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FPGA Implementation of Biometric based Elevator Controller

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ABSTRACT

In this technical world, with the increasing in the number of skyscrapers, malls, commercial complexes, hotels etc. the need of elevator/lift is essential and it is now become an important part of every skyscraper. It is a device that carries people or luggage to their destined floors inside buildings. Nowadays biometric access is used in elevators to increase security of any lab, hospital or research center. This access allows, with only approach the entrance, the device identifies the person by facial, eye or fingerprint recognition and the doors would open. Biometrics is getting great importance in this advanced technical world. Biometrics is a scientific authentication process which depends on attributes of a person.

This paper proposes a novel approach to implement a vein fingerprints based elevator controller using FPGA (Field programmable gate array). Xilinx ISE (Integrated simulation environment) version 14.5 and Verilog HDL (Hardware descriptive language) is used for coding and simulation of the controller.

KEYWORDS

Elevator Controller, FPGA, Biometrics, Sensors, FSM, Verilog, HDL, Xilinx ISE, Vein Fingerprints.

INTRODUCTION

Archimedes made the first known elevator in 236 BC. In 1852, Otis demonstrated the first safety based elevator and in 1857 he installed the first passenger elevator. A method that allows elevator doors to open and close safely was patented by J.W Meeker in 1874. The first residential elevator was created by Clearance Conrad in 1929. The elevator controller in its basic form is a finite state machine (FSM). It is a mathematical abstraction used to design digital logic circuit or computer programs. The proposed biometric elevator controller is based on Mealy machine in which the output is depend on its current state and the current inputs. Chinese ancient civilizations first used fingerprints as recognition of a person since 6000 to 7000 BC. Personal recognition and verification system based on biometrics are more trusted compared to traditional methods because biometric attributes are cannot be forgotten and lost, moreover these attributes are cannot be copy or duplicated and person is needed to be present at the time of the verification [1].

Fingerprints recognition methods are of three types:-

1. Minutiae based Ridge.
2. Correlation Based.
3. Gradient Based

In this proposed paper our approach was to develop a cost effective and more reliable biometric based elevator controller using FPGA. [2].

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FIELD PROGRAMMABLE GATE ARRAY (FPGA)

FPGA (Field Programmable Gate Array) belongs to Programmable Logic Devices (PLD's) IC. PLDs allow the programmer to use it in several ways. It also allows the programmer to interface the different digital logic circuits of various sizes and complexities. FPGA comprises of programmable logic components, reconfigurable interconnections for interconnecting logic blocks. They are generally used to perform simple logic functions and some complex combinational functions. FPGAs are generally used to implement logical [3]. Users can program FPGA according to their desired function; this feature makes FPGA superior to ASIC. Application specific integrated circuit is an IC that is manufactured only for a specific application and cannot be reprogrammed by used like FPGA.

The components of FPGA are given below:

1. Programmable Logic Blocks
2. Interconnect Resources
3. I/O blocks

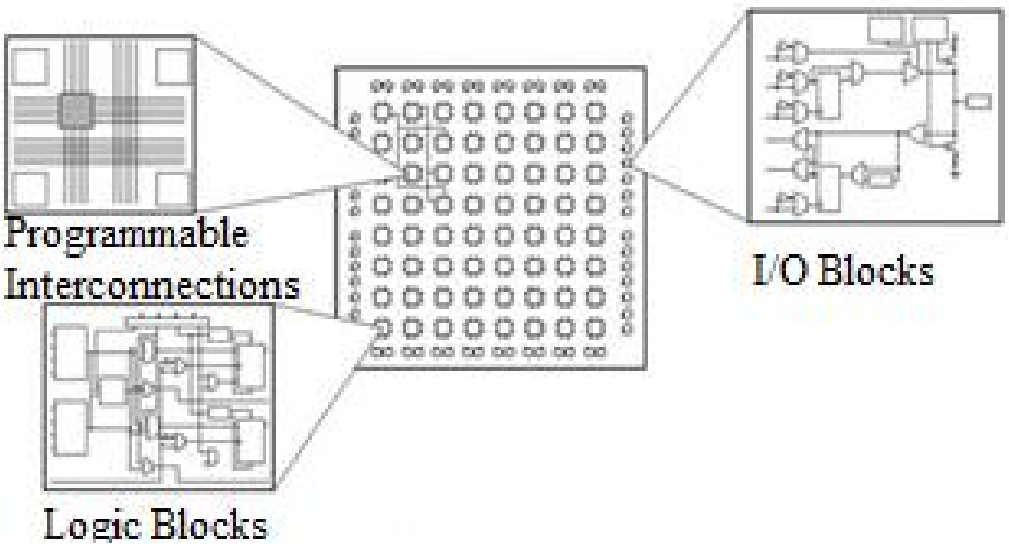

Figure:-1 FPGA Architecture

PRINCIPLE OF ELEVATOR CONTROLLER

An elevator is a simple machine that is used to save human efforts and time. The elevator won't need to use much energy at all the time because it will always be getting back as much (when it goes down) as it gives out (when it goes up). It uses more energy to lift people up but it would have no way of getting that energy back. So elevator is the good example of law of energy conservation. When people are coming down there is small amount of loss in cable and brakes.

Elevator controller can be developed for n. number of floors. The controller consist control buttons to move the elevator in upward and downward direction. The floors of the building consists call buttons to call the elevator at the floors.

The elevator system is operated by a main controller by a set of program instructions. The information of every elevator system is sends to the main controller.

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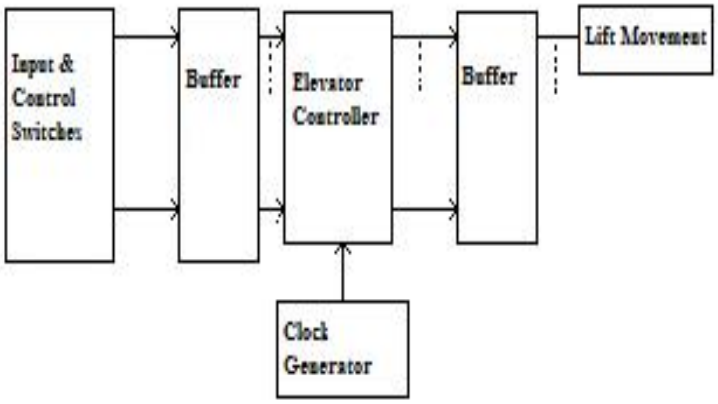

Figure:-2 Block diagram of an elevator controller

WORKING OF ELEVATOR CONTROLLER

Some design considerations should keep in mind while developing an elevator controller, such as reliability, speed, cost-effectiveness etc. The proximity sensors are used to detect the positions of the lift [4]. The controller unit also checks whether there is any requests from the different elevator units or not using the flip-flops. If the gate of any elevator is open, the timer signals from the elevator send an instruction to the controller unit notifying that elevator is busy at the moment.

CONTROL STATE MACHINE (CSM)

The control state machine (CSM) gets all the instructions and commands. It is a predefined algorithm program that controls the whole operation of the system. To move the elevator in its next destination, the CSM produces control commands and instructions. If a person calls an elevator he has to first press the button then the sensor present in the button will send a request instruction to the main controller, then system identifies the floor button, the used had pressed. If there is any new request, it moves to the list of the floor. Sometime the elevator is at standstill situation, in this case elevator control system finds out in which direction the elevator should go to serve new request, when user presses door button of the elevator. When door is closed the system sends an instruction to the dc motor present in the elevator, to start moving elevator in upward and downward according to the pressed button. While carrying people between the floors the proximity sensor detects that the elevator is coming to a floor and sends an instruction to the system to stop the elevator and to open the door of the elevator.

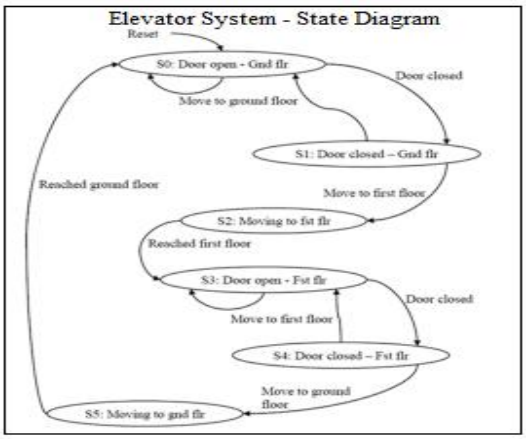

Figure:-3 Proposed flow diagram of elevator unit

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ASSUMPTIONS OF AN ELEVATOR SYSTEM

The elevator controller has to face some conflict while operating the system like which elevator unit should allow to follow the call of elevator when both are present at the same time. Therefore some assumptions have to assign in the elevator algorithm. These assumptions are:

Elevator Priority: Generally in all the elevator control system, the elevator 1 deals with the all request of first floor and floor 2 deals with the all request of the second floor.

Default State: In order to increase the speed and response of the elevator, the elevator 1 with closed gate at first floor should be set as default and elevator 2 with the closed gate at second floor and so on.

Closing the Elevator Door: The gate of the elevator should be closed automatically after sometime and closing time is predefined in the program. The timer should count 0 at the time of closing the gate and after closing the gate it should count 1.

BIOMETRICS

The term "biometrics" is derived from the Greek words bio (life) and metric (to measure). It is more reliable technique to distinguish between an authorized person and an imposter compared to other traditional techniques. Biometrics basically recognizes a pattern based on physiological and behavioral attributes of a person like fingerprint, face pattern, voice, handwriting, etc. The system that successfully recognizes and verifies these biological attributes of a person is called biometric system. Biometrics security systems now become the most trusted method in process of recognition and verification of a person. Among all the biometrics attributes fingerprints are known to be oldest and most used attribute in recognition process.

In this paper our main aim is to develop a vein fingerprint based elevator controller that only few people have the authority to access the elevator by going through a process of vein fingerprint recognition and verification.

The basic building blocks of a biometric system are shown in figure 4.

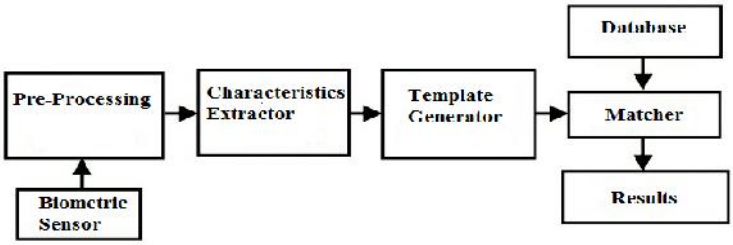

Figure:-4 Basic block diagram of biometric system

The extraction of the minutiae from the scanned fingerprint image is the most important stage in vein fingerprint recognition. Minutiae extraction depends on the quality of the scanned fingerprint image. The quality of input vein fingerprint image should be fine to ensure the successfulness of the fingerprint recognition; hence it is required to use image enhancing method to enhance the quality of the scanned image of the vein fingerprint.

FINGER VEIN BIOMETRICS

In this technical era, biometric attributes like iris, fingerprint, and keystrokes [6] are already being in use, and are considered as the traditional ones, biometrics utilizing vein patterns are more recent and therefore less developed. However, with traditional biometric methods, it is relatively easy for another person to obtain unauthorized biometric data, since they achieve authentication by utilizing information from the external body.

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The simple approach to realize fingerprint recognition system is depicted in figure 5. It comprises of a fingerprint recognition process and a minutiae matcher. Fingerprint recognition process comprises of cascaded blocks of preprocessing, feature extraction and post processing stages. It converts the input vein fingerprint image into a set of minutiae, stored as template for future matching purpose. The minutiae matcher provides the acceptance / rejection of fingerprint under test by comparing it with the saved images of users stored in database of the system.

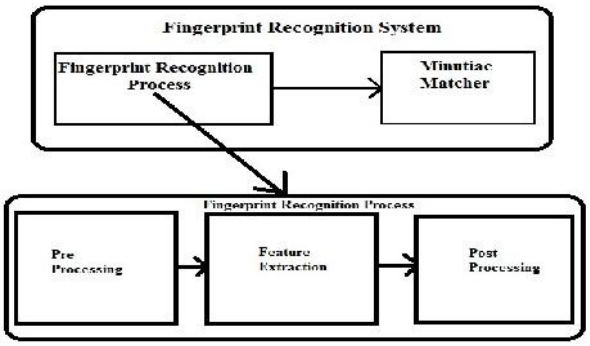

Figure:-5 Simple Fingerprint Recognition System

Vein biometrics basically uses a network of blood vessels inside the person's skin which are already proved to be unique to each individual just like the fingerprints and also are not change naturally for many years [7]. Since these veins are present inside the person's skin and are not visible to human eye, thus these veins are difficult to replicate by any imposter and also are safe from external damage. Moreover the vein fingerprint also senses the flow of blood in the vessel aliveness detection is automatically present in the system. It helps to make sure that only alive person is capable to access the elevator, hence reducing the chances of frauds. Vein fingerprint provides more security, reliability for a biometric recognition and verification system because these patterns are unique, offers better stability compared to the other traditional methods of authentication and also has great resistivity to the criminals and imposters.

DESCRIPTION & SYSTEM ARCHITECTURE

Figure 6 shows the top-level conceptual design of the proposed biometric system. In this proposed system, the vein pattern is captured by using a low-cost modified IR webcam connected to a PC.

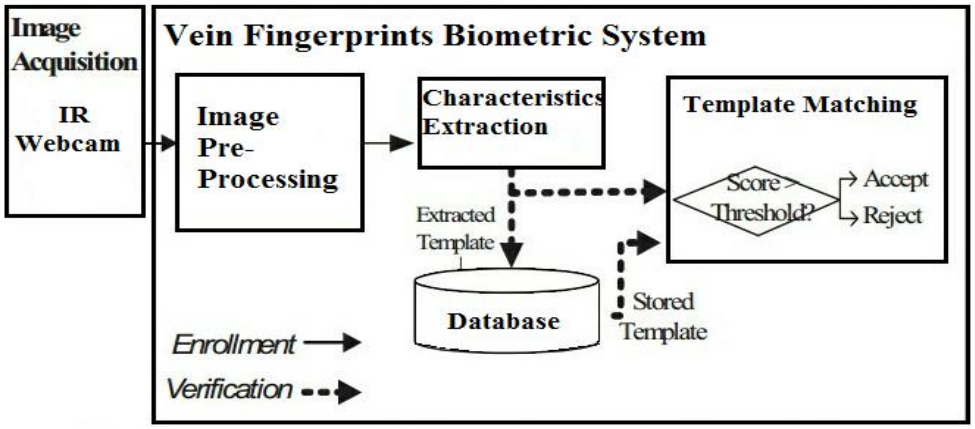

Figure:-6 Conceptual design of proposed biometric system

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In this method we use an IR sensor having wavelength of 1000nm. This IR sensor scans the blood vessels of a person and hemoglobin present in the blood to observe the pattern of vein fingerprint in order to store it in database of the system [8]. In this controller light transmission technique as shown in figure 7 with NIR technique is used. In this technique, the finger of a person is put between the infrared light-emitting diode (IR LED) and an image acquisition module to capture the image, generally a modified webcam with an attached IR filter is used in this purpose. In the resulting image, the vein patterns taken appear to be darker. Image captured is 320wx240h pixels in size, with 3 bytes per pixel.

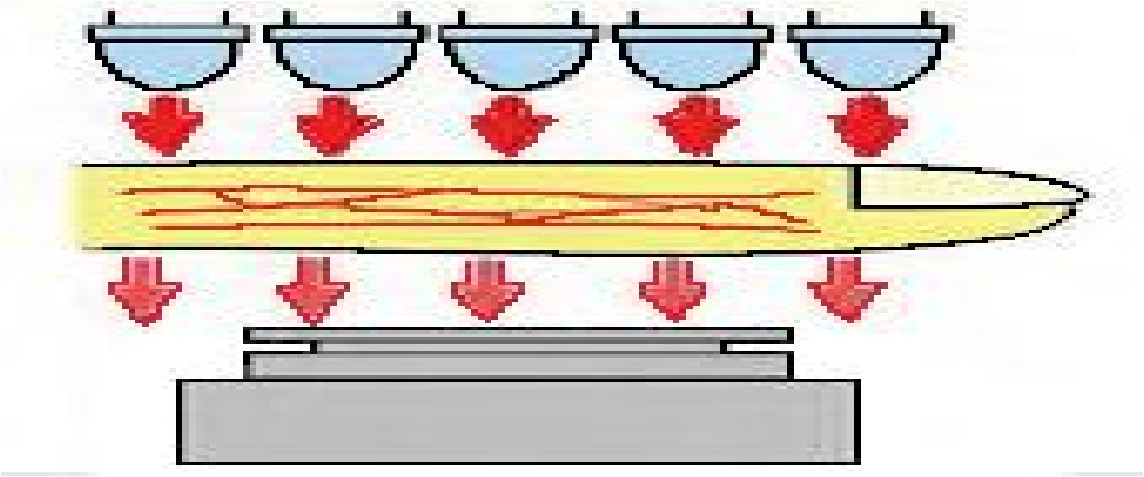

Figure:-7 Finger vein imaging technique

The captured image is then transferred to an FPGA System on chip for recognition and verification, which involves the process flow of image preprocessing, feature extraction and template matching. As shown in Figure 6, in the enrollment stage of the process, users register their fingerprint data with the system. The vein fingerprint templates are stored in the database in the on-board flash memory, thus providing strong security. In the verification stage, users present their vein fingerprints as well as the information of the claimed identity to the system, and then system scans all the data present in the database one by one. Based on the result of this scan, the system determines the user as either a genuine user or as an imposter.

PROPOSED SYSTEM

We proposed a vein fingerprints based elevator control system using FPGA. It is expected that this system will provide more security from unauthorized access to the elevator [9]. The system that we proposed here stores the vein fingerprints pattern of the authorized users in the database. To use the elevator, user vein fingerprint has to be verified otherwise the door of elevator would not open [10]. If the image of vein fingerprints are matched with the image of vein fingerprints feed in the database, access will be allowed to the user and door of the elevator would open.

Figure 8 shows the system architecture of the proposed system in a FPGA-based SOC platform [11]. We have applied the hardware-software partitioning that leads to an effective cost-speed tradeoff. Speed performance is achieved by the application of hardware-software co-design methodology, using hardware acceleration for the compute-intensive image preprocessing tasks and image buffer management while leaving feature extraction and template matching processes to software [12]. The on-board SDRAM and flash memory units will contain the Nios2-Linux RTOS and the template database respectively.

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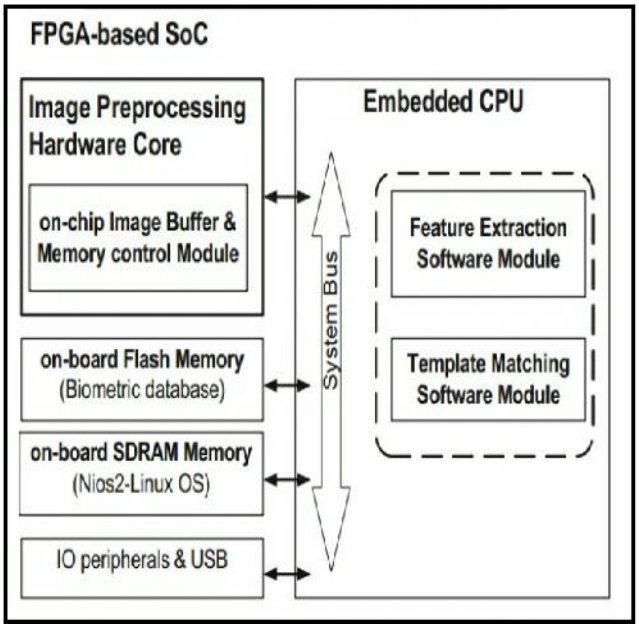

Figure:-8 System architecture of proposed biometric system

RESULTS AND REPORTS

In this paper the biometric based elevator is proposed successfully. To design the elevator system Xilinx-ISE tool is used. The programming of the controller is completed by using Verilog HDL [13-14].

From the result it is clear that vein fingerprint based elevator controller is a way more secure than other used traditional technologies.

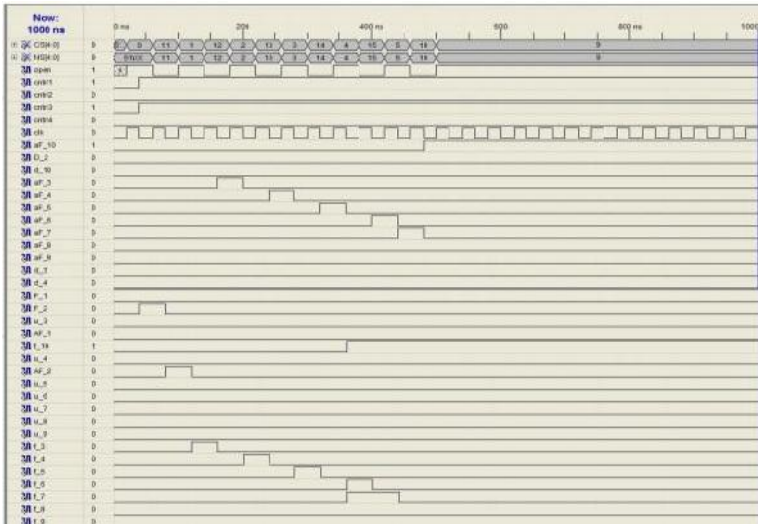

Figure:-9 Simulation Result

From the simulation result we observed that when signals passed through the FPGA, the transformation and translation of the signal from input moved to rapidly to the output of the system.

Figure 11 shows that the output image of each module in the image pre-processing HW core. The figures show clearly the vein pattern extracted. Figure 10 illustrates minutiae template extracted from a sample finger vein pattern.

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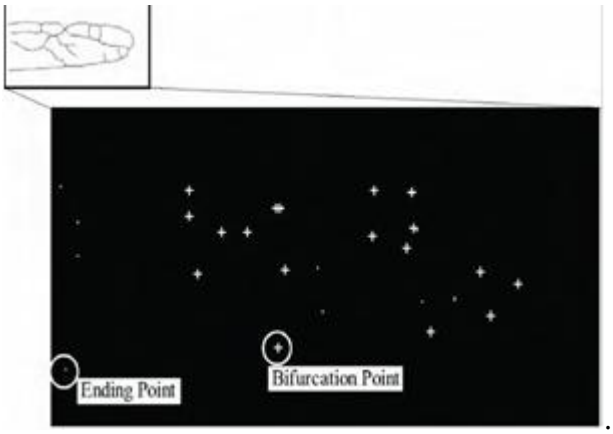

Figure:-10 Extracted minutiae template of sample finger vein

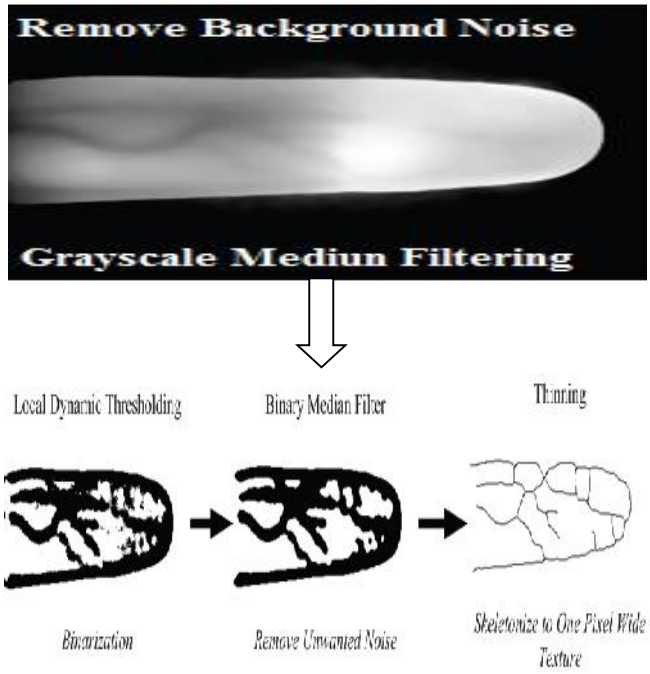

Figure:-11 Output image of image processing

The SOC is prototyped on an Altera Nios2 FPGA development board running the Nios2-Linux OS at 50MHz clock. The experimental results have shown the performance bottlenecks, and future opportunities for optimizing the system have been identified.

CONCLUSION

The proposed elevator controller based on biometrics offer greater reliability, security, and is more stable compared to the traditional biometrics recognition and verification techniques. Since FPGA [15-16] has many advantages over microcontroller, to design this elevator controller is more cost-effective compared to microprocessor based controllers. We proposed this elevator controller in such a way that very few resources required for developing this controller that makes it more efficient when compared to other controllers based

on microcontrollers. For simulation FPGA Altera Nios II prototype board is used. The key contributions of the proposed work are minimal utilization of the available hardware resource, low processing time and low power consumption. In future by enhancing the quality of the vein fingerprint image we can reduce the errors and make system more reliable.

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