266 via HTTP and ESP sent this status to blynk (human, animal (animal name like dog, cow), or safe (if nothing detects)). The system also uses an automated water pump. If an animal is detected, then ESP8266 sends a notification alert to the Blynk app. Figure 3 shows the sequence diagram.

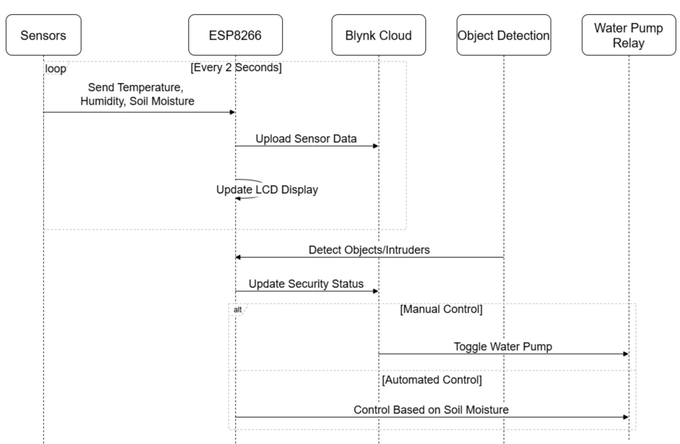

Fig. 3. Sequence-Diagram

IV. RESULT AND DISCUSSION

This section presents experimental results and highlights the performance and effectiveness of the proposed system.

A. System performance

DHT21 sensor can measure temperature from -40°C to +80°C. So it works in various temperature conditions. For the detection of animals and humans in various light conditions, such as intense sunlight or low light environments, slightly affects object detection, as it depends on image quality. Figure 4 shows the hardware setup and mobile blynk app for Plant monitoring system and figure 5 shows animal detection via webcam.

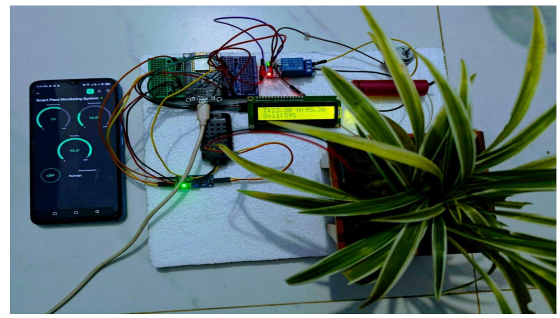

Fig. 4. Plant Monitoring System Setup

Fig. 5. Animal Detection

Table I shows the accuracy of MediaPipe in detecting humans at various distances. The table presents the total number of test cases, true positives (TP), false positives (FP), false negatives (FN), and the corresponding accuracy at different distances ranging from 1 to 10 m. As the distance increases, the accuracy of human detection decreases, with a notable drop in performance beyond 7 meters.

TABLE I
MEDIAPIPE ACCURACY FOR HUMAN DETECTION BY DISTANCE

Dist. (m)	Total	TP	FP	FN	Accuracy (%)
1	20	19	1	1	95.0
3	20	18	2	2	90.0
5	20	16	3	4	80.0
7	20	14	4	6	70.0
10	20	12	5	8	60.0

Table II illustrates the accuracy of the YOLOv8 model in detecting dogs and cows at varying distances. Similar to

Table I, this table includes the total number of test cases, true positives, false positives, false negatives, and accuracy for each target (dog and cow) at distances from 1 to 10 m. The results indicate that detection accuracy decreases with increasing distance for both animals, with cows showing a slightly lower accuracy than dogs at each distance interval.

TABLE II
YOLOv8 ACCURACY FOR DOG AND COW DETECTION BY DISTANCE

Distance(m)	Target	Total	TP	FP	FN	Accuracy (%)
1	Dog	20	19	1	1	95.0
1	Cow	20	18	2	2	90.0
3	Dog	20	18	2	2	90.0
3	Cow	20	17	3	3	85.0
5	Dog	20	16	3	4	80.0
5	Cow	20	15	4	5	75.0
7	Dog	20	14	4	6	70.0
7	Cow	20	12	5	8	60.0
10	Dog	20	12	5	8	60.0
10	Cow	20	10	6	10	50.0

B. Comparison with other existing works

Table III provides a comparative analysis of the proposed system against the aforementioned existing works, focusing on key parameters such as sensor types, microcontrollers, IoT platforms, object detection capabilities, communication protocols, local displays, mobile app integration, energy efficiency, automation, detection accuracy, and cost. This comparison highlights that the proposed system excels in multiple aspects, offering a balanced combination of advanced features, high detection accuracy, energy efficiency, and cost-effectiveness.

TABLE III
COMPARISON OF PROPOSED SCHEME WITH EXISTING SCHEMES

Feature	Proposed System	H. M. Jokhab [5]	A. E. Mezouari [6]	Anusha K. [1]
Sensor Types	DHT21, Soil moisture	DHT11, Soil moisture, GSM, Ultrasonic,	Soil moisture, Temperature, Water flow sensors	LM35, soil moisture, IR, Temperature sensor,
Microcontroller	ESP8266	Arduino Mega, ESP8266	Arduino Uno	Raspberry Pi
IoT Platform	Blynk IoT, HTTP Server	Blynk IoT	CSV-based data logging	None
Object Detection	YOLOv8 for human /animal	PIR Motion Sensor	None	IR sensor
Communication Protocol	WiFi (ESP8266)	WiFi (ESP8266)	Local serial communication	Ethernet
Local Display	LCD	LCD	None	None
Mobile App Integration	Blynk app	Blynk app	None	Web app
Automation	Automatic irrigation, remote manual control	Automatic irrigation only	Automatic motor switching	Automatic irrigation only
Energy Efficiency	No solar power (future work)	Solar-powered	Battery-powered	None
Detection Accuracy	High (YOLOv8)	Moderate (PIR)	None	Low
Cost	Low	Low	Low	High

V. CONCLUSION

The proposed system integrated a plant monitoring system with an animal and human detection system to provide a comprehensive solution for smart gardening and property protection. For plant monitoring, the system utilizes temperature, humidity, and soil moisture sensors. Data were displayed locally on an LCD screen and transmitted to a mobile application using the Blynk platform. For security, the system incorporated a Python program integrated with OpenCV, MediPipe, and YOLOv8 for animal and human detection. By running this Python program on a server, the system communicates with the ESP8266 microcontroller and transmits status updates using the HTTP protocol. Integration of solar power, ultrasonic sound to scare away animals or unauthorized intruders, and extended monitoring capabilities such as pH level sensors, CO2 sensors, and air quality monitoring.

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