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DETERMINING HIGH RATE ANGULAR VELOCITY FROM STAR TRACKER MEASUREMENTS

Abstract

This paper focuses on a current ESA project whose aim is to address hardware and software solutions for the extension of the maximum angular rate magnitude up to 25deg/s onboard Selex ES APS Star Trackers (AA-STR and SPACESTAR). A new "Rate Mode", which determines high rate angular velocity from star-tracker measurements, would allow fully gyroless solutions - for nominal and contingency operations – with significant benefits in terms of reducing AOCS costs and complexity. The Rate Mode under development will allow achieving reliable and accurate measurements for angular rates from 10 to 25 deg/s. When a star tracker acquires images at high angular rates, the stars produce streaks on the focal plane. APS sensors capture images using a horizontal scanning across the scene (rolling shutter). The line read-out time introduces an image distortion, where the streaks are stretched or shortened depending on how the star moves in the image plane; that is, same direction or opposite direction of the line read-out. In fact, the APS reads the image line by line (each line is read in 200 microseconds), thus each line is acquired at different time intervals, giving about 25% error when estimating the length of the streaks. Because the streak length is strictly related to the angular rate, the paper analyzes in depth the APS read-out distortion. The angular velocity direction is identified by projecting the streak pixels to the unit sphere. The projected pixels have to belong to an arc of a spherical circle. A geometrical approach is used to find the line direction at which all the projected pixels have the same distance, thus yielding the angular velocity direction. We have developed a numerical high fidelity simulator to test the algorithm in operative scenarios. The numerical results show the capability to reliably measure spacecraft high rates using star trackers.