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Statistical Analysis of MM-Wave Signals for Enhanced Biodiversity Monitoring

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Extended Abstract

Monitoring biodiversity is crucial as it serves as a key indicator of ecosystem stability. Tracking temporal variations in biodiversity allows the identification of species at risk, enabling timely conservation interventions to protect vulnerable populations and maintain ecological balance [1, 2]. Pollinating insects are essential for sustainable functioning and integrity of terrestrial ecosystems. Nevertheless, the recent decline in pollinator populations has prompted significant concern among scientists and policymakers due to its potential impacts on biodiversity and ecosystem stability [3].

Traditional insect monitoring techniques, such as visual surveys and trapping, yield valuable information. However, these approaches are typically time-consuming, labor-intensive, and costly [4]. Recent advancements in statistical and computational methods – especially the advent of machine learning techniques - offer promising opportunities to accelerate routine insect classification tasks. Currently, most research efforts focus on insect classification using these techniques, primarily through visual image processing [5, 6]. While digitization of insect biodiversity has been has been explored in image-based systems.

Contrary to those works, we propose the use of machine learning techniques with millimeter-wave (mm-Wave) signal analysis for digitization of insect biodiversity. This new approach offers a new dimension of information and analysis, enabling continuous monitoring both day and night, regardless of weather conditions, remote analysis as well as operation over obstacles, e.g. inside hives, trees or other predominantly dielectric objects. By recording and analyzing back-reflected mm-Wave signatures from individual insects, this work explores the time-frequency representation of wingbeat dynamics of insects, allowing for detailed analysis of insect behavior, and species differentiation patterns. Our approach demonstrates high accuracy and offers a scalable, cost-effective solution for real-time, high-resolution insect biodiversity monitoring, paving the way for more sustainable and responsive ecosystem management.

References

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