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LOW-COST SATELLITE ANGULAR VELOCITY DETERMINATION METHOD THROUGH OPTICAL FLOW TRACKING BASED ON FLOWNET

Abstract

Many satellites utilize both star trackers and gyroscopes as part of their high-performance navigation systems. However, this leads to increased volume, weight, and cost within the satellites. This is a significant consideration, especially for low-cost satellites like CubeSats. To overcome these drawbacks, research is being conducted to either replace gyroscopes with star trackers for measuring the satellite's angular velocity or to enhance the accuracy of angular velocity measurement through cross-validation. Conventional methods for estimating angular velocity using star trackers typically involve matching the same stars using techniques such as the method of angular distance and region-based matching, and measuring optical flow. However, these methods have the limitation that they cannot accurately estimate angular velocity when there are significant changes in star positions due to large satellite angular velocities. In this paper, we propose an algorithm that utilizes Flownet, an end-to-end Convolutional Neural Network (CNN), to derive the patterned optical flow of stars and compute the satellite's angular velocity. Initially, stars are extracted from images using a global threshold segmentation method, and feature extraction is performed using a star centering algorithm. Subsequently, the Flownet's FlowNetCorr architecture is utilized to derive optical flow from consecutive images, overcoming the limitation of the previous algorithm where feature matching did not occur between consecutive images when the satellite's angular velocity was high. From the extracted optical flow, unit vectors are transformed into derivatives, considering camera calibration parameters, and using these transformed vectors, angular velocity is estimated through the Poisson equation and the least squares method. To validate the effectiveness of the proposed algorithm, simulated star images generated from star catalogs are created, and by comparing the estimated angular velocity with the actual angular velocity, the performance of the algorithm is demonstrated.