A NOVEL APPROACH OF AN FPGA DESIGN TO IMPROVE MONOCULAR SLAM FEATURE STATE COVARIANCE MATRIX COMPUTATION

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Abstract. Monocular SLAM is a study which concentrates on deriving the position and motion estimation information from tracked features using a single camera. In this paper, a novel approach to improve the computation speed of a Monocular SLAM is proposed. The research concentrates on the feature initialization process which takes place before the standard Extended Kalman Filter (EKF). In order to find the most time consuming process at the initialization stage, a software profiling tool is used. From the result, the section of a program which demands high processing computation is identified. Following that, a specialized design is proposed to improve the computation speed. An FPGA approach is chosen with the intention to offload software processing to a dedicated hardware for overall performance acceleration. In order to accomplish this goal, the section demanding high processing computation is carefully studied. From the studies, it is found that the original approach can be improved by reducing the multiplication process and incorporating parallel processing capability of an FPGA. At the end of the paper, the comparison results of the software and hardware processing are presented.

Keywords: Simultaneous localization and mapping (SLAM), Parallel design, Matrix multiplication landmark initialization, Inverse depth parameterization

1. Introduction. Simultaneous Localization and Mapping (SLAM) is a process where a mobile robot can build a map of the surrounding environment and concurrently use this map to compute its own location. Due to the promising advantages of vision sensor such as being compact, accurate, noninvasive, cheap, well understood and ubiquitous [1,2], various vision SLAM algorithms [3] have been studied. Monocular SLAM is a Bearing-Only SLAM which utilizes a single vision sensor to measure the bearing of image features. From the measured bearings, the depth information is estimated using feature parallax. In this context, parallax is a measured angle of an object or captured rays viewed from two different lines of sight. One of the frequent problems occurring in the Bearing Only SLAM is the robustness of the new feature initialization process in determining the depth information [4]. This initialization problem is commonly addressed by using Delayed and Undelayed approaches. Both approaches have their own advantages and disadvantages. The Delayed approach has an advantage whereby it is able to reject weak features. However, the Delayed approach has to wait until the sensor movement generates sufficient degrees of parallax. On the other hand, the Undelayed approach benefits from the information about the sensor orientation from the beginning. The downside of the Undelayed approach is that the depth estimation is modeled with huge