

Use of Artificial Intelligence (AI) in Agricultural Entomology

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Introduction

Artificial Intelligence (AI) is a branch of computer science that enables machines to perform tasks that normally require human intelligence, such as learning, problem-solving, decision-making, and pattern recognition. In agriculture, AI is revolutionizing pest management by improving the detection, identification, monitoring, and control of insect pests. Traditional pest monitoring methods are often labor-intensive, time-consuming, and depend on expert knowledge. AI overcomes these limitations by analyzing large amounts of data quickly and accurately.

AI technologies such as Machine Learning (ML), Deep Learning (DL), Computer Vision, Robotics, the Internet of Things (IoT), and Remote Sensing are increasingly being used in agricultural entomology. These technologies analyze images, weather data, crop conditions, and pest populations to provide real-time recommendations for farmers. AI supports Integrated Pest Management (IPM) by enabling early pest detection, reducing unnecessary pesticide use, improving crop productivity, and promoting environmentally sustainable agriculture.

Applications of AI in Agricultural Entomology

1. Insect Pest Identification

Correct identification of insect pests is the first step in effective pest management. AI-based image recognition systems use machine learning and deep learning algorithms to identify insect species from photographs captured using smartphones, drones, or digital cameras. Computer vision compares captured insect images with thousands of stored images in databases and identifies the species within seconds. This technology helps farmers and extension workers identify pests accurately without requiring specialized taxonomic expertise.

Benefits

- Rapid and accurate pest identification.
- Reduces dependence on taxonomic experts.
- Enables early detection and timely pest management.
- Minimizes misidentification of pests.

2. Pest Monitoring and Surveillance

AI-powered monitoring systems continuously observe insect populations using smart traps equipped with cameras and sensors. These traps automatically detect, count, and classify insects based on their shape, size, and movement

patterns. The collected information is transmitted to cloud-based platforms where AI analyzes pest abundance and population trends.

Benefits

- Continuous real-time monitoring.
- Accurate estimation of pest populations.
- Reduces manual field scouting.
- Provides timely alerts to farmers.

3. Pest Outbreak Prediction

AI models predict pest outbreaks by analyzing weather conditions, crop growth stages, historical pest records, and environmental factors. Machine learning algorithms identify patterns associated with pest population increases and provide early warning systems before severe infestations occur.

Data Used

- Temperature
- Relative humidity
- Rainfall
- Wind speed
- Soil moisture
- Crop phenology
- Historical pest incidence

Benefits

- Early warning of pest outbreaks.
- Better planning of pest management strategies.
- Reduction in crop losses.
- More efficient use of pesticides.

4. Precision Pest Management

AI enables precision agriculture by identifying pest-infested areas and recommending site-specific pesticide application instead of spraying the entire field. Using GPS, drones, satellite imagery, and field sensors, AI determines the exact location and severity of infestations.

Benefits

- Reduced pesticide consumption.
- Lower production costs.
- Protection of beneficial insects.
- Reduced environmental pollution.
- Improved pesticide efficiency.

5. Automated Pest Detection Using Drones

Drones equipped with high-resolution cameras and AI software rapidly inspect large agricultural fields. The captured images are analyzed to detect insect damage, pest populations, and affected crop areas. Drones can monitor crops that are difficult to inspect manually and generate infestation maps for precision management.

Applications

- Detection of insect infestations.
- Monitoring crop damage.
- Mapping pest distribution.
- Assessing crop health.

Benefits

- Rapid field inspection.
- Covers large areas in a short time.
- Reduces labor requirements.
- Provides accurate pest distribution maps.

6. Smart Pest Traps

Smart pest traps integrate cameras, sensors, wireless communication, and AI algorithms to automatically monitor insect populations. These traps can recognize specific insect species and send pest data directly to farmers through mobile applications or cloud platforms.

Benefits

- Continuous pest monitoring.
- Automatic insect counting.
- Remote data access.
- Reduced field visits.

7. Decision Support Systems (DSS)

AI-based Decision Support Systems integrate weather forecasts, pest populations, crop growth stages, and economic thresholds to recommend suitable pest management strategies. The system provides scientifically based recommendations for farmers. Recommendations include

- Best time for pesticide application.
- Selection of appropriate pesticides.
- Biological control options.
- Economic Threshold Level (ETL).
- Integrated Pest Management (IPM) strategies.

Benefits

- Improves decision-making.
- Reduces unnecessary pesticide use.
- Increases management efficiency.

8. Biological Control: AI supports biological control by identifying suitable predators, parasitoids, and pathogens for

specific insect pests. AI models can predict the most effective time for releasing biological control agents.

Benefits

- Reduces chemical pesticide use.
- Protects biodiversity.
- Promotes sustainable pest management.

9. Insect Behavior Analysis

Computer vision and AI algorithms analyze insect movement, feeding behavior, mating activity, migration, and dispersal patterns. Understanding insect behavior helps researchers develop better pest forecasting models and management strategies.

Applications

- Studying pest ecology.
- Understanding life cycles.
- Monitoring migration.
- Improving forecasting models.

10. Research and Data Analysis

Agricultural entomology generates large amounts of data from field experiments, remote sensing, molecular biology, and insect surveys. AI can process these datasets rapidly and identify complex relationships that are difficult to detect manually.

Benefits

- Faster research.
- Improved data accuracy.
- Better understanding of insect ecology.
- Supports development of predictive models.

Advantages of AI in Agricultural Entomology

- Provides rapid and accurate insect pest identification.
- Detects pest infestations at an early stage.
- Enables real-time pest monitoring.
- Reduces unnecessary pesticide application.
- Lowers labor and operational costs.
- Improves crop productivity and quality.
- Supports Integrated Pest Management (IPM).
- Environmentally friendly and sustainable.
- Provides accurate, data-driven decision making.
- Enhances precision agriculture and resource-use efficiency.

Limitations of AI in Agricultural Entomology

- High initial investment for AI equipment and software.
- Requires reliable internet connectivity and digital infrastructure.

• Depends on large, high-quality datasets for model training. • Accuracy may decrease under poor lighting or unfavorable environmental conditions. • Limited adoption among small and marginal farmers due to high costs. • Requires technical knowledge for operation and maintenance. • Regular software updates and calibration are necessary. • Data privacy and cybersecurity concerns may arise in cloud-based systems. Future Prospects The future of AI in agricultural entomology is highly promising. Advances in artificial intelligence, robotics, and sensor technologies are expected to transform pest management practices. Future developments include: • AI-powered agricultural robots for automatic pest detection and removal. • Autonomous drones capable of identifying pests and applying pesticides precisely. • IoT-enabled smart insect monitoring networks for real-time surveillance. • Smartphone applications for instant pest diagnosis using image recognition.	• Integration of AI with satellite remote sensing for regional pest forecasting. • Climate-based predictive models to forecast future pest outbreaks. • AI-assisted biological control programs using natural enemies. • Development of fully automated precision pest management systems. These innovations will help increase crop productivity, reduce environmental pollution, and promote sustainable agriculture. Conclusion Artificial Intelligence has become a powerful tool in modern agricultural entomology by improving the identification, monitoring, prediction, and management of insect pests. AI technologies such as machine learning, computer vision, drones, smart sensors, and IoT enable farmers to make timely and informed decisions while reducing pesticide use and production costs. By supporting Integrated Pest Management (IPM), AI contributes to sustainable crop protection and environmental conservation. As technology continues to advance, AI is expected to play a central role in developing intelligent, automated, and climate-resilient agricultural systems capable of ensuring future food security.
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