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Image Processing to Collect the Radius of Human Pupil.

Carlos Frederico Fronza*[1], Yasser Issmail Mohsen[1], Jefferson Luiz Brum Marques[1]
Institute of biomedical engineering of the electrical engineering department, Federal Universityof Santa Catarina, Campus Universitário Reitor João David Ferreira Lima, Trindade – Florianópolis- Santa Catarina - Brasil Cep: 88040-970.

ABSTRACT
The human activity is played by the nervous system, the neuropathy destroy the neuron and with that the capacity of data transmission by the nervous system is jeopardize[1]. Theanalysis of the autonomic nervous system (ANS) can give some crucial answers regarding to the level of diabetic neuropathy allowing the earlier diagnosis[2]. Thehuman pupil light response.The follow project proposes the development a multiplatform methodology, using FPGAtoolfor acquiring, processing, analysis andclassification the data capture aimed theearly diagnosisofautonomic neuropathyin individuals withdiabetes mellitus.

Key words: Diabetes Mellitus, Autonomic Neuropathy, FPGA, Heart Rate Variability, Blood Pressure, Biomedical Instrumentation.

I. INTRODUCTION

The humanpupil size, shape in time after the light reaction have been used to indicatesome neurological. In the eye exist a circular and radial muscle that controls the pupilsize. The anterior is innervated by parasympatheticfibers, and the latter, by sympathetic fibers [3]. Hence, the pupil opening is controlledby both the sympathetic and parasympathetic autonomic nervous system inresponse to light, it is called the pupil light reflex. Consequently,the pupillary opening response to an external light stimulus could provide a way tomeasure the integrity of neuronal pathways controlling pupil size [4] . To collect and store the pupil radius the FPGA (Field Programmable Gate Array) was chosen due its speed and flexibility. The FPGA offer a vastly parallel hardware architecture and counting with low power depletion, an alternative for digital signal processing [5].

By the FPGAs incredible capacity toprocessing image and data. This work treats about a FPGA Altera cyclone IV to perform the image processing of the human eye, in order to study the behavior autonomic neuropathy.

II. METODOLOGY

The assessment of autonomic dysfunctions caused by diabetes mellitus can be observed by stimulating the autonomic nervous system through the pupilometry, heart hate variability, blood pressure, respiratory frequency [6][7]. This three variables cited before made the system have more credibility once increase the probability of system accuracy [8].

The FPGA come to better develop the understanding of the disease, due to the precision, velocity of image capture and processing. The light architecture and the facility to work and comprehend the functions are advantages and motivate the use the FPGA tools [9].

It was used the Altera FPGA cyclone IV, with 114480 LEs, 529 IOs. The FPGA is integrated to Terasic student board DE2-115 with 128Mbits SDRAM memory. Was used a 100 frames/s camera and a 320x240 video size. The frame speed mentioned help to captured better minor behavior of the eye to see more accurate the consequences of the human eye movement during the pupil contraction and relaxing when exposure to light. A HDL system was created to assure that our architecture works at machine speed. However for the final processing of the threated image data was necessary the use of NIOSII.

The architecture comprehends several blocks who describe the main system. The flux of the blocks was developed in QSYS system tool and after joined to Quartus2-12.1 top level file. The video data flow system begins with the video_in block that instantiates what kind of camera and video image is to be used. The video av_config in Qsys system helps to regulate the video entrance to NiosII. The clocks used for this system was the main clock(50MHz), the SDRAM_CLK (100MHZ) and VGA_CLK (27MHz), also was made a sdc in quartus to held to finish with the time problem. Before the data reach the memory, VGA_output and the PC, the video data go through the images processors. The processors will transform the image using filters, FT transforms, bits and

Chroma resample, Black and white transform and edge detection. After all data transformation, the image is stored at SDRAM, after that the image data pass to a connected labelling block to extracted the radius from the video. In the same time it is captured the others two physiological signals, the HRV and BP, this two will be concentrated and through the RS-232 port arrive at FPGA to be processed after be NiosII. The main structure of the system, the pupilometry can be seen in figure 1.

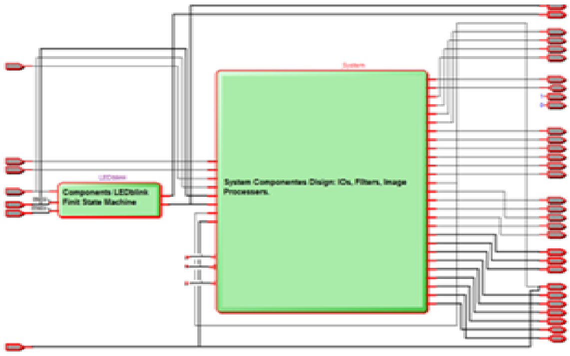


Figure 1. How the data flows in the architecture proposed.

The top level design was made in Verilog computation language. The Verilog was chosen due its lean characteristic making the image processing even faster. The figure 2 shows the pupilometry, led blink and the serial port view structure. top.

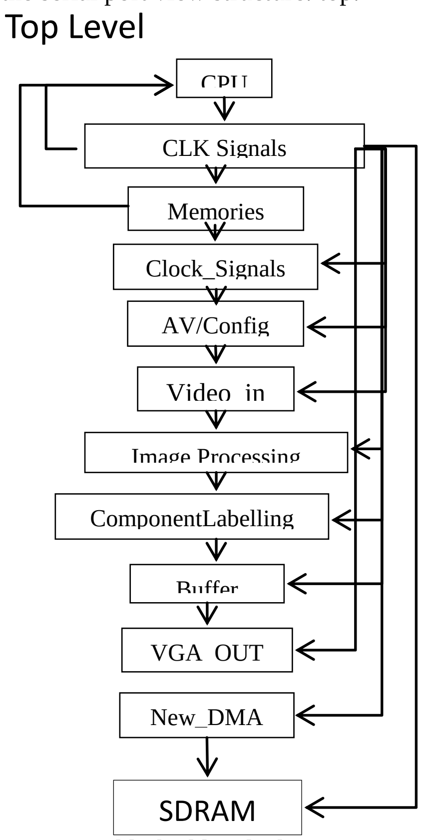


Figure 2. Top and linked levels diagram FPGA.

The LED_blink function was created to stimulate the eyes with differences frequencies and interval time light flash, using VHDL language it was made a Finite State Machine (FSM) to give the dynamic necessary to give the system the possibility to regulate the flash light blink during the experiment thought the DE2-115 board. The design was made to possibility human interaction by the switches to choose the better timing and intensity of blinking led during the experiment.

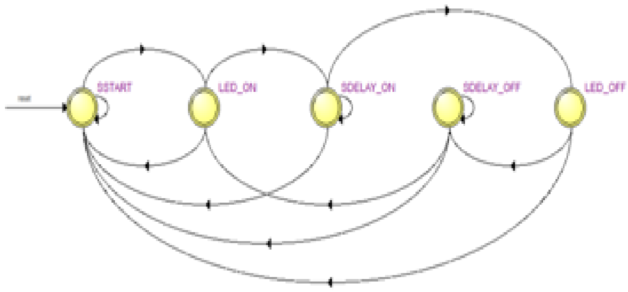


Figure 3. Ledblink finite state machine.

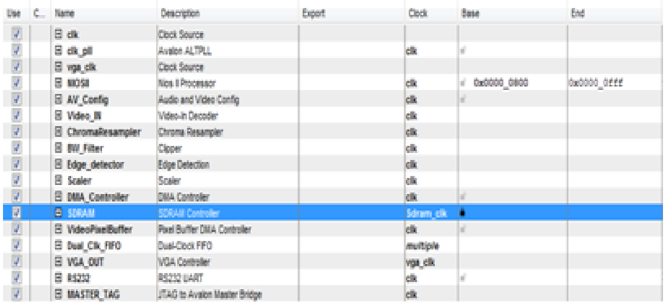
2.1 PUPILOMETRY

Pupilometry is simple, low-cost, and not invasive method to evaluate the autonomic nervous system, through a pupil evaluation in light reaction, using a series of flash lights [10], [11]. The pupil analysis to discovery autonomics dysfunctions is the most sensitive technique [12]. The pupilometry regarded as the measurement of pupil size in time before and after a flash light, when the patient pupil remains in a dark environment during all the experiment [13].

For the pupilometry work in the dark was utilized the infrared light that doesn't stimulate the pupil however it's light is reflected by the pupil dark aspect, that is solved by a simple image processing [14] [15].

2.2 QSYS

QSYS is an important IP core integration device from Altera that helps to have a better use and understanding of the low level design we choose to make. Using the QSYS toll it's possible to simplify the top level architecture, and peripherals code saving time during the project development, once it's capable to give to the programmer the data flow in the design, interconnecting logical blocks to connect intellectual property (IP) functions and subsystems[8]. In this Qsys project was insert in the main context a master tag the available us to manipulate the board in real time to better configure the system without serials of compilation, The figure 4 shows a model used in Qsys system.



Use	C...	Name	Description	Export	Clock	Base	End
✓		clk	Clock Source				
✓		clk_pll	Avalon ALTPLL		clk	✓	
✓		vga_clk	Clock Source				
✓		NIOSII	Nios II Processor		clk	✓ 0x0000_0800	0x0000_0fff
✓		AV_Config	Audio and Video Config		clk	✓	
✓		Video_IN	Video-In Decoder		clk		
✓		ChromaResampler	Chroma Resampler		clk		
✓		BW_Filter	Clipper		clk		
✓		Edge_detector	Edge Detection		clk		
✓		Scaler	Scaler		clk		
✓		DMA_Controller	DMA Controller		clk	✓	
✓		SDRAM	SDRAM Controller		Sdram_clk		
✓		VideoPixelBuffer	Pixel Buffer DMA Controller		clk	✓	
✓		Dual_Clk_FIFO	Dual-Clock FIFO		multiple		
✓		VGA_OUT	VGA Controller		vga_clk		
✓		RS232	RS232 UART		clk	✓	
✓		MASTER_TAG	JTAG to Avalon Master Bridge		clk		

Figure 4. Qsys System from Altera.

To process the video stream was first use a Gaussian smoothing filter and decrease noise in the images. Afterfirststepthe stream gets through a Sobel operator processor, which computes the gradient of the image intensity. Then, the stream is processed by a non-maximum suppression filter, which finds the directions of the gradients. Finally, the stream is processed through a hysteresis filter to determine which gradients are edges. It can be seen at Figure 4 that shows the block diagram of the core[16].

The goal of image edge detection is to discoveryin a frame an abruptchange in brightness, indicating the limit of the image. Through edge detection can be founded the discontinuities in surface[17].

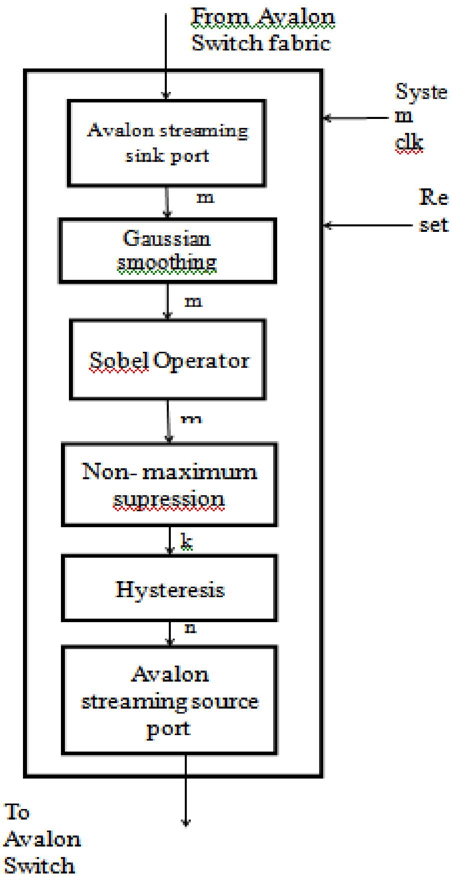


Figure 5. Edge detector block diagram.

Source: ALTERA, 2013.

2.3 Processing Image.

The final request of image processing was the radius and time data collect and storage. Once after the first image processing the image stored in SDRAM are a black and white image, where the pupil is black and the background is white, as show in figure 5. Now we are able to find the center o mass of the image we want.

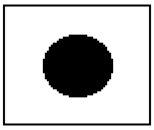


Figure 6.shows the pupil all black and the rest of the image white, a binary image.

To give the accuracy to that this system required, was made a center of mass and radius find block and insert in qsys flow.The out coming is the radius in time of the pupil stored in the on chip memory and pc thought the host based file system waiting for the statistical analysis.

In the Figure 8 it can be seen the final image processing. The edge detector in the eye separated the pupil from the rest. The algorithm search in the frame for the edge and after found start to count until find the another edge, stored size number in a vector, and continuous till find the greatest size, the pupil diameter. It is shown in red in Figure 7.

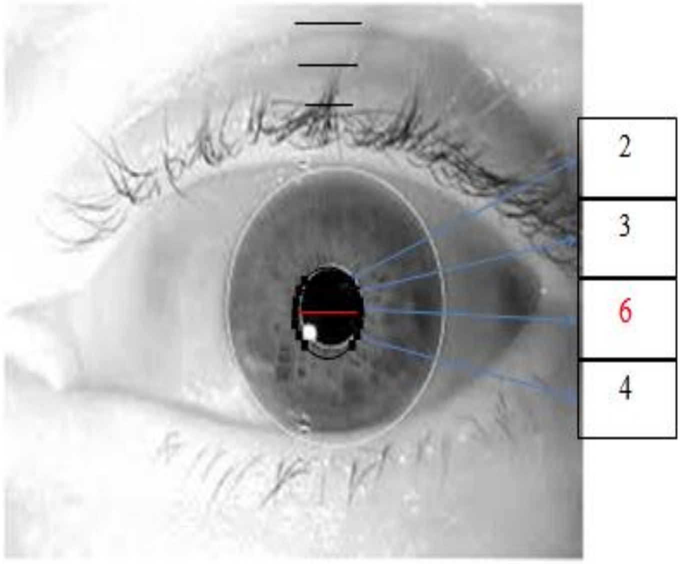


Figure 7. Pupil Image Processing finding the diameter.

III.PROJECT OUTCOMMING

We were able to extract images from the camera, treat the images with images processing system and stored into the SDRAM. Once in the SDRAM the video was extracted and the pupil radius was calculated and was made the connection with the personal computer and collects the data to make the analysis of the out coming. The images in PC give to us the possibility to processing in matlab to confirm the accuracy of the system.

3.1 IMAGES FROM THE CAMERA

After all processing the video output is raw image in black and white using the pupil edge detector, ready to processing, after the image treating the result is frames in bmp format and a csv file containing the pupil radius dimensions in time. The figure 7 show the image collected before and after the flash light demonstrating the differences of pupil ray. The pupil ray can be used to find disease that affects the human neurons, the neuropathy.

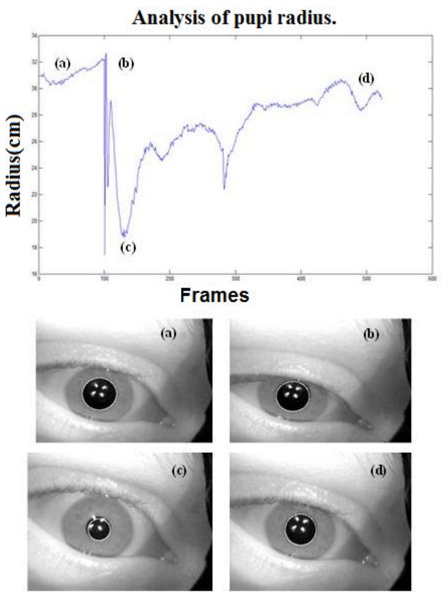


Figure 8. Show the pupil radius contraction and relaxing after the flash light, were a. moment before the flash, (b) and (c) show the contraction after the flash and in (d) the eye is back to normal.

IV. CONCLUSION

By means of the system proposed it were able to collect the images frame by frameand stored in a SDRAM memory and give the second processing collecting the radius. All the image processing occurs at the same time of image collect showing the fast processing and image analysis.

With the collected data it is possible to analyses the human autonomic system.

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