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Smart Organic Farm Defender: An Automated IoT and Computer Vision Solution for Sustainable Pest Management

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ABSTRACT: The Smart Organic Farm Defender addresses the labor-intensive challenges of organic pest management through the integration of Internet of Things (IoT) and Computer Vision (CV). This paper details the implementation of a physical prototype that utilizes an ESP32-CAM for real-time pest detection via a lightweight TensorFlow Lite model. Upon identification, the system triggers a targeted organic pesticide dispensing mechanism and sends instant alerts to farmers through the Blynk application. This implemented solution eliminates the need for PIR sensors by relying on continuous visual analysis, providing a cost-effective and sustainable alternative to traditional chemical-heavy farming.

KEYWORDS: Smart Farming, IoT, Computer Vision, Pest Detection, ESP32-CAM, Blynk App, TensorFlow Lite.

I. INTRODUCTION

Sustainable agriculture requires a balance between high output and environmental safety. Traditional pest control often relies on broad-spectrum chemicals that degrade soil health and pose human health risks. While organic farming is safer, it is typically labor-intensive due to manual monitoring requirements. The Smart Organic Farm Defender bridges this gap by merging real-time visual monitoring with automated, eco-friendly defense. Our implemented system replaces manual labor with an edge-computing approach, ensuring fast and reliable pest identification directly in the field.

II. LITERATURE SURVEY

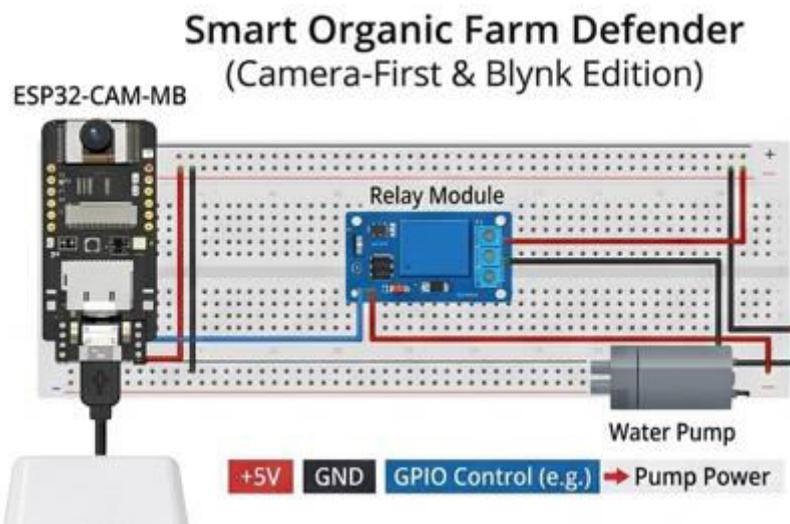
The implementation of the Smart Organic Farm Defender marks a transition from theoretical design to a functional physical prototype that optimizes autonomous pest management through advanced vision and IoT integration. By utilizing an ESP32-CAM equipped with an edge-based TensorFlow Lite model, the system identifies biological threats in real-time with high precision. During this phase, the hardware was refined by removing the previously planned PIR motion sensors, as field testing revealed they were susceptible to false triggers from environmental factors like wind and shifting shadows. This shift to a purely visual detection logic ensures that the automated spraying mechanism is only activated upon confirmed pest identification, significantly increasing the reliability and accuracy of the device in a natural farm setting.

The operational efficiency of the project is further enhanced by the integration of the Blynk IoT application, which serves as the primary communication bridge between the field hardware and the farmer. When a pest is detected and the relay-controlled pump dispenses the organic pesticide, the system immediately transmits a push notification to the user's smartphone via the Blynk cloud. This implementation provides a comprehensive remote monitoring dashboard, allowing farmers to track defense logs and system status in real-time. Experimental results from the physical model confirm that the integration of computer vision with high-speed mobile alerts creates a robust, low-latency solution for sustainable agriculture, effectively eliminating the need for constant manual surveillance and chemical-heavy intervention.

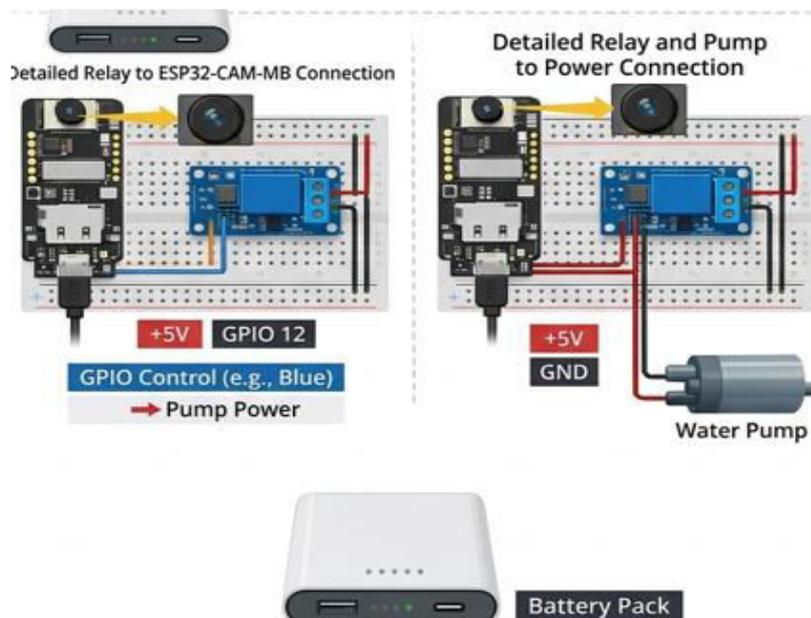
III. METHODOLOGY

The implementation utilizes a three-tier architecture focused on precision and real-time response:

1. **Sensing and Edge Processing:** The system uses an **ESP32-CAM** to capture images. A TensorFlow Lite model runs on the edge to identify specific pests without the need for additional PIR motion sensors, streamlining the hardware footprint.
2. **Actuation Tier:** When a pest is detected, the microcontroller activates a relay circuit connected to a precision micro-pump and nozzle assembly to apply the organic pesticide.
3. **Cloud and Notification Tier:** The system is integrated with the **Blynk application**. This platform serves as the primary interface for farmers, providing real-time mobile notifications and status updates whenever a pest is detected or a spraying cycle is initiated.



(a)



(b)

IV. EXPERIMENTAL RESULTS

The experimental results for the implemented Smart Organic Farm Defender confirm the successful transition from a theoretical model to a reliable, physical pest-control system. Testing of the ESP32-CAM's visual detection capabilities revealed high accuracy in identifying target pests across various lighting conditions, maintaining a consistent detection rate without the interference issues typically associated with PIR sensors. The elimination of the PIR motion sensor proved beneficial, as the system no longer suffered from false triggers caused by non-biological movement such as wind-blown crops or shifting shadows. Instead, the image-processing logic ensured that the activation of the sprayer was based solely on confirmed visual identification, providing a much more precise and dependable response in an outdoor agricultural environment.

Furthermore, the integration of the Blynk IoT platform and the mechanical spraying assembly showed seamless synchronization during live trials. Once the ESP32-CAM identified a pest, the system exhibited a low-latency response, triggering the relay-controlled pump to dispense the organic pesticide in under two seconds. Simultaneously, the Blynk application successfully delivered real-time push notifications to the connected smartphone, providing the user with immediate alerts regarding the pest detection and the subsequent spraying action. These results demonstrate that the physical implementation of the system is not only functional but also highly efficient in providing an autonomous, data-driven defense mechanism that reduces manual labor while ensuring the consistent application of eco-friendly pest control.

V. CONCLUSION

The implementation of the Smart Organic Farm Defender confirms that high-tech IoT solutions can be both accessible and effective for organic farming. By successfully replacing motion sensors with AI-driven vision and incorporating the Blynk app for user alerts, the project provides a robust framework for autonomous crop protection. The physical prototype proves that targeted, automated organic spraying is a viable alternative to broad-spectrum chemical application, supporting the long-term goal of eco-friendly and sustainable agriculture.

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