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Smart Automatic Insect Catching System

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Abstract

Introduction: Agricultural insect pests cause an estimated 30-40% of global crop losses annually, threatening food security and farmer livelihoods. Conventional pest control relies heavily on broad-spectrum chemical pesticides, which pose significant risks including environmental contamination, non-target organism harm, pesticide resistance development, and human health concerns. Integrated Pest Management (IPM) offers a sustainable alternative by combining monitoring, biological controls, and targeted interventions to reduce pesticide dependence while maintaining crop protection.

Smart Automatic Insect Catching System is a prototype designed to attract, detect, capture, monitor, and eliminate harmful agricultural insects using a multi-modal approach. The current prototype integrates an Arduino Uno microcontroller, LDR-based insect detection, LEDs, a servo-actuated mechanical trap, neem-oil spraying, and an electrical wire mesh. The main objective of the project is not only to catch harmful

insects but also to demonstrate how modern electronics and automation can support sustainable and environmentally friendly farming practices.

Methodology: The various components used in the Smart Automatic Insect Catching System are:

1. LDR (Light Dependent Resistor)

An LDR is a sensor that measures the amount of light in its surroundings. During the daytime, when there is plenty of sunlight, its electrical resistance becomes very low. During the night, when light decreases, its resistance increases.The LDR continuously checks whether it is day or night and also to detect insect movement near the device. This information is sent to the controller so that the system knows exactly when it should start operating.

2. LED, or Light Emitting Diode.

The LEDs are used as the light source because many insects are naturally attracted to bright light during the night. When the surroundings become dark, the LEDs automatically switch ON and attract insects toward the trap.LEDs are chosen because they consume very little electricity, generate less heat, have a long lifespan, and are highly energy-efficient.

3. **Jumper wires**.

Jumper wires play a very important role. They connect all the electronic components, allowing electrical signals and power to flow between the sensor, controller, LEDs, servo motor, and camera. Without proper wiring, none of the components would be able to communicate with each other.

4.Servo motor.

A servo motor rotates only to a specific angle with high precision. This makes it ideal for applications where controlled movement is required. The servo motor controls the opening and closing of the insect trap. The trap door is connected to a collection container, which acts as the main chamber for capturing and storing insects after they enter the trap. When insects are attracted near the LEDs, the controller commands the servo motor to rotate and open the trap door. After a few seconds, once the insects have entered, the servo rotates back to close the door, preventing the insects from escaping.

Because the servo moves accurately every time, the trap operates consistently without manual intervention. This automatic movement makes the entire insect-catching process efficient and reliable.

5. **ESP32 Camera Module**.

The ESP32 Camera is a compact microcontroller with a built-in camera. Unlike an ordinary camera, it can capture images and transmit them electronically for monitoring purposes.

In the project, the camera continuously observes the area around the insect trap. It allows us to monitor insect activity and verify whether insects are being attracted and captured successfully.

6.Neem oil spray mechanism

After insects are attracted into the trap, the spray sprays neem oil inside the collection chamber. This helps immobilize the insects and also kill them making them easier to contain while also preventing them from escaping. It provides a simple and environmentally friendly alternative to using harmful chemicals.

7.Electrical Wire Mesh

Neem oil might only immobilize the insect and not kill them. So, as a more efficient method, an electrical wire mesh is placed below the oil spraying mechanism to kill any left-over insects with higher precision.This makes the project not only an insect-catching system but also an insect-monitoring system.

Current Detection Mechanism (LDR-Based)

The operational sequence is:

1. **Insect approaches** → shadows or reflects light near the LDR

2. **Arduino processes signal** → validates detection (debouncing, minimum pulse width)
3. **Trap activates** → servo motor rotates to close trap door
4. **Elimination** → neem-oil pump sprays on the captured insect

Results & Discussion:

The current Smart Automatic Insect Catching System prototype has been assembled and tested in a controlled indoor environment. Key observations include:

- **LDR Detection:** The LDR sensors reliably detect objects passing within ~2–5 cm, triggering the servo motor.
- **Servo Actuation:** The servo motor successfully opens and closes the trap mechanism within~1–2 seconds of detection. Mechanical reliability depends on trap design (e.g., funnel vs. door) and insect size.
- **Neem Spray:** Due to budget constraints, we were unable to test the activation part of the neem oil spray, but contact with neem residue is expected to cause feeding inhibition and growth disruption in captured insects over hours to days due to biochemical properties present in the neem oil which are vulnerable to the insects.
- **LEDs Attraction:** LEDs visibly attract small flying insects (e.g., fruit flies, moths) in darkened rooms. Attraction is visibly stronger at night or in low-light conditions, aligning with research on nocturnal photo taxis.

No quantitative field trials have been conducted. All results are prototype-level observations.

Conclusion:

- The The project operates automatically without requiring manual switching.
- It saves electricity because the LEDs operate only during nighttime.
- It is affordable since the components used are inexpensive and easily available.

- The camera provides visual monitoring, allowing farmers or researchers to observe insect activity without visiting the field continuously.
- The project also reduces the need for excessive pesticide use, making it safer for the environment.

In the future, this project can be improved by:

1. Adding solar panels for renewable energy.
2. Using UV lights instead of LEDs to as UV lights would attract insects with higher precision.
3. A camera module (e.g., Raspberry Pi Camera, or OV2640) will replace or supplement LDR detection. The camera will:
4. Capture images of insects approaching inside the trap.
5. Transmit images to a mobile/web application via Wi-Fi or GSM
6. The camera will be AI enabled to detect and analyze whether the insects are harmful or harmless. Based on this data, the trap will work accordingly.

1. Existing LDRs could be repurposed as ambient light sensors to control UV LED operation:

- **Daytime (high ambient light)** →UV LEDs OFF (conserve power, avoid non-target attraction)
- **Nighttime (low ambient light)** →UV LEDs ON (target nocturnal pests)

2. Autonomous drone equipped with UV LEDs and/or pheromone dispensers:

- Drone flies over farm area with UV lights ON, attracting insects from a wide radius.
- Drone approaches stationary Smart Automatic Insect Catching System.
- Drone UV lights switch OFF; trap UV lights switch ON.
- Insects follow stronger UV gradient toward trap.
- Trap detects and captures insects.

Keywords: Agricultural pest control, smart insect trap, LDR-based detection, Arduino Uno, ESP32-CAM, automated pest management, LED-based insect attraction, sustainable agriculture.

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