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AUTONOMOUS ARTIFICIAL INTELLIGENCE-AIDED GROUND POINTING SYSTEM FOR OPTICAL COMMUNICATION IN LOW EARTH ORBIT NANO-SATELLITES

Abstract

The volume of data coming from space has been witnessing a significant increase over the past few years. This, in turn, has required the need for faster and more efficient ways to download the information from space to ground, which translates in the need for higher data rate transfer. One solution to the problem is using optical communication transceivers, which have data rates in the order of Gbit/s, contrary to the Mbit/s order of magnitude guaranteed by the widely used radio frequency communication devices. However, the optical communication has one unsolved problem: since its laser beam is tight, it demands a very high pointing accuracy at a reasonable transceiver's power consumption. Considering the space segment the pointing accuracy has to be lower than 10 arcsec. The current attitude determination and control algorithms, such the ones using dynamic methods and star trackers, are not able to provide a sufficient precision with respect to non-inertial reference frame so that the optical communication can be used efficiently.

The aim of this paper is to introduce an innovative attitude determination and control device that guarantees the requested pointing accuracy for optical communication.

The system is composed by an high resolution camera, an optical transceiver, a recognition algorithm and an on-board computer that calculates the actuation torque needed. In particular, the research group exploited the potentialities of artificial intelligence algorithms to let the satellites autonomously detect and point at the ground stations through a system that instantaneously follows the targets by identifying some key features of the Earth's surface. With the support of Politecnico di Milano, Politecnico di Torino and Alta Scuola Politecnica the team has realised a bench test and started to validate the recognition and control algorithm. The overall system and feasibility study is presented in this paper. The pointing accuracy reached is below 50 arcsec. In addition, the present work describes the development of a scalable and modular device which easily adapts to every nano satellite following the CubeSat standards. The device was developed using an Agile methodology. In the last section, the economic benefits in terms of ground stations operating costs are also described and analysed.

The results of this research will have a strong impact on the space communication field because it introduces a device that solves the issue of optical communication pointing accuracy. Furthermore, it will increase the amount space data available on ground for research purposes.