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Smart Sticky Trap: AI-Driven Surveillance for Sucking Pests in Vegetable Crops

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Introduction

For vegetable growers, one of the most persistent challenges comes from tiny yet destructive enemies—sucking pests. These include thrips (*Thrips tabaci* Lindeman), whiteflies (*Bemisia tabaci* Gennadius), aphids (*Aphis gossypii* Glover), jassids (*Amrasca biguttula biguttula* Ishida), and mites (*Tetranychus* spp.). Despite their small size, these pests inflict heavy economic losses by feeding on plant sap, resulting in leaf curling, yellowing, stunted growth, and flower or fruit drop (Nagrare *et al*., 2022).

Moreover, many of these pests are efficient vectors of viral diseases such as Tomato Leaf Curl Virus (ToLCV) and Chilli Leaf Curl Virus (ChiLCV), causing yield losses up to 70–90% in severe cases (Reddy *et al*., 2019). Managing these pests effectively and sustainably remains a major concern for vegetable farmers across India.

The Challenge in the Field

Monitoring sucking pests through field scouting and sticky traps has been a standard practice in Integrated Pest Management (IPM) (Prasanna *et al.*, 2021). However, these methods have notable limitations.

Due to their minute size and cryptic behavior, these pests often go unnoticed until infestations become severe. Manual counting and trap inspections are time-consuming and labor-intensive, particularly in large farms.

Consequently, pest detection often occurs too late, forcing farmers to resort to blanket pesticide applications. This practice increases production costs, accelerates pesticide resistance, and threatens beneficial insects and pollinators (Desneux *et al*., 2007). Hence, there is a need for an automated, accurate, and real-time pest surveillance system.

A Smart Solution: AI Meets Sticky Traps

To address these challenges, an innovative AI- and IoT-enabled Smart Sticky Trap System is proposed for the automated detection of major sucking pests in vegetable crops.

This system combines traditional sticky traps with modern digital technologies such as Artificial Intelligence (AI), machine vision, and Internet of Things (IoT) connectivity to revolutionize pest monitoring.

The trap consists of a standard yellow or blue sticky card equipped with a microcontroller (e.g., Raspberry Pi or Arduino), a camera module, and a solar-powered power source.

The camera captures high-resolution images of trapped insects at fixed intervals and transmits them

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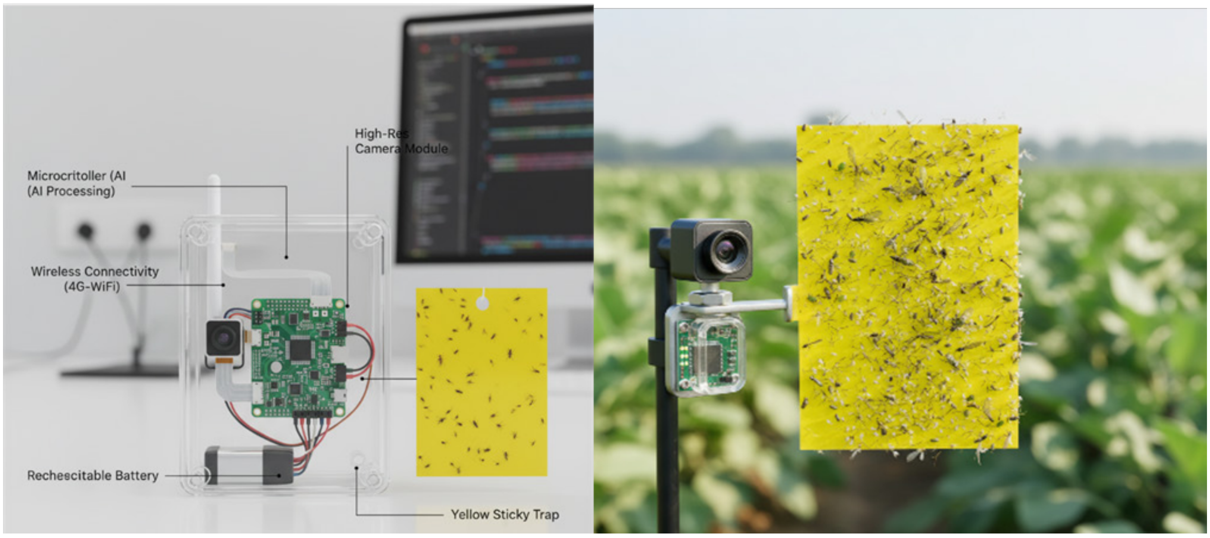
via Wi-Fi or 4G network to a cloud-based server for processing.

How the System Works

Component	Function
Sticky Traps (Yellow/Blue)	Attract and capture the flying sucking pests
Microcontroller & Camera	A Raspberry Pi/Arduino with a camera module captures high-resolution images of the trapped insects
Power Supply	Battery or solar power supply ensures continuous operation
Connectivity	Wireless connectivity (Wi-Fi/4G) instantly sends images and data
AI Model	Trained on annotated pest images (e.g., using models like YOLOv5 or MobileNet), the AI automatically detects, identifies, and counts the insects in real-time



The AI model, trained on a dataset of labeled pest images, automatically recognizes key morphological features such as body color, wing shape, and size. Models such as YOLOv5 (Redmon *et al.*, 2016) and MobileNet (Howard *et al.*, 2017) are particularly effective due to their lightweight structure and high-speed detection capabilities.

Turning images into actionable insights

Captured images are analyzed at regular intervals, and the pest population per trap is estimated. These data points are visualized as graphs or heat maps showing temporal and spatial pest dynamics.

Researchers can validate AI predictions by comparing them with manual counts using statistical indices such as Precision, Recall, F1-score, and Root Mean Square Error (RMSE) (Zhang *et al.*, 2021).

Such real-time surveillance empowers farmers and researchers with data-driven decisions for pest control—enabling timely interventions before populations exceed the economic threshold level.

Benefits of the Smart Sticky Trap System

1. **Real-Time Pest Alerts**: Enables continuous and remote pest surveillance, ensuring timely action.

2. **Labor Efficiency:** Minimizes manual counting and scouting efforts, saving time and workforce.

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3. **Eco-Friendly Farming**: Reduces pesticide overuse and promotes eco-friendly IPM practices.

4. **Improved Accuracy**: AI-based detection ensures objectivity and eliminates human error.

5. **Data for Decision Support**: Continuous monitoring aids in regional pest forecasting models.

6. **Enhanced Profitability**: Optimized pest management improves yield and reduces input costs.

The Future of Digital Entomology

The Smart Sticky Trap marks a milestone in the era of digital entomology and precision pest management. Once validated, it can be integrated with pest forecasting systems, weather-based advisory models, and farmer-friendly mobile applications (Prathibha *et al*., 2024).

In the future, such systems could be linked with AI-guided drones for automated surveillance or targeted pesticide application, offering a holistic solution for sustainable crop protection. By adopting such technologies, Indian vegetable farmers can transition from reactive pest control to proactive, predictive, and precision-based management—enhancing productivity, profitability, and environmental safety.

Conclusion

As agriculture enters the digital era, the fusion of AI, IoT, and entomological expertise opens new avenues for smart pest management.

The AI-based Smart Sticky Trap System is not only a technological innovation but also a step toward sustainable farming. By offering real-time pest detection, eco-friendly management, and data-driven insights, it holds immense potential to transform the way farmers protect their crops—making every harvest safer, smarter, and more profitable.

"Adopt smart surveillance today for a safer and more profitable harvest tomorrow!"

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