Editorial

Overview of Artificial Intelligence in Medical Entomology and Its Research

Introduction

Medical Entomology (ME) is the details of insects, arthropods, mosquito vectors, mites, and ticks' behaviours and its effects in the ecosystems. [1] ME plays a important role in the study of biodiversity, and the insects and ecologically important sector among various types of animals. In this article, I have to discuss about the traditional methods in ME research, its limitations and challenges, disease vector analysis, AI in data collection, and future directions and needs of AI in ME.

Old/Traditional Methods in Medical Entomology Research [2]

In the ancient years, entomological research has long been the foundation of the field, providing valuable insights into insect biology, behaviours, and ecology. These methods primarily include specimen collection and observation. Researchers have relied on field sampling, manual identification, and morphological analysis to study insect species and their distributions. However, it is interesting to note that while these traditional approaches remain important, they are increasingly being complemented by advanced technologies. For instance, environmental DNA analysis offers a non-invasive alternative to traditional specimen collection, allowing researchers to monitor elusive or endangered insect species. Similarly, artificial intelligence and machine learning are now being employed for automated species identification, potentially surpassing traditional morphological identification methods in terms of accuracy and speed. While traditional entomological methods continue to play a crucial role, the field is rapidly evolving.

The integration of new technologies and approaches, such as NGS-based methods, citizen science initiatives, and molecular techniques, is transforming entomological research. This evolution is enabling researchers to address more complex ecological questions and tackle grand challenges facing entomology in the 21st century, including the need for global-scale data synthesis and rapid sharing of research results.

Species identifications of insects using AI

Species identification of insects has become increasingly important in various fields, including agriculture, environmental monitoring, and entomology. Computer vision and machine learning techniques have shown promising results in accurately classifying large numbers of closely related insect species. These methods can handle complex tasks such as identifying fruit flies (Diptera: Tephritidae) and mosquitoes (Diptera: Culicidae) with high accuracy.

In another way, a CNN-based approach for identifying plant bug species demonstrated expert-level accuracy, even for taxonomically challenging groups. Automated insect species identification has made significant progress, with various methods showing high classification rates. These systems offer potential solutions for non-destructive, real-time monitoring of insects and can provide valuable insights into insect behaviour and ecology. However, challenges remain, such as handling class imbalance and improving performance on diverse datasets. As these technologies continue to evolve, they are likely to revolutionize insect systematics and contribute to more efficient pest management and biodiversity monitoring. [3]

Analysis of Disease Vector

In this analysis, Deep learning and artificial intelligence techniques are increasingly being applied to analyze and predict vector- borne disease outbreaks caused by insects and other arthropods. Convolutional neural networks and artificial neural networks

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have shown promising results in classifying and predicting outbreaks of diseases like chikungunya, malaria, and dengue across the Indian subcontinent, with prediction accuracies of 88% and 86% respectively. Conventional strategies for managing vector-borne pathogens focus on keeping vector populations below a threshold based on the basic reproductive ratio (R0), bio-economic approaches that balance ecological and economic trade-offs may be more cost-effective. [4]

Enumeration of Data and Processing with AI

Artificial intelligence has revolutionized data collection and processing related to insects, offering innovative solutions for species identification, pest management, and ecological research. AI-powered tools like AInsectID Ver.1.1 have demonstrated remarkable accuracy in insect species identification, achieving a validation accuracy of 99.65% using the ResNet 101 convolutional neural network model. This software integrates transfer learning and hyper-parameter optimization to improve prediction performance, particularly addressing challenges posed by insect mimics. In agricultural settings, AI and IoT techniques have shown promising results in detecting, classifying, and counting cotton insect pests and beneficial insects, with accuracy rates ranging from 70% to 98%. AI has shown great potential in insect-related applications, there are still limitations to overcome. For instance, the detection and characterization of immature and predatory insects remain challenging, and only a few species have been targeted for detection and classification by AI and IoT systems. Additionally, factors such as insect location, data size, concentrated insects on images, and similarity in species appearance pose obstacles to AI implementation. [5]

Expected Challenges and Limitations of AI in Medical Entomology

Applications of AI in ME face several challenges and limitations, despite their potential to revolutionize the field. The primary challenge is the scarcity and quality of data available for training AI models in ME. Unlike other fields with abundant data, entomology often deals with rare species or limited sample sizes, making it difficult to develop robust AI systems. This data limitation can lead to biases and inaccuracies in AI-driven insect identification and classification. Additionally, the vast diversity of insect species and their morphological variations pose significant challenges for AI algorithms to accurately distinguish between closely related species. While AI shows promise in detecting plant diseases, which could indirectly benefit entomology by identifying insect-borne plant pathogens, there are still obstacles in implementing these technologies in resource-constrained environments. This limitation could hinder the adoption of AI tools in field ME, particularly in remote or underdeveloped areas where insect- related research is often conducted. [6]

Expectations and Future Directions of AI in Medical Entomology in Future Years

AI methods have shown significant potential in revolutionizing various aspects of entomological research, offering improved accuracy, speed, and efficiency across multiple subfields. In behavioural biology, AI-based tracking systems have enhanced the classification of insect behaviors and movement patterns. For species identification, deep learning neural network models have demonstrated superior performance compared to traditional morphological methods.

The application of AI in ME has extended to critical areas such as climate change research, pest management, and disease vector control. AI-driven tools have improved habitat modelling, allowing for more accurate predictions of insect distribution and abundance in response to environmental changes. In agriculture, smart traps and monitoring systems powered by AI can detect and identify pest species in real-time, enabling targeted control measures. Similarly, AI-based predictive models have enhanced disease vector control by identifying areas at risk of disease transmission. Despite these advancements, future research in AI for medical entomology should focus on developing more sophisticated tools to address complex ecological questions. [4 – 5]

Conclusion

From this, I concluded that AI application is very much useful in medical entomology researches. AI application is very much useful in ME and give accuracy in the enumeration of data and processing for the researchers/entomologist/scientists. Some challenges and limitations are also there when using AI tools. Need of AI in the research of entomology (in the real data scenario) enormous in future.

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