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SPECIAL ISSUE

VLSI implementation of star detection and centroid calculation algorithms for star tracking applications

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Abstract Nowadays, hardware implementation of image and video processing algorithms on application specific integrated circuit (ASIC) has become a viable target in many applications. Star tracking algorithm is commonly used in space missions to recover the attitude of the satellite or spaceship. The algorithm matches stars of the satellite camera with the stars in a catalog to calculate the camera orientation (attitude). The number of stars in the catalog has the major impact on the accuracy of the star tracking algorithm. However, the higher number of stars in the catalog increases the computation burden and decreases the update rate of the algorithm. Hardware implementation of the star tracking algorithm using parallel and pipelined architecture is a proper solution to ensure higher accuracy as well as higher update rate. Noise filtering and also the detection of stars and their centroids in the camera image are the main stages in most of the star tracking algorithms. In this paper, we propose a new hardware architecture for star detection and centroid calculation in star tracking applications. The method contains several stages, including noise smoothing with fast Gaussian and median filters, connected component labeling, and centroid calculation. We introduce a new and fast algorithm for star labeling and centroid calculation that needs only one scan of the input image.

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1 Introduction

Star trackers are widely used systems in many space-based applications and satellites. Star tracking algorithms determine the attitude of satellite or spaceship by matching stars of the satellite camera with the stars in a catalog. Although other sensors like GPS, sun tracker, and magnetometer may be used for attitude determination, star trackers have the advantage of producing higher accuracy. They also have the capability of attitude determination without prior information, which is known as the Lost-In-Space (LIS) capability.

Different algorithms have been proposed for the task of star tracking. Graph matching algorithm is the most commonly used approach for star tracking. In this approach, stars are considered as vertices of an undirected graph G, which the angular separation between each pair of stars is the edge weights. Triplet algorithm [1, 2] is the well-known algorithm of this group, where the three angular separations between three stars or triplet vertices are used for star identification. In [3] the angular separations of more than three stars were used for star matching or star identification. The algorithm generates match groups through star pair matching. Then smaller match groups are removed and the remaining groups are validated by checking distances between all stars in the group, and finally a group with the largest number of matches is selected as the true match. The algorithm of Kolomenkin et al. [4] is based on a geometric voting scheme. In this approach, a pair of stars in the camera

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