Abstract No: PS-30

Calibration of the rolling angle of a Quadrant Photo Detector mounted in the image plane of a dark-field passive LIDAR system

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Passive Light Detection and Ranging (LIDAR) has successfully been used for observing insects and their activities. It was reported that such techniques are more efficient compared to traditional approaches. Quadrant Photo Detectors (QPDs) are widely used at the image plane with the use of a modified eye-piece to detect both wing-beats and heading angles of insects. In these systems, knowing the exact orientation of the QPD in the image plane is an imperative task. This study was carried out to propose a method to calibrate the rolling angle of a QPD mounted in the image plane of a Newtonian telescope in a dark-field passive LIDAR system using a Hamamatsu S4349 Silicon QPD. Each segment of the QPD was connected to a data acquisition card through four Trans-impedance amplifiers and programmable gain amplifiers. A white coloured inverted pendulum oscillated across the Field of View (FOV) of the QPD at a known distance was used for calibration. Intensities registered at the individual segments of the QPD were recorded at a rate of 10 kHz while the pendulum swept the FOV. Thirty-six of such measurements were obtained by changing the rolling angles by 10-degree at a time. The four filtered and normalized signals were used to calculate the activation times (full width at 10%) and four unique sinusoidal functions were fitted to the whole range of angles. These coefficients can be used to estimate the rolling angle of the QPD using a test oscillation. It was found that the accuracy of the estimate was ± 6.04 degrees. A ray tracing-based simulation was conducted to simulate this activity and findings from the activity agrees with the theoretical simulation results. It was noted that the highest performance can be obtained when the pendulum oscillates in a plane normal to the optical axis.

Keywords: LIDAR, QPD, Rolling angle calibration, Heading angle, Entomological LIDAR.