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EAGLEAI: ESTIMATION OF ATTITUDE GEO-LOCALIZING LANDMARKS ON EARTH

Abstract

Attitude estimation is a crucial task in satellite operations as it determines the orientation and pointing of the satellite with respect to its surroundings. Conventional techniques for estimating satellite attitude require the calibration, weighting and filtering of multiple sensor inputs and the bespoke tuning of complex estimation algorithms. This makes their adoption often tricky and hardly portable. The present paper introduces an offline visual attitude estimator, based on machine learning, suitable to detect the attitude of a satellite starting from its position on the ground-track and a picture of the Earth.

The approach adopted, targeting a deployment on-ground, exploits computer vision techniques which leverage image data collected by cameras onboard the satellite to geographically localize the landmarks captured, and provide an estimation of the spacecraft attitude. In the proposed procedure we can identify three main steps: (1) first, the retrieval of a dataset of reference geo-localized pictures; (2) then, the selection of the best candidate pictures for the matching by means of a convolutional Siamese neural network, trained on a large dataset of synthetically modified Sentinel images; (3) finally, a pixel-level keypoint matching performed by the combination of Scale-Invariant Feature Transform (SIFT) and Random Sample Consensus (RANSAC) algorithms that enables the overlap of the input images and the geo-localization of the query. Results from the experiments demonstrate the feasibility of the proposed method, showing how it can effectively provide an accurate estimation of the attitude starting from a picture, its timestamp and the satellite's orbit. Furthermore, an in-depth study of the literature allows to point-out possible future developments to enhance its efficiency and robustness.

The main contribution of this work is to demonstrate how promising AI-based systems are in the context of satellite operations, and to show how they can challenge the performances of state-of-the-art attitude control systems built on traditional approaches. Overall, our suggested methodology offers a viable path forward and a solid starting point for improving CubeSat attitude determination capabilities.