

A system for real-time 2-D feature detection based on field programmable gate arrays

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We have designed and implemented a system for real-time detection of 2-D image features on a reconfigurable computer based on Field Programmable Gate Arrays (FPGA's). We envision this device as the front-end of a system able to track image features in real-time vision applications like autonomous vehicle navigation and "structure from motion". The algorithm employed to select good features is inspired by the method of Tomasi and Kanade. Compared to the original method, the algorithm that we have devised does not require any floating point or transcendental operations, and maps efficiently into a highly pipelined architecture, well suited to be implemented in FPGA technology. We have implemented the algorithm on a low-cost reconfigurable computer equipped with video decoder and encoder interfaces. Reliable operation has been observed on an image stream generated by a standard NTSC commercial video camera at 30 Hz on different scenes and under different light conditions. This result compares favorably to the implementation of the same algorithm on a system based on the TI C80 DSP, able to process at most 5 frames/second.

1. Introduction

Feature selection and tracking is a fundamental problem in computer vision research. By measuring the displacement of features in the sequence of images seen by a camera, it is possible to recover information both on the structure of the environment and on the motion of the viewer. Thus, a feature tracker is the front-end for any system employed to solve many practical control problems, like autonomous navigation and "structure from motion". In this paper, we pay attention to

feature selection because it is the most computationally intensive task to be carried out by a tracking system; we believe that once the locations of the features are known at each frame, a conventional processor will be able to solve the correspondence problem. To the best of our knowledge, the only real-time feature selection system described in literature is the system employed by the ASSET-2 [8] motion segmentation and shape tracking system. This system comprises four VME boards, equipped with custom hardware circuits performing the different stages of the Harris corner finding algorithm [6]. The system that we propose here, on the other hand, has been implemented on a low-cost reconfigurable computer based on Field Programmable Gate Arrays (FPGA's). Reconfigurable computers are sufficiently flexible to permit the implementation of new algorithms on existing hardware, and their performance is adequate for real-time operation of many image processing problems [1]. Our feature detection system is based on the work of Tomasi and Kanade [10]. We have decreased the complexity of this method by eliminating the need for any transcendental arithmetic operations, and this simplification has led to the implementation of the algorithm on six XC4028EX Xilinx FPGA's [11] hosted by a Gigaops Spectrum G800 PC board [4]. The rest of the paper is organized as follows. In the next section the feature selection method is presented in detail. In Section 3 we give a brief overview on FPGA-based custom computing machines, while in Section 4 we present the details of the implementation of the feature selection system. Finally, in Section 5 experimental results are reported and some conclusions are drawn.

2. Description of the method

The feature selection method that we have implemented is based on the work of Tomasi and Kanade [10], which we will briefly review here. Let $I(x, y, t)$ denote the continuous function defining the brightness values of a sequence of images seen by a

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