AUTOMOBILE SURVEILANCE SYSTEM: FUZZY BASED IMPLEMENTATION OF FACE RECOGNITION ALGORITHM ON FPGA PLATFORM

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Abstract : Face acceptance is a form of biometric identification that builds on data acquired from face of individuals & compared with the database of individuals. The main objective of this paper was to develop a real time hardware face recognition system based on Field Programmable Gate Array (FPGA). The chosen image processing algorithm is Sobel Edge Detection algorithm. The hardware platform is based on Altera DE1- SoC development board with TRDBD5M 5 Mega pixel digital camera from Terasic Technologies and a PC monitor. Verilog HDL was used as hardware programming language for real time sobel edge detection system using Quartus Prime 16.1 lite edition. The final output of the system is given to the Alarm system, Door motor control system and a message alert to a particular person using GSM

IndexTerms **- FPGA, DE1-SoC development board, TRDB- D5M Digital Camera, PC monitor, Sobel Edge Operator, Edge Detection and Image Processing.**

I. INTRODUCTION

An edge may be the result of changes in light absorption, color, shade and texture, and these changes can be used to determine the depth, size, orientation and surface properties of a digital image [1]. In analyzing the image digitally, edge detection involves filtering irrelevant information to select the edge points. The detection of subtle changes may be mixed up by noise and this depends on the pixel threshold of change that defines an edge. Detection of these continuous edges is very difficult and time consuming especially when an image is corrupted by noise [2].

Edge detectors hold a significance place in modern day computer vision systems. The Edge detection minimizes the amount of data processing, thus the image analysis process is very much simplified [3].The main application areas of edge detectors include: geography, military, medicine, robotics, meteorology and pattern recognition systems [4], [5], [6], [7], [8], [9].

Biometric is an emerging set of pattern acceptance technologies used in security systems, which accurately and automatically identifies or verifies individuals based on persons unique physical characteristics. There are many biometric techniques available now days: fingerprint, figure and hand geometry, palm print, iris pattern, and retina pattern, face recognition, voice recognition, signature Dynamics etc. We chose and developed a face recognition system [9] in this paper, which fulfils the need of vehicle security so as to prevent vehicle theft [10], [11].

I chose the FPGA as a modular, configurable and versatile hardware platform for real time video and image processing [12]. Altera DE1- SoC development board becomes one of the most widely used FPGA board powered by Cyclone V, for development of FPGA design and implementation. The Purpose of this board is to provide the ideal path for studying about FPGA board, logic gates, digital logic and computer organization. The board offers a large set of features that make it suitable for use in laboratory environment for the variety of design papers and for the development of digital systems.

II. SYSTEMARCHITECTURE

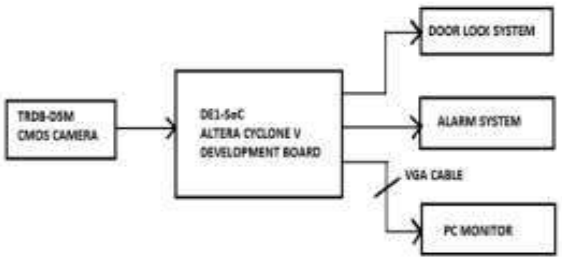

Fig.1 –System Architecture

In Fig.1 the system architecture based on Altera Cyclone V DE1-SoC FPGA processor is presented. The TRDB_D5M camera kit provides a 5 Megapixel digital camera on the Altera DE1-SoC board. This digital camera is used to capture the image which is used as input to Sobel edge detection algorithm and face recognition module. The processor unit deals with image decoding, edge detection, face recognition and data transmission to the PC monitor through VGA controller. The on chip SRAM is used to store the paper code while an external SDRAM isused to store the gray scale and binary images data generated by face recognition module. The processor process the incoming signals from camera unit and send the output data to output units i.e. PC monitor, Door motor control system, Alarm system.

III. AN EDGE DETECTION MODEL BASED ON SOBEL OPERATOR

Sobel edge operator could be very beneficial for carrying out two dimensional spatial pitch measurement on an image and highlights regions of high spatial gradient that matches the edges. It is typically used to find the absolute gradient magnitude at each point in an input gray scale image. Below are the main advantages of Sobel edge operator over the others:
1. It has smoothing effect to the random noise of the image.
2. Elements of the edge on both sides has been enhanced since, it is the differential of two rows or two columns. Because of this enhancement the edge seems to be thicker and brighter.
The operator utilizes two 3x3 kernels: one estimates the gradient in the x-direction, while the other one estimates the gradient in the y- direction.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Fig 2.Sobel Operator uses 3*3 Kernel masks

The image is convolved with both kernels to approximate the derivatives in horizontal and vertical change. At each given point, magnitude of the gradient can be approximated with:

$G = [(GX*GX) + (GY*GY)] \wedge (1/2)$

However, it is faster to compute the gradient magnitude with:

$G = |GX| + |GY|$

The angle of orientation of the edge giving rise to
the spatial gradient is given by,

$\Theta = \tan^{-1} (GY/GX)$

Due to Sobel operator's smoothing effect (Gaussian smoothing), it is less sensitive to noise present in images. On the other hand, smoothing affects the accuracy of edge detection. In other words, the Sobel method does not produce image with high accuracy for edge detection, but its quality is adequate enough to be used in numerous applications. The normal input image is shown in Fig 3.a and 4.a, and the gray scale images are shown in 3.b and4.b.

IV.PSEUDO CODE FOR SOBEL EDGE DETECTION

Input : A sample images.

Output : Detected edges.

Step-1 : Receive the input image.

Step-2 : Put on mask Gx, Gy to the input image.

Step-3 : Smear sobel edge detection algorithm and the gradient.

Step-4 : Mask manipulation of Gx, Gy particularly on the input image.

Step-5 : Results combined to find the absolute magnitude of the gradient

Step-6 : The absolute magnitude is the output edges.

Examples of sobel edge detection:

Example-1:

Fig 3. a. Original Image

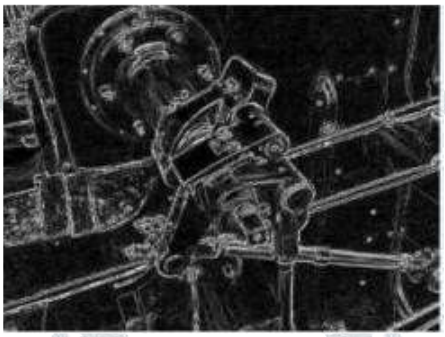

Fig 3. b. Sobel edge detection Image

Example-2:

Fig 4. a. Original Image

Fig 4. b. Sobel edge detection Image

V.FACERECOGANITION

Sobel Edge detection algorithm is used to detect the edges of the face in the images and to extract features. The edges data at the output of sobel module is used as input to "Face Recognition Module".

Face recognition module has the algorithm that detects the row having maximum summation of edge data values in two halves. For every „0" output of sobel module corresponding „1" is added to the row summation. Summation of row values of "5" rows is

stored and average is calculated. The maximum average value in the first half is stored and the corresponding row is stored as "Row having the Eye Feature". The same procedure is repeated for other half to get the "Row having Mouth Feature". After obtaining these row feature values the difference in the corresponding rows is computed and stored. This difference is used to recognize the face, the processing flow of the system is as shown in Fig.5.

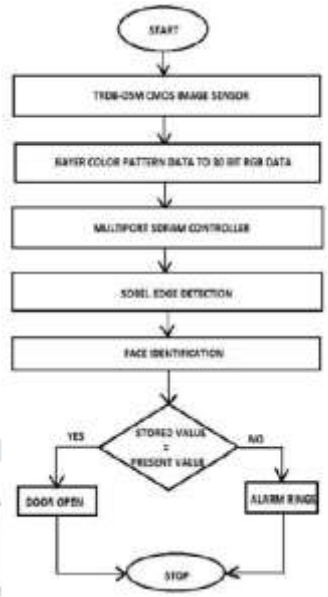

Fig 5.a.Face Identification Flow chart

VI.EXPERIMENTAL SETUP

The TRDB-D5M CMOS camera interfacing with Altera Cyclone V DE1-SoC development board is shown in Fig.6

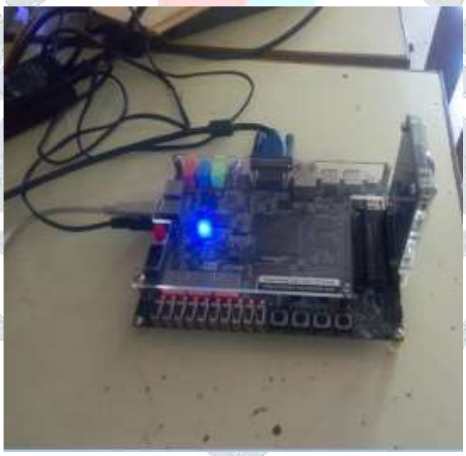

Fig 6.Altera Cyclone V DE1 SoC development board interface with TRDB-D5M camera

The Altera DE1-SoC development board and TRDB-D5M CMOS camera shown in fig 6.a and 6.b respectively.

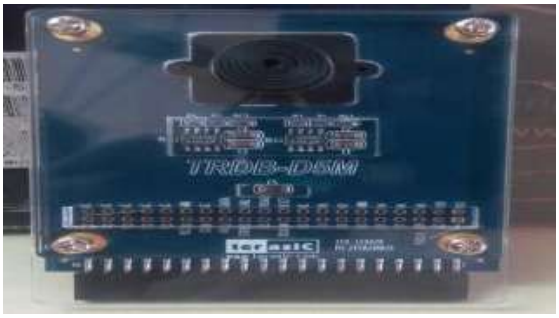

Fig.6.a.Altera Cyclone V DE1 SoC development

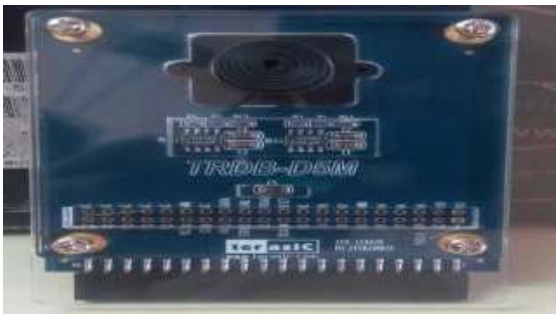

Fig.6.b.TRDB-D5M CMOS camera.

VII.RESULT

The output images of Grey scale and Sobel edge detection on the PC monitor is as shown in Fig.7.a, and 7.b respectively. The image is captured and the row feature values of "Rows having Eye feature" & "Rows having Mouth feature" is computed and stored in SDRAM. This stored value is compared with predefined values and if the face is recognized i.e. the present value stored in SDRAM is matched with the predefined value then the output signal is given to the Door motor control system otherwise given to the Alarm system

Fig 7.a.Original Image

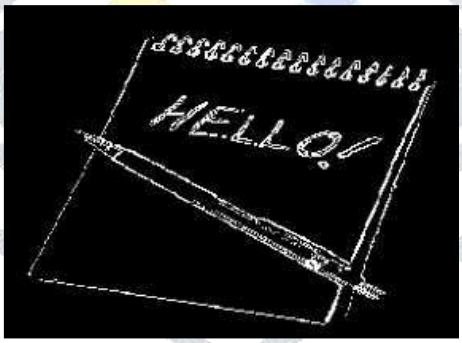

Fig 7.b.Sobel edge detection image

VIII.CONCLUSION

There are so many controller available in market to do a image and video processing but FPGA platform is a powerful tool compared to other controller for image and video processing to provide a high resolution images and videos by interfacing the camera in it and it has a high speed processor to capture the images and videos and give it to the output side simultaneously without any delay. The face recognition algorithm with high resolution images and videos using an FPGA can be implemented at any types of automobiles and can be used at any place where face recognition is needed. However the results may vary due to certain limitations of system based on facial recognition such as intensity of light changes in facial expression and background conditions. This system is portable and reconfigurable therefore it can be programmed and deployed at security systems for Law enforcement at airports, geography, military, medicine, robotics, meteorology, pattern recognition systems and international borders customized according to their requirements.

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