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PERFORMANCE COMPARISON OF ACQUISITION SCAN PATTERNS FOR OPTICAL COMMUNICATIONS IN LEO SATELLITES

Abstract

Free-Space Optical Communications (FSOC) represent an expanding field within satellite communication systems, with active development observed in this area. The advancement of this technology has facilitated its integration even into small spacecraft, such as CubeSats. An integral part of this technology is the Pointing, Acquisition, and Tracking (PAT) subsystem, as pointing accuracy in the range of tens of microradians is required for successful links. Typical FSOC architectures rely on a laser beacon emitted from the receiver, enabling the transmitter to finely determine the receiver's position and point in the required direction. Acquiring this beacon is a key task of the PAT subsystem, to accurately track it.

This contribution presents a laboratory comparison, using hardware-in-the-loop, of different search patterns commonly utilised in the Acquisition stage. The primary objective is to analyse various communication scenarios, identifying the most efficient pattern in terms of acquisition time, whilst considering platform jitter and atmospheric effects on the beacon itself (e.g., beam wander, scintillation, etc.).

To conduct this study, a hardware disturbance simulator capable of emulating these types of atmospheric disturbances has been developed to observe the search pattern behaviour and refine the system's pointing algorithm. This simulator allows for the accurate recreation of adverse conditions that could affect the beacon signal, such as atmospheric fluctuations or pointing issues, providing a valuable tool for evaluating the robustness of search patterns under realistic operating conditions.

By evaluating these search patterns in controlled laboratory settings, researchers aspire to provide valuable insights for optimising FSOC PAT subsystems for real-world applications in small satellites. The findings can significantly contribute to improving the reliability and efficiency of FSOC links, especially in the context of CubeSat missions and small satellites where space and resources are limited. This systematic approach to the analysis and optimisation of the PAT subsystem not only enhances the performance of FSOC communications but also opens new possibilities for the design of future satellite missions reliant on this emerging technology.