Identification of Bioaerosols Heading Direction Using a Quadrant Photo Detector

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Insects are so important to the natural eco system as well as to humans that they are involved in pollination, nutrient cycling, disease spreading, medicine, aesthetics, and biological control. Besides, monitoring insects' activities is a crucial part of understanding their behaviour though most of the insect monitoring techniques have their own limitations. For instance, passive LIDAR is one of the emerging techniques that is capable of in situ monitoring of insects. However, the detection of insect heading direction is very challenging with passive LIDAR. A novel methodology in detecting insect flight direction for a passive LIDAR system was developed with the use of a quadrant photodetector (Hamamatsu S4349).

A control experiment was conducted by sending beads in selected directions of the field of view of the LIDAR system where the quadrant detector is at the focus of the telescope. The data is sampled at a 10 kHz rate for all four channels of the quadrant detector and analysis was done in iterations. The flight direction can easily be determined by analyzing the time domain signal through understanding the orientation of the quadrant detector. However, this method did not reveal whether the insects flew in transverse or longitudinal direction. In the first iteration, insect detection was determined by considering all four channels. The next step was selecting the data set of full width at 10% of the peak signal of the event for each channel. The dataset was transferred into the frequency domain and then compressed with the Singular Value Decomposition (SVD). By selecting the most dominant components after data compression, the feature set was classified using Hierarchical Cluster Analysis (HCA). Upon investigation of individual clusters with the use of an expert dataset, it was found that the heading direction can be identified in both longitudinal and transverse components with the sensitivity of 96%, specificity of 95 % and accuracy of 96 %.

Keywords: Insect monitoring, Heading direction, Entomological Lidar.