High Frame Rate Real-time Scene Change Detection System

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Abstract- Scene change detection, one of the fundamental and most important problems of computer vision, plays a very important role in the realization of a complete industrial vision system as well as automated video surveillance system - for automatic scene analysis, monitoring, and generation of alerts based on relevant changes in a video stream. Therefore, in addition to being accurate and robust, a successful scene change detection system must also be of very high frame rate in order to detect scene changes which goes off within a glimpse of the eye and often goes unnoticeable by the conventional frame rate cameras. Keeping this high frame rate processing as main focus, a very high frame rate real-time scene change detection system is developed by leveraging VLSI design to achieve high performance. This is accomplished by proposing, designing, and implementing an area-efficient scene change detection VLSI architecture on FPGA-based IDP Express platform. The complete real-time scene change detection system is capable of processing 2000 frames per second for 512x512 video resolution and the developed prototype is tested for the same. The proposed and implemented system architecture is adaptable and scalable for different video resolutions and frame rates.

Keywords: High Speed Scene Change Detection; VLSI Architecture; FPGA Implementation; Automated Video Surveillance System

1 Introduction

The long-term monitoring of high-speed phenomena using high frame rate cameras requires a large amount of storage space and high communication bandwidth over a network. Real-time high frame rate scene change detection allows more efficient hard disk storage by only archiving video frames where actual change in scene has occurred and also reduces the communication and further processing overheads in a remote video surveillance scenario by selecting the frames of relevant scene changes. However, the most of the existing implementations of scene change detection algo-

rithms are done for conventional video camera (25 fps to 30 fps), and, therefore, these are not capable of automatically detecting the high speed scene change phenomena.

In this work, we have addressed this problem by developing a real-time very high frame rate system for automatic scene change detection in live incoming video streams. The high performance was achieved by leveraging VLSI design based approach. A dedicated VLSI architecture has been proposed and designed for computationally efficient clustering based scene change detection scheme [1]. The designed architecture is coded in VHDL, simulated using ModelSim, and synthesized using Xilinx ISE 10.1 design tool chain. The architecture has been integrated with real-time video input / output interfaces. The complete final design has been implemented on FPGA-based IDP Express platform. The implemented scene change detection system is capable of processing 2000 frames per second for 512x512 resolution in live incoming video streams. It has been tested for different real-world scenarios for scene change detection and the system shows good results.

The rest of the paper is organized as follows: in the next section, we present a literature review of existing real-time implementations of scene change detection schemes. A brief of clustering based scene change detection scheme is presented in section three. The details of complete scene change detection system and associated VLSI architecture are presented in section four. The synthesis results and scene change detection results are presented in section five. Finally, we conclude this paper with a short summary.

2 Literature Review

The importance of scene change detection for designing industrial vision systems and automated video surveillance systems can be gauged from the availability of a large number of robust and complex algorithms and their implementations that have been developed to-date, and the even larger number of articles that have been published on this topic so far. The simplest approach to change detection is the frame differencing method in which change detection can be achieved by finding the difference of the pixels between two adjacent frames. If the difference is higher than a threshold, the pixel is identified as foreground otherwise background. The threshold is chosen empirically. Different methods and criteria for choosing the threshold have been surveyed and their comparative results have been reported in the literature [2]-[4]. The simplicity of frame differencing based approaches comes at the cost of change detection quality. For a chosen threshold, simple differencing based approaches are unlikely to outperform the more advanced algorithms proposed for real-world surveillance applications. A comprehensive description and comparative analysis of these methods has been presented by Radke et al. [5].

The practical real-world video surveillance applications demand a continuous updating of the background frame to incorporate any permanent scene change i.e. if a pixel has remained stationary for a sufficient number of frames, it must be copied into the background frame such as , for example, light intensity changes in day time must be a part of the background. For this purpose, several researchers [6]-[8] have de-