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CRACKING THE CODE OF INSECT COMMUNICATION: A MACHINE LEARNING APPROACH IN ACOUSTIC ENTOMOLOGY

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Introduction

Insects are fascinating creatures that vastly outnumber humans on Earth, with over 1.4 billion insects for each human (Worrall, 2017). We are all familiar with the sounds that insects make, such as the chirping of crickets at night. However, these sounds are not for our annoyance, but have important functions such as communication, mate selection, defence, and warning predators. Acoustic entomology is a field that uses sound to study insects and gain insights into their behaviour, and when combined with machine learning, it can be even more powerful. By leveraging machine learning algorithms, researchers can analyse vast amounts of acoustic data to better understand insect behaviour and ecology.

Machine Learning for Insect Sound Analysis

Specialized equipment's like acoustic sensors, microphones, piezoelectric sensors, and accelerometers can be used to record the sounds and vibrations of insects (Mankin and Hagstrum, 2012). However, analysing these recordings manually can be time-consuming and challenging. Machine learning techniques offer a promising solution to this problem by enabling automated analysis of insect sounds and vibrations. Machine learning algorithms can be trained to automatically classify insect sounds based on their acoustic signatures, allowing researchers to identify different species of insects and track changes in their populations over time. In agricultural fields, machine learning can be used to predict the presence or absence of pest insects based on their acoustic signals, which can help farmers make more informed decisions about when and where to apply pesticides or other control measures.

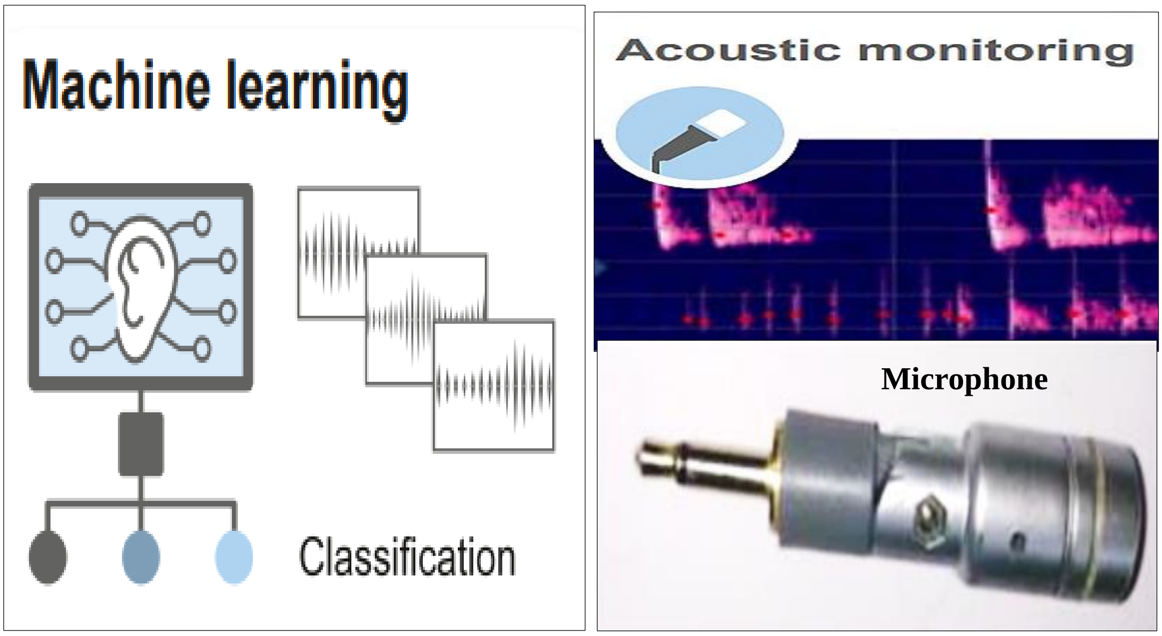

Fig 1: Machine Learning methodology

Applications

Machine learning is commonly used to identify insect species based on their distinct sounds and vibrations. Every insect species has unique sound and vibration patterns that distinguish them. For instance cicada species, *Cicadatra cataphractica* produces sounds at a dominant frequency of 9.6 KHz, while *Cicadatra querula* produces at 8 KHz (Popov, 1989). Researchers can train machine learning algorithms to recognize these distinguishing characteristics, allowing them to identify different insect species quickly and accurately.

Machine learning has found another useful application in detecting insect pests by analysing their sounds and vibrations. Certain insects, including the red palm weevil, *Rhynchophorus ferrugineus* and cashew stem and root borer, *Neoplocaederus ferrugineus* can cause extensive damage to trees in plantations. By using machine learning algorithms, the presence of red palm weevils can be identified by their distinct behaviours, such as biting, eating, and moving. In the case of cashew stem and root borer, it is difficult to detect the larvae in the early stages, and checking every tree manually is not practical. Additionally, adult attractants have not yet been identified for trapping and monitoring. To overcome these challenges, the number of burst counts and impulses produced by the pests are analysed to predict the possibility of infestation. By detecting the specific sounds and vibrations produced by these pests, machine learning algorithms enable early detection and intervention.

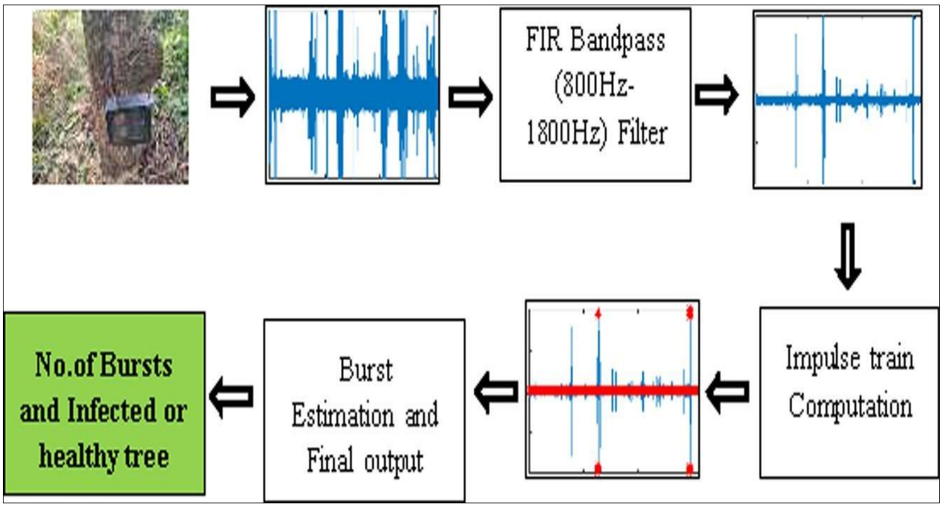

Fig. 2: Burst analysis for cashew stem and root borer

Researchers can use machine learning techniques to investigate the behaviour of insects, such as studying the sounds produced by bees in their hives. By analysing these sounds, insights into various aspects of bee behaviour can be gained, including the timing and frequency of foraging trips, colony activity levels, and indications of disease or stress. Traditional inspection methods, such as checking the queen bee, can disturb the colony, so non-invasive methods like acoustic detection can be used to confirm the presence of a healthy queen.

Fig 3: Beehive with microphone installed

Researchers are utilizing machine learning to study insect sounds and vibrations, particularly in the field of biodiversity monitoring. Insects play a crucial role in the ecosystem, but their survival is threatened by habitat destruction, climate change, and other factors. Acoustic sampling is an effective and non-destructive way of detecting insects even from long distances, and machine learning can automate the process. However, species identification based on their sounds is still limited by the size of reference libraries, which are less developed for insects compared to those for vertebrates (Van *et. al.*, 2022). By applying machine learning to analyse insect sounds and vibrations, researchers can quickly and accurately track changes in insect populations, which can be useful for conservation efforts.

Advantages

- Non-invasive examination and diagnosis of insect pest
- More effective pest control at early stages
- Non-destructive and inexpensive sampling for ecological studies
- Increased accuracy in species identification and automated analysis
- Improved understanding of insect communication

Challenges

Despite the exciting potential of machine learning approaches in the study of insect noises and vibrations, various hurdles must be overcome such as;

- Complex and diverse insect communication signals
- Limited availability of insect communication data
- Background noise and interference
- Limited computational resources
- Difficulty in interpreting the results

Scope/future prospects

1. Raising awareness: Machine learning algorithms can be utilized to develop user-friendly tools, such as mobile apps, that can identify different insect sounds in the environment. This can enable ordinary citizens to become more aware of the insect species around them and their behaviours.
2. Early detection: By installing sound detectors in their fields, farmers can detect insect infestations at an early stage. This can enable farmers to take preventive measures and reduce pesticide usage by incorporating it into their Integrated Pest Management (IPM) strategy.
3. Pest management: Machine learning algorithms can analyse recorded sounds of insect mating, aggregation, or food calls, and re-emit them coupled with traps to manage insect populations. This can be an effective IPM strategy to manage insects in an environmentally friendly way.

4. Hidden pest detection: Machine learning can also help in identifying and confirming the hidden presence of insect pests in stored food products. This can aid in preventing food contamination and reducing food waste.
5. Environmental insights: Decoding insect communication through machine learning can provide valuable insights into the environmental health and the impact of environmental changes on insect populations. This can be useful information for ecologists and conservationists to better understand the effects of human activities on the insect world.

Conclusion

To summarize, the use of machine learning techniques is proving highly effective in the study of insect noise and vibration, offering valuable insights into insect behaviour, pest control, and biodiversity monitoring. Employing machine learning algorithms to automatically analyse insect sound recordings holds promise as a solution to the challenges posed by manual analysis, which can be time-consuming and tedious. However, there are still obstacles to overcome, such as developing accurate and dependable algorithms, expanding reference libraries, and gathering ample amounts of data. By utilizing machine learning, scientists can gain a better understanding of insect behaviour and take measures to safeguard them against threats like climate change and habitat destruction. In the future, regular individuals could use straightforward tools and mobile apps to become more aware of the insects in their surroundings, while farmers could use sound detectors and traps as a new element in integrated pest management.

References

Mankin R and Hagstrum DW. (2012). 22 Acoustic Monitoring of Insects. *Stored Product Protection* **52**: 263-270.

Popov AV. (1989). Species of singing cicadas revealed on the basis of peculiarities of acoustic behavior. 1. Cicadatra cataphractica popov of acoustic behavior 1. (EX GR. Querula)(Homoptera, Cicadidae). *Entomological review (USA)*.

Van Klink R, August T, Bas Y, Bodesheim P, Bonn A, Fossoy F, and Bowler DE (2022). Emerging technologies revolutionise insect ecology and monitoring. *Trends in ecology & evolution* **37**: 872-885.

Worrall S. (2017). Without bugs, we might all be dead. *National Geographic.* *https://www.nationalgeographic.com/animals/article/insect-bug-medicine-food-macneal*