Artificial Intelligence in Insect Pest Management

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OPEN ACCESS

Keywords

Artificial intelligence, CNN models, Economic Injury level

How to cite this article:

Tripathi, V., Maurya, A., Singh, E. and Shahi, S., 2024. Artificial Intelligence in Insect Pest Management. *Vigyan Varta* 5(11): 112-115.

ABSTRACT

Due to insect damage in their crops, farmers worldwide suffer huge output losses, ranging from 5 to 30 per cent, plus an additional 3 to 20 per cent in post-harvest losses. Various techniques, including biological, cultural, and physical approaches, are used to lessen these problems. But the advent of new technology, especially artificial intelligence (AI), has created fresh opportunities for efficient pest control. This article investigates the use of artificial intelligence (AI), specifically CNN models, to locate pests, track their numbers, and forecast possible pest outbreaks. Farmers can be proactive before they hit the Economic Injury Level (EIL) by implementing AI systems.

INTRODUCTION

The dynamic field of computer science known as artificial intelligence (AI) is devoted to developing intelligent systems that can mimic human intelligence. AI systems are capable of deciphering and comprehending complex facts, and they can respond and make judgements accordingly (Li *et al*., 2021). For robots to comprehend and react to visual and aural inputs, two essential components of artificial intelligence are voice recognition and visual perception. AI's foundations are machine learning and deep learning. Deep learning and machine learning are crucial parts of artificial intelligence (Bhoi *et al.*, 2021). Utilising past data, machines are trained through machine learning to forecast future output values. Machines can learn from their experiences and gradually get better at what they do thanks to this process. Neural networks are used in deep learning, a subset of machine learning, to analyse complex data. These neural networks are made up of several layers that process inputs and then go through several filtering processes to produce an output.

CNNs, or convolutional neural networks: An Essential Deep Learning Method.

An essential component of deep learning is convolutional neural networks or CNNs. CNNs are made to handle data with a topology resembling a grid, like photographs (Kariyanna and Sowjanya, 2024). They are made up of several layers, such as fully connected, pooling, and convolutional layers. Together, these layers enable feature extraction from inputs, object classification, and prediction. Tasks involving object detection, picture segmentation, and image recognition have all been transformed by CNNs.

Famous CNN Models

VGG-16 and AlexNet some well-known CNN models have made a substantial contribution to the development of AI. CNNs are promising for picture categorisation; in 2012, AlexNet, a deep neural network, won the ImageNet Large Scale Visual Recognition Challenge (ILSVRC). Another well-known model, VGG-16, has been applied widely to problems involving object detection and picture recognition. Numerous variations and computer vision applications have been influenced by these models.

AI-Based Insect Pest Management Techniques: There are several advantages of using AI-driven methods for managing insect pests. Among them are:

- **Accurate Pest Identification:** By using CNN VGG-16 models, pests may be precisely managed, even down to the genus and species levels of identification.
- **Automated Monitoring:** Artificial intelligence systems are capable of identifying pests in the field by analysing camera photos. The ability to distinguish between beneficial insects and pests is made possible by computer vision techniques, which improve pest population monitoring and prompt intervention.
- **Predicting Pest Outbreaks:** AI systems are able to forecast pest outbreaks by analysing environmental data, including temperature, humidity, and crop growth phases. Artificial intelligence (AI) produces precise projections about the date and location of possible pest occurrences by combining historical data, meteorological forecasts, and pest behaviour models.

AI Intervention in Insect Physiology

By mapping intricate neuronal networks in insects using deep learning, AI helps to comprehend their behaviours and physiological functions. AI systems for behavioural analysis make it possible to follow an insect's motions as it reacts to different stimuli.

Neural Mapping and Behavioural Analysis

The complex brain networks that control the behaviours and physiological functions of insects. An aspect of artificial intelligence called deep learning has made it easier to map and understand these intricate brain networks in insects. Artificial intelligence algorithms can detect neural patterns and distinguish particular neurones associated with different behaviours by evaluating brain activity data (Kasinathan *et al.*, 2021). Furthermore, AI-powered behavioural analysis monitors and classifies insect motions brought on by environmental cues like temperature, light, or chemical signals called pheromones. This sheds light on mating habits, foraging strategies, and reactions to environmental cues. One such instance is the categorisation of pesticide pollution in bees. When combined with multivariate behavioural data, AI algorithms show a high degree of accuracy in identifying the distinct effects of agrochemicals such as imidacloprid and glyphosate on the midgut physiology of *M. quadrifasciata*.

Internet of Things (IoT) Technology for Managing Insects: IoT technology has many uses in insect management, including population reduction, control, and monitoring:

- **Daucus Image Recognition Toolkit (DIRT):** DIRT uses fixed cameras to monitor *Bactrocera oleae* using McPhail traps. Once trained, it can track fruit fly activity around the trap to estimate the number of individuals in a given area.
- **Stored-Grain Pitfall Trap:** These cone-shaped traps are inserted into bulk grain and are used to monitor stored-grain insects. They let insects in but keep them out, allowing for efficient monitoring in silos, warehouses, and processing facilities.
- **Biological Specimen Discovery Using Vision-Enabled Robotics, or BIODISCOVER:** This gadget is unique and makes it easier to sort, identify, and evaluate the biomass of insects. By using photos to separate insects according to their mass, shape, and size, BIODISCOVER offers insightful information.
- **Sensors:** Spectrophotometers, soil-moisture sensors, temperature sensors, humidity sensors, and leaf-wetness sensors were used in the monitoring of whiteflies. These sensors take pictures and record environmental data for accurate tracking.
- **The PICSAN Trap:** Designed to combat the damaging red palm weevil, this trap combines optical sensors and aggregation pheromones. By using GPRS communication, these sensors identify adult pests that are dropping and send count information and environmental conditions.
- **Funnel Trap Prototype:** To attract male moths, the ZARL VARL probe uses pheromones for automated moth detection. The sensor on the trap uses remote sensing to identify moths and sends information to a web interface. To remove insects that are not intended for use, Artificial Neural Networks (ANN) are utilised (Preti et al., 2021).
- **The Lindgren Trap**: This funnel trap uses pheromones to catch and track pest populations. It is used to draw in the pine beetle, *Dendroctonus ponderosae*.
- **Drones:** Outfitted with high-definition cameras, these aerial vehicles scan the foliage in order to obtain pictures of locusts. Drones can be remotely signalled to apply targeted pesticides after they recognise images of swarms.

CONCLUSION:

Artificial Intelligence (AI) has the potential to revolutionise the agricultural sector in India. India is a resource-rich country, but it is not as good at using AI to advance agriculture as it could be. Across the world, nations are utilising AI's potential to increase agriculture yields, decrease waste, and advance sustainable farming methods. India needs to jump on this and take advantage of AI-driven developments. AI-powered pest control is an important application with lots of advantages. Artificial intelligence (AI) systems use sensor data, satellite imagery, and machine learning algorithms to identify insect outbreaks early on and alert farmers so they may take preventative action. As a result, less pesticides are used, production costs are decreased, and human error is reduced. Additionally, farmers may improve accuracy, maximise resource allocation, and make well-informed decisions with the help of AI-powered decision support systems. India can take advantage of AI's disruptive potential and secure a better future for its farmers, economy, and environment by investing in and developing the technology further.

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