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AI in Entomology

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For a layman, artificial intelligence (AI) is the ability of a machine or a computer program to think and learn. AI is a simulation of human intelligence in machines which are programmed to think and mimic human actions. Every core subject is invaded and complimented by AI. In entomology, AI in recent times is rampantly increasing to study insects more efficiently and gain new insights into their biology and ecology. Our article aims to highlight the potential of AI for advancing our understanding of insects and their roles in our ecosystems. Here are some ways AI is used in this field:

Species Identification: AI algorithms can identify insect species from images or sounds at faster rates which is useful for monitoring biodiversity and studying insect populations in various habitats. It classifies insects with precision, saving time and effort compared to manual identification. Studying insect population dynamics is made much easier with AI.

Kasinathan *et al.* (2021) conducted research on artificial neural networks (ANNs), support vector machines (SVM), k-nearest neighbours (KNN), naive Bayes (NB), and a CNN model. Their investigation revealed that an improved CNN model outperformed the other techniques, achieving a top classification accuracy of 91.5% for nine-class insects and 90% for 24-class insects. Johari *et al.* (2023) evaluated five distinct CNN architectures for detecting various insect pests infesting cotton plants. The system achieved an accuracy of over 95% in pest identification, exceeding the performance of traditional manual approaches. Once an AI system is trained to recognize insect pests, leveraging transfer learning can further augment its capability to identify diverse pest species with harmful potential (Johari *et al.*, 2023; Xing & Lee, 2022).

Pest Management: AI is utilized for monitoring and forecasting pest populations. It can analyze environmental data to predict pest outbreaks and recommend effective control strategies timely. It is employed in applied research to monitor and control pest species, crucial for anticipating locust swarms and insect-transmitted diseases. Furthermore, AI tools help study the intricate ecological relationships between insects and their environment.

Behavioral Studies: AI can analyze insect behavior based on video recordings to sunderstand mating habits, foraging patterns. By modeling insect behavior and interactions, AI can predict how environmental factors impact insect populations, enabling the development of effective insect management and ecosystem conservation techniques, crucial in the face of global change.

Genomic Analysis: AI analyzes large genomic datasets from insect studies for genetics and evolution experiments by identifying genetic markers linked to traits, offering new avenues for insect conservation and pest control. High-throughput DNA sequencing enables the generation of extensive genomic data from insects, which AI algorithms analyze to identify genetic patterns and infer evolutionary relationships. These methods are used to study phylogenetic relationships among insect species. (Hartbauer, 2024)

To quantify phenotypic distances between *Heliconius* butterflies, a deep CNN was trained by Hoyal *et al*., 2019 to classify museum photographs of *Heliconius* butterflies by subspecies, with 1500 of the 2468 total images used for CNN network training and the remainder for testing. Image classification was performed using a 15-layer deep learning network called ButterflyNet which decoded *Heliconius* evolution and providing a roadmap for future research.

Species conservation: AI also analyses data from remote sensing platforms, such as satellites and drones (Jung *et al*., 2021). Thus, accurate predictions of future species distributions are generated by machine learning algorithms based on climate projections. Moreover, AI can help researchers prioritize species specific conservation efforts and management. For example, eButterfly helps better understand the biological patterns of butterfly species diversity and how environmental conditions shape these patterns in space and time (Prudic *et al*., 2017).

Ecological Modeling: This machine learning method has been used to estimate honeybee posture, distinguish between pollen-bearing and non-bearing honeybees (Sledevic, 2018), monitor interactions of honeybees in a hive (Boenisch *et al*., 2018), and AI-enabled video tracking was also used to study the gait dynamics of the fruit fly Drosophila melanogaster in a laboratory setting (Pereira *et al*., 2019).

Although the proponents of the use of AI in entomology currently display remarkable techno-optimism and do not mention ethical concerns, AI does have the potential to be usefully combined with nonlethal methods. An optical sensor connected to an AI-based recognition system for monitoring soil-living arthropods (Daouti *et al.*, 2022), collects soil-active arthropods into alcohol-filled containers. The same device, once properly calibrated, can possibly be combined with live traps from which arthropods can be released. Video equipment can be combined with AI that can help identify the arthropods recorded. Such video surveillance can be set up at flowering plants to record flower-visiting arthropods (Coetzer *et al.,* 2016) or at prey decoys to identify the most active predators (Zou *et al.*, 2017).

By making use of the power of AI, we can make significant progress in addressing the challenges in facing insect populations and developing effective strategies for their conservation and management. The aim of this article is to provide an idea bout AI prevalence. This can be taken as inspiration to look for targeted ai softwares and applications required for one’s research.

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