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IOT Based Pest Detection

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IoT creates a vigorous platform that meets the requirements for effective application in agriculture IoT devices have been investigated for their use in agriculture in developed countries. In recent times, IoT solutions have made their mark in many areas of human life, the environment, and industries. These IoT devices are also competent of exchanging data with their gateway. Smart agriculture is a major IoT application area along with smart health care, smart cities, smart industries, autonomous vehicles, smart homes, and others.

Introduction

IoT has revolutionized not just how we live our lives but also how we operate (Nayagam *et al*., 2023). The adoption of IoT is growing quickly across many industries, whether it be agricultural, safety, or healthcare (Kour *et al*.,2020). IoT with robotics and artificial intelligence will increase the convolution of commercial farms while reducing manual workers from 90% to 10%. One of the world's major scientific efforts in agriculture is thought to be happening in India (Wani *et al*.,2022). Agricultural growth has advanced as a result of numerous advancements in modern technology and creativity. Previous research has examined application of contemporary methods in the agricultural industry, including IoT, sensors, cloud services, mobile computing, and big data analysis .According to a study on an IoT-based process in the context of agriculture, the outcomes were remarkable. The efficiency increased slightly, and what had previously been a human-intensive industry like agriculture has become more scientific (Mukhopadhyay *et al*., 2021). There are numerous different sorts of equipment and machinery on the market today that weren't there in the early 1920s. In-field surveillance and mechanization in the agriculture industry decrease human work and show being helpful.

IoT in pest management

Spensa Tech Z-Trap is an insect trap device that automatically detects the number of target insects captured by the trap and wirelessly sends the data to the grower's mobile phone or computer. It was developed to automatically monitor insect pest populations and decrease the number of insecticides released into the environment. Z-trap also comes with the My Traps software package, which is a web or mobile application that allows the user to effectively view and examine insect population data collected by insect traps. This application can also be used as a general insect monitoring tool for traditional surveillance systems. Instead of writing down the pest count on paper, the catch numbers can be entered using the mobile app and the data then gets uploaded to the server for viewing and analysis. Z-Trap estimates the number of target insects detected by the system based on several characteristics, such as sensor response, pheromone selectivity, and target insect's flight time. Z-Trap is equipped with a high-density lithium iron phosphate battery, known to be highly efficient as the lithium-ion battery used in laptops and mobile phones. However, Z-Traps can easily be modified to monitor other pest species as long as there is attractant available for that species.

Semios BIO is another wireless communication that will change the world of fruit and nut insect monitoring is SemiosBIO, discovered by Michael Gilbert in Canada. SemiosBIO has programmed us to start with a traditional sticky insect tracking trap that measures the insect population in an orchard, places a small camera on the roof of the trap, and sends back an image of what was captured, every 10 minutes. In Image-based solutions for in situ monitoring cameras and deep learning algorithms can be used to identify the pest of olive trees' fruits, *Bactrocera oleae*, as well as more generic pests, such as ants and spiders . Mayo *et al*.,2006 in their experiment concluded that insects are collected using a McPhail-type trap or an adhesive-lined trap, and the results were presented. A microprocessor captures images, which are subsequently sent to a distant server for analysis by computer experts. A deep learning-based object detection algorithm is used in conjunction with a digital camera and microcontroller to count trapped people in real time.

In another study, Okuyama *et al*. (2011) proposed Automatic count system for fruit flies. It contained an infrared device to count the number of fruit flies entering the methyl eugenol trap. The device also recorded environment parameters and transmitted it to the server. Black pyramid trap which contains the aggregation pheromones along with optical sensor sense adult pests that enter the trap and count the number of pests as well. It also has the facility to measure the environmental parameters. This collected data are transmitted straight to the internet through General Public Radio Service (GPRS) (Potamitis *et al*. 2017).
The lid of the trap will contain five LED opposite to the receiving photodiodes. When insect fall in the trap it will interrupt the light thereby voltage variation may occur, and this is considered as insect count. This trap also has the provision to record the data regarding environmental conditions. Collected monitoring data are sent to the server for further processing (Potamitis *et al*. 2017).

This novel bimodal system includes an opto electrical sensor based on stereo recording device. When a fruit fly enters the trap, it records the wing beat frequency. This system can differentiate two fruit fly species *Ceratitis capitata* and *Bactrocera olae* with 98.99 per cent accuracy (Lima *et al*. 2021). Azfar *et al*., 2023 conducted a study based on an IoT System for Efficient Detection of Cotton Pest. This study proposes a Cotton Flying Moths (CFMs) detection mechanism using a custom-built IoT-based solution. The significant contribution of the proposed mechanism includes the low cost solution to detect moths damaging the cotton crops along with wireless sensor network (WSN) and IoT efficiency in the cotton pest detection field. The proposed framework would provide easy and real-time pest detection and monitoring with very effective, light communication and automatic spraying capabilities. Considering the importance of cotton products, timely identification of pests (flying moths—being a significant threat to cotton crops) helps to protect cotton crops and improve their production and quality. This study proposes real-time detection of Cotton Flying Moths (CFMs) with the assistance of an Internet of Things (IoT)-based system in the agricultural field.

The proposed pest detection algorithm detects the flying insects presence by monitoring variations in the reflected light. Based on this, it sends a detection alert to the gateway device. The gateway device sends detection coordinates to the drone/UAV to respond by spraying pesticide in the detection region. A real testbed and simulation scenarios were implemented to evaluate the effectiveness of the proposed detection system. The results of the testbed implementation suggest the effectiveness of the sensor design and CFM detection. Initial results from the simulation study indicate the suitability of the proposed prototype deployment in the agricultural field. The proposed prototype would not only help minimize the use of pesticides but also maintain the quality and quantity of cotton products.

Kawakati and Sato, 2023 conducted a study towards automatic monitoring of insect pests using IoT camera-equipped pheromone traps to efficiently monitor insect pests, we developed an electronic device that incorporates a pheromone trap and an Internet of things (IoT) camera (E-trap) that can semi automatically check the daily number of captured insects.

Advantages of IoT-based insect-pest management over the traditional system

Although the use of pheromone bait traps to monitor insect populations has been efficacious, manual inspecting of these traps takes time to monitor the number of insects in one and makes insect population monitoring also one of the most dreaded and neglected tasks in IPM. To solve these problems, many new technologies have been developed using inexpensive wireless sensor systems that can automatically count and record target insects caught in traps. It also provides unmatched real-time, high-resolution insect population information to growers, which could radically change the concept and the implementations of IPM. Compared to traditional technologies, the new IoT technology has other potential applications, such as early detection of different species of insects, mapping of insect population distribution, mapping of frequencies of resistant pesticides, and monitoring of predators.

Conclusion

In conclusion, innovations in IoT technology are crucial to precession and smart farming. Development in durable, miniature and energy efficient sensing technology is needed. Standardization in IoT based farm equipment must be done. To develop a IoT agricultural ecosystem, expertise across multiple domain such as engineering and technology, environmental sensing and monitoring, agronomy, soil fertility, entomology, machine learning and robotics involvement is required. Development is also needed to make sensing technology cost effective so it can be applied on a large scale. Development in cornerstone infrastructure is needed to make the system function. Availability of reliable internet connection in the rural/areas is needed.

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