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FAST STAR TRACKER HARDWARE IMPLEMENTATION ON A FPGA DEVICE.

Abstract

Star Trackers are instruments used on board a spacecraft that utilizes digital image sensors, optics and digital hardware to accurately determine the attitude of the spacecraft. Currently these star trackers are the most accurate sensor system used on board a spacecraft ADS (attitude determination system) with accuracies ranging from tens of arcseconds to sub-arcsecond accuracy. High precision instruments used for satellite missions demand a very accurate attitude system and stresses the need for star trackers. The trend towards small satellites has also pushed technology for lighter instruments and less power consumption for ADSs. To determine attitude, star trackers need to process a large amount of pixel data during operation. The execution time of these image processing algorithms affect the update rate of the star tracker. High-performance attitude control systems, especially when making use of Control Moment Gyros (CMG's), typically require update rates of around 10Hz.

Our paper discusses a novel design where a large part of the star detection algorithm is implemented in a parallel pipelined hardware system using a FPGA (Field Programmable Gate Array) device. This solution makes it possible to detect stars at the same time as the pixel data is streamed from the sensor. Instead of storing the entire image in memory, only the star positions are saved and used further in the attitude determination algorithms. This design leads to significantly faster update rates without compromising accuracy or power usage.

Our proposed solution is implemented on a Xilinx SoC (System on a Chip) development platform which includes a FPGA and an ARM processor. Various tests are performed using simulated star images, real reference star images, and a real star sensor. The sensor interface is also simulated on an external microprocessor to test the hardware functionality in a controlled environment.

The final solution, discussed in the paper, is a lightweight, low resource star tracker prototype with sub-pixel star detection accuracy and an update rate of 10Hz or more.