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Hardware Software Co _Design of Image Edge Detection Using Canny Algorithm

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Abstract:

In this paper, a video surveillance-based image processing system is developed on Xilinx Spartan3 Field Programmable Gate Array (FPGA) device using embedded development kit (EDK) tools from Xilinx. Two different hardware architectures of two dimensional (2-D) video surveillance have been implemented as a coprocessor in an embedded system. It is direct implementation of video surveillance by Moving object detection algorithm. Oncethe object to be tracked is segmented and its feature extracted, the position of the moving object is predicted using Median filter which is nonlinear digital filtering technique, often used to remove noise. Median Filter efficiently tracks the moving object in real time applications. The proposed algorithm accurately segments the moving object by reducing the effect of the shadowing and/or noisy pixels and successfully tracks the moving object. In addition, the hardware cost of these two architectures is compared for benchmark images.

Keywords:

video surveillance, FPGA, EDK, Micro Blaze.

I. INTRODUCTION:

Many embedded DSP systems make use of a DSP chip utilizing a single processing core with high-bandwidth memory connections to implement DSP algorithms. In this investigation, we developed an alternative approach based on an embedded FPGA system for image processing. Field Programmable Gate Array (FPGA) is widely used in embedded applications such as automotive, communications, industrial automation, motor control, medical imaging etc.FPGA is chosen due to its reconfigurable ability. Without requiring hardware change-out, the use of FPGA type devices expands the product life by updating data stream files. FPGAs have grown to have the capability to hold an entire system on a single chip meanwhile, it allows in- platform testing and debugging of the system.

Furthermore, it offers the opportunity of utilizing hardware/software co-design to develop a high performance system for different applications by incorporating processors (hardware core processor or software core processor), on-chip busses, memory, and hardware accelerators for specific software functions.In this paper, video surveillance is a -based on image processing system is developed on a Xilinx Spartan3 Field Programmable Gate Array (FPGA) device using an embedded development kit (EDK) from Xilinx. Video surveillance is one of the most popular transform coding techniques for image and video Segmentation. The video processing and image compression standards such as JPEG, MPEG, and H.26x have adopted as video surveillance the transform coder [1-3]. Consequently, video surveillance is chosen as the application algorithm for the embedded system. This paper is organized as follows: Section II briefly reviews Back Ground Subtraction method. Section III discusses the design flow. Section IV covers different architecture for video surveillance co-processor and compares their performance. Section V is the conclusion part.

II. MOVING OBJECT DETECTION:

Video Object tracking deals with the analysis of motion in a sequence of video frames based on kinematics of the moving object. The problem of tracking becomes complicated due to the partial or total disappearance of object, variation in lighting Conditions, presence of noise, presence of more than one object etc. To track moving object, the object should first be accurately segmented from the background and its appropriate features should be selected. After proper segmentation the object is tracked from frame to frame using motion model and its extracted features. The proposed algorithm for moving object tracking involves following two steps:

A. Moving Object Extraction:

The background image Bk(x, y) is obtained by the frame, subtract the background image Bk(x,y) from the current frame Fk (x, y). If the pixel difference is greater than the set threshold T , then determines that the pixels appear in the moving object, otherwise, as the background pixels. The moving object can be detected after threshold operation. Its expression is as follows:

$$D_k(x, y) = \begin{cases} 1, & |(F_K(x, y))-B_K(x, y)| > T \\ 0, & others \end{cases}$$

Where Dk(x, y) is the binary image of differential results. T is gray-scale threshold; its size determines the accuracy of object identification. As in the algorithm T is a fixed value, only for an ideal situation, is not suitable for complex environment with lighting changes.

The segmented object obtained from the initial differencing is not so accurate because pixels near the moving object may also be in motion due to effects like shadow etc. The shadowed pixel is generally on darker side and has intensity lower than the background and may appear as foreground objects. Thus the intensity of each pixel is increased by certain amount so that the intensity of shadowed pixel reaches close to that of the background pixels. Further instead of using a single threshold value, adaptive pixel wise thresholding will help in effective removal of these shadowed pixels.

$$D_k(x, y) = \begin{cases} 1, & |(F_K(x, y) + \delta) - B_K(x, y)| > T_a \\ 0, & others \end{cases}$$

δ reflects the overall changes in the environment. If small changes in image illumination, dynamic threshold δ takes a very small value. Under the premise of enough pixels in the detection region δ will tend to 0. If the image illumination changes significantly, then the dynamic threshold δ will increasesignificantly. This method can effectively suppress the impact of light changes.

B. Reprocessing:

As the complexity of the background, the difference image obtained contains the motion region, in addition, also a large number of noises. Therefore, noise needs to be removed. This paper adopts median filter with the 3 X 3 window and filters out some noise.

If n is even
median=(arr[n/2]+arr[n/2+1])/2.0
If n is odd
median=arr[n/2+1]

After the median filter, in addition the motion region, includes not only moving vehicles, but also may include body parts, flying birds, flowing clouds and swaying trees and other non body parts. Morphological methods are used for further processing.

Firstly, corrosion operation is taken to effectively filter out non-object activity areas. Secondly, using the expansion operation to filter out most of the non-body motion regions while preserving the shape of object motion without injury. After expansion and corrosion operations, some isolated spots of the image and some interference of small pieces are eliminated, and we get more accurate object motion region.

C. Extraction of Moving object:

After median filtering and morphological operations, some accurate edge regions will be got, but the region belongs to the moving object could not be determined. Through observation, we can find out that when moving object appears, shadow will appear in some regions of the scene.

The presence of shadow will affect the accurate extraction of the moving object. By analyzing the characteristics of motion detection, we combine the projection operator with the previous methods.Based on the results of the methods above, adopting the method of combining vertical with horizontal projection to detect the height of the motion region.

This can eliminate the impact of the shadow to a certain degree. Then we analyze the vertical projection value and set the threshold value (determined by experience) to remove the pseudo-local maximum value and the pseudo-local minimum value of the vertical projection to determine the number and width of the vehicle in the motion region, we will get the moving object with precise edge. This article assumes that vehicle in the scene are all in upright-moving state.

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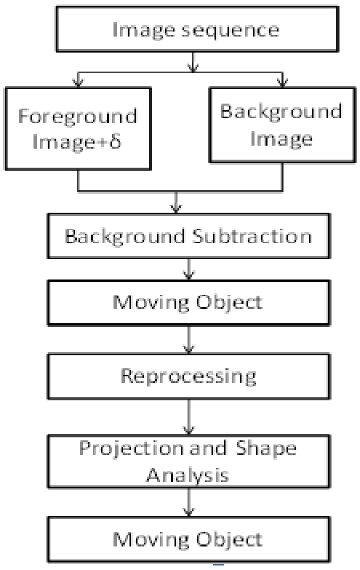

Fig1: Moving Object Detection

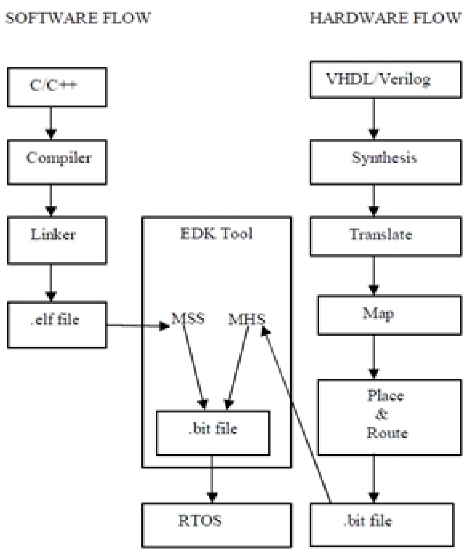

Fig 2 Design flow

Moving object detection is to identify the corresponding part of object from the moving region. But the extracted moving region may correspond to different moving objects, such as pedestrians, vehicles and other such birds, floating clouds, the swaying tree and other moving objects.

Hence we use the shape features of motion regions to further determine whether the moving object is a vehicle. Judging criteria are as follows the object area is larger than the set threshold the aspect ratio of the object region should conform to the set ratio. If these two conditions are met, the moving object is the moving vehicle, or is not a vehicle.

III. DESIGN FLOW:

To build an embedded system on Xilinx FPGAs, the embedded development kit (EDK) is used to complete the reconfigurable design. Figure 2 shows the design flow.

Unlike the design flow in the traditional software design using C/C++ language or hardware design using hardware description languages, the EDK enables the integration of both hardware and software components of an embedded system. For the hardware side, the design entry from VHDL/Verilog is first synthesized into a gate-level net list, and then translated into the primitives, mapped on the specific device resources such as Look-up tables, flip-flops, and block memories. The location and interconnections of these device resources are then placed and routed to meet with the timing Constraints. A downloadable .bit file is created for the whole hardware platform. The software side follows the standard embedded software flow to compile the source codes into an executable and linkable file (ELF) format. Meanwhile, a microprocessor software specification (MSS) file and a microprocessor hardware specification (MHS) file are used to define software structure and hardware connection of the system. The EDK uses these files to control the design flow and eventually merge the system into a single downloadable file. The whole design runs on a real-time operating system (RTOS).

IV.VEDIOSURVILLANCE CO−PROCESSOR:

There are different ways to include processors inside Xilinx FPGA for System-on-a-Chip (SoC): PowerPC hard processor core, or Xilinx MicroBlaze soft processor core, or user-defined soft processor core in VHDL/Verilog.

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In this work, The 32-bit MicroBlaze processor is chosen because of the flexibility. The user can tailor the processor with or without advance features, based on the budget of hardware. The advance features include memory management unit, floating processing unit, hardware multiplier, hardware divider, instruction and data cache links etc. The architecture overview of the system is shown in Figure 3. It can be seen that there are two different buses (i.e., processor local bus (PLB) and fast simplex link (FSLbus) used in the system [5-6].

PLB follows IBMCore connect bus architecture, which supports high bandwidth master and slave devices, provides up to 128- bit data bus, up to 64-bit address bus and centralized busArbitration. It is a type of shared bus. Besides the access overhead, PLB potentially has the risk of hardware/software incoherent due to bus arbitration. On the other hand, FSL supports point-to-point unidirectional communication. A pair of FSL buses (from processor to peripheral and from peripheral to processor) can form a dedicated high speed bus without arbitration mechanism. Xilinx provides C and assembly language support for easy access. Therefore, most of peripherals are connected to the processor through PLB; the DWT coprocessor is connected through FSL instead.

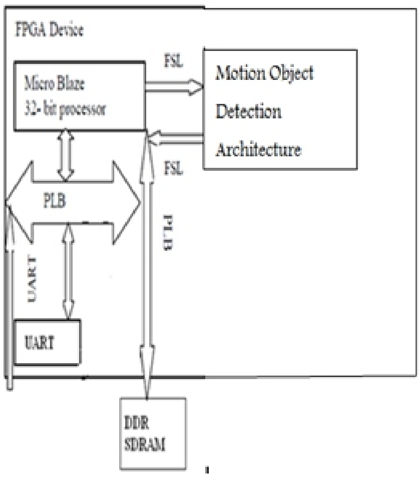

Fig 3 System Overview

The current system offers several methods for distributing the data. These methods are a UART, and VGA, and Ethernet controllers. The UART is used for providing an interface to a host computer, allowing user interaction with the system and facilitating data transfer. The VGA core produces a standalone real-time display.

The Ethernet connection allows a convenient way to export the data for use and analysis on other systems. In our work, to validate the DWT coprocessor, an image data stream is formed using VISUAL BASIC, then transmitted from the host computer to FPGA board through UART port.

CANNY EDGE DETECTION:

The Canny operator is used in image processing, particularly within edge detection algorithms. Technically, it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the canny operator is either the corresponding gradient vector or the norm of this vector.

The Canny operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. On the other hand, the gradient approximation that it produces is relatively crude, in particular for high frequency variations in the image.

V.EXPERIMENTAL RESULTS:

Experiments are performed on gray level images to verify the proposed method. These images are represented by 8 bits/pixel and size is 128 x 128. Image used for experiments are shown in below figure.

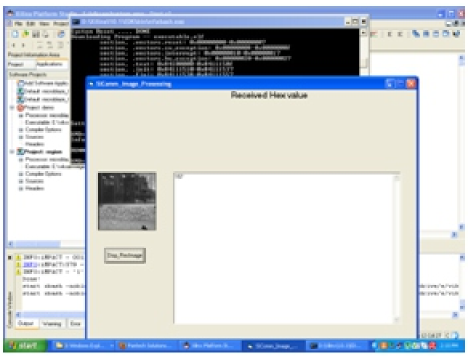

Fig 4 background image.

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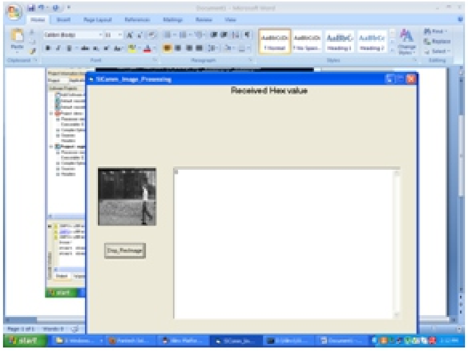

Fig 5 Foreground image.

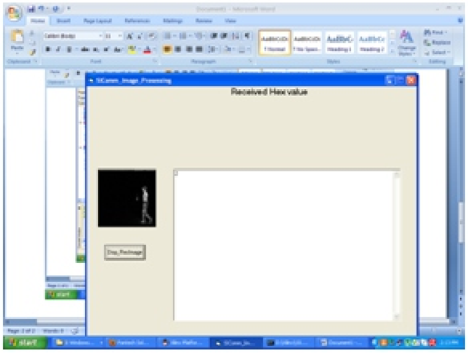

Fig 6 output image

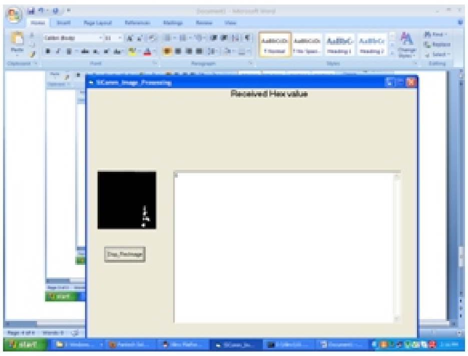

Fig 7 Edge Detection Image

VI. CONCLUSION:

In this paper, a Background Subtraction-based reconfigurable system is designed using the EDK tool. Hardware architectures of Moving object detection algorithm have been implemented as a coprocessor in an embedded system. Median Filter efficiently tracks the moving object in real time applications. The proposed algorithm accurately segmented the moving object by reducing the effect of the shadowing and/or noisy pixels and successfully tracks the moving object. In addition, the hardware cost of these two architectures is compared for benchmark images.

The hardware cost of this architecture is compared for benchmark images. This type of work using EDK can be extended to other applications of embedded system.

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