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Near-infrared Optical Sensors to Monitor Flying Insects[1]

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Insects, through their large diversity, numbers, and biomass, play a crucial role in a variety of processes. Whether it is to study beneficial species, such as pollinators, or to implement mitigation methods for detrimental species, such as mosquitoes, fine scale measurements of insect behavior is critical. However, monitoring change in insect distribution, diversity, and abundance poses a significant challenge to entomologists. Most studies rely on physical traps using light, pheromones, food, or CO_2 as bait. While traps provide a high accuracy for the identification of the captured insects, they have strong limitations. Notably, they require long and expensive laboratory analysis, making data on insect population dynamics scarce and often geographically or temporally limited. Photonics surveillance of the insect fauna and entomological lidars offer a potential solution and have shown promising development over the last decade. The methodology generally relies on identifying and counting insects flying through a near-infrared laser beam, by retrieving their optical properties from either backscattered or transmitted optical signals. In this contribution, we present results from both laboratory and field experiments, showing that the family, species, sex group, and even gravidity of insects can be retrieved from spectral and polarimetric backscattered measurements. Fluctuations of the optical cross-section caused by the rapid movement of the wings allow for the retrieval of the wing beat frequency and associated Mel-frequency cepstral coefficients. These constitute a series of predictor variables used in a supervised machine learning classifier to identify each insect transiting through the laser beam. Finally, results obtained from season-long field campaigns in New Jersey are presented, where multiple infrared sensors have been deployed to continuously monitor insect activities as well as aerial density and circadian rhythm.

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