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IMAGE ENHANCEMENT AND HARDWARE IMPLEMENTATION OF EDGE DETECTED VASCULAR IMAGES USING SIMULINK MODEL

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Abstract: Vascular Imaging is a key component in comprehensive stroke diagnosis. Aiming at the complex background of vascular images, weak contrast between the vessels and the background, a new vascular enhancement method based on classical image processing techniques is proposed. The problem in Canny's hysteresis thresholding method having two threshold values which yielded low performance in localization and noise rejection has been overcome with a not complicated and accurate algorithm.

In this paper an efficient image enhancement algorithm i.e., pre processing, contrast adjustment and edge abstraction is implemented on Spartan -3 FPGA using Simulink model which comprises of Simulink blocks and Xilinx blocks. Accurate and faster results are obtained by interfacing with Matlab and XSG through the workspace of Matlab.

Keywords: Segmentation, Vessel extraction, Canny edge detector, thresholding, Image enhancement, FPGA Implementation, Xilinx System Generator (XSG), Simulink, Co-simulation.

I. INTRODUCTION

The purpose of detecting sharp changes in image is to capture important events .Edge detection is of fundamental importance in image processing particularly in feature extraction. Detecting edges from a low-quality image where gradient signals are degraded is a challenging task Segmentation plays a vital role in the detection of blood vessels in an angiogram image. It is a process of partitioning an vascular into several non-overlapping regions. Thus it is used to extract the vascular and background regions. but this method does not provide sufficient information for locating the boundary of the blood vessel and hence the performance of segmentation becomes complicated [1, 2, 6, 8, 11].

Thus edge detection is done using first order derivative (Gradient operator), Second-order derivative (Laplacian operator) and also using the Sobel and Prewitt algorithms [7, 9]. Canny proposed the hysteresis thresholding method in which two threshold values have to be given. However, its performance was not good enough with respect to detection, localization, and resolution and noise rejection. The percentage of true edges detected is also less as compared to the other algorithms so proposed in the literature [14].

In this paper, the edges of the vessel in the vascular image is detected using the proposed algorithm which involves the Pre-processing step, where the noise is removed using the Median filter and Histogram equalization technique, instead of the Canny edge Detector. Median filtering is useful in eliminating the intensity spikes while preserves the edges in Histogram equalization stretches the image and FIR filter is used to detect the edges.

Communications, signal processing, video processing and image processing [4].

II. IMAGE ENHANCEMENT ALGORITHM

The proposed algorithm has overcome the drawbacks of Canny edge detection method has the following steps:

(i)Smoothing:

Smoothing is used to remove the noise. The Gaussian Filter has been used to remove the noise.
The kernel of a Gaussian filter with a standard deviation of σ = 1.4 is

$$B = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix}$$

(ii)Finding Gradients:

The edges whose gradients are large are marked here. The gradient is approximated by using the kernels

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$$K_{GX}=\begin{bmatrix}-1 & 0 & 1\\ -2 & 0 & 2\\ -1 & 0 & 1\end{bmatrix}$$

$$K_{GY}=\begin{bmatrix}1 & 2 & 1\\ 0 & 0 & 0\\ -1 & -2 & -1\end{bmatrix}$$

The gradient magnitudes can be determined as an Euclidean distance measure by applying the law of Pythagoras

$$|G|=\sqrt{G_X^2+G_Y^2}$$
$$|G|=|G_X|+|G_Y|$$

The direction of the images can be determined by

$$\theta=\arctan\left(\frac{|G_Y|}{|G_X|}\right)$$

(iii)Non-maximum Suppression:

This makes only the local maxima as the edges.

(iv)Double Thresholding:

The thresholding is used to determine the potential edges.

(v)Edge Tracking by Hysteresis:

Edge tracking is implemented by using BLOB analysis. By this the final edges are determined by suppressing the edges which are not connected to the potential edges.

Enhancement Algorithm:

A. Pre-processing- Median Filter:

The Algorithm proposed has replaced the Gaussian filter with the Median filter for the complete removal of the salt and pepper noise. Median filter is a non-linear filter which performs digital filtering technique. Noise reduction is a typical pre-processing step to improve the results of later processing.

B. Histogram Equalization:

Histogram equalization is a method in image processing for contrast adjustment. This method is useful in images with backgrounds and foregrounds that are both bright or both dark.

Let r represent the grey levels in the image to be enhanced. Assume r to be normalized in the interval [0, 1], with r =0 representing black and r = 1 representing white. For any value r in the interval [0,1], the image transformation is given as,

$$S = T(r),\ 0 \le r \le 1.$$

The probability of occurrence of gray level r_k in an image is approximated by

$$p_r(r_k) = \frac{n_k}{n} \qquad k = 0,1 \ldots.\ L-1$$

Cumulative distribution function corresponding p_x is given as

$$cdf_x(i) = \sum_{j=0}^{i} p_x(j)$$

The CDF must be normalized to $[0, 255]$. The general histogram equalization formula is: $h(v) = round\left(\frac{cdf(v)-cdf_{min}}{(M\times N)-cdf_{min}} \times (L-1)\right)$

C. Edge Detection-2D FIR Filter:

The filter is rotated 180 degrees in order to perform the two-dimensional correlation which basically involves the two-dimensional convolution to detect the edges. For a digital image, we consider a discrete 2D array of space or of space and time and consider the discrete imaging equation given by

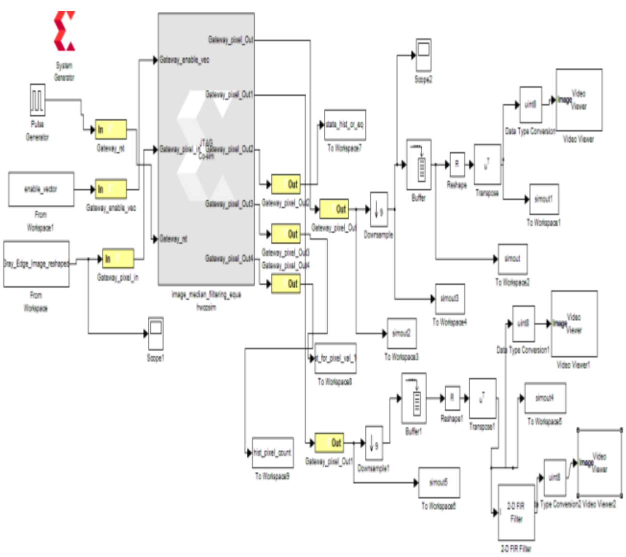
$$S_{ij} = p_{ij} \otimes\otimes f_{ij} + n_{ij}$$
$$= \sum_n \sum_m p_{i-n,j-m} f_{nm} + n_{ij}$$

Where

$\sum_n \equiv \sum_{n=-N}^{N}$ and $\sum_m \equiv \sum_{m=-M}^{M}$.

III. SIMULIN MODEL

Matlab is a tool used for algorithm development and analysis of the data. The Image Enhancement Algorithm has been extended to the Matlab model. Simulink is a graphical tool which allows the user to graphically design the architecture and perform simulation. Simulink helps to build up the models from libraries of pre-built blocks. Xilinx System Generator (XSG) for DSP is a tool which offers block libraries that plugs into Simulink tool.[11]. Xilinx System Generator is a DSP design tool from Xilinx that enables the use of the Math works model-based design environment Simulink for FPGA design. It extends Simulink in many ways to provide a modeling environment that is well suited to hardware design. The tool provides high-level abstractions that are automatically compiled into an FPGA at the push of a button [11]. All of the downstream FPGA implementation steps including synthesis and place and route are automatically performed to generate an FPGA programming file. System Generator provides many features such as System Resource Estimation to take full advantage of the FPGA resources, Hardware Co-Simulation and accelerated simulation through hardware in the loop co-simulation; which give many orders of simulation performance increase [11]. The Image Enhancement Algorithm has been verified using the Matlab Simulink model and the model is:



IV. COMPARISON OF RESULTS:

Angiogram Image is given as input to different algorithms and the results are presented

Input Image:

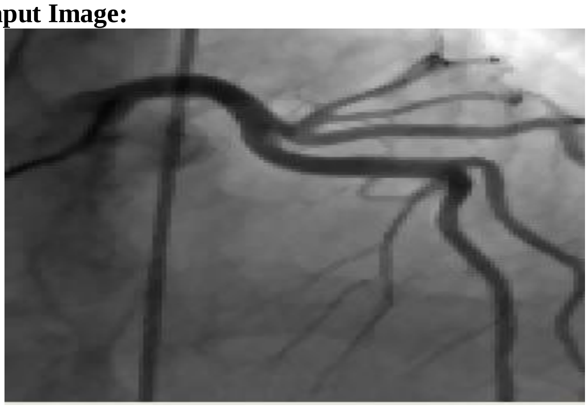
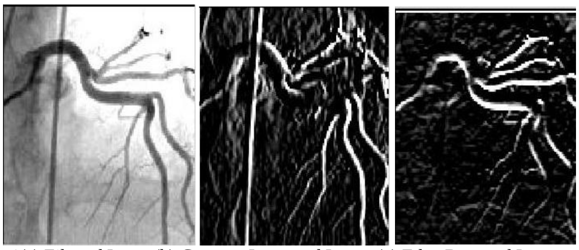


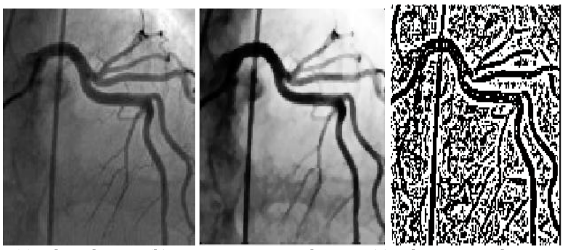
Figure 1:The Original Image

Canny Edge Detection Result:



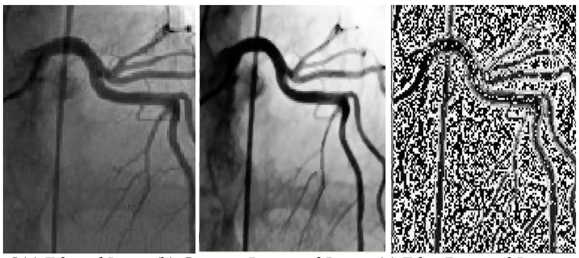
1(a) Filtered Image(b) Contrast Improved Image (c) Edge Detected Image

Image Enhancement Algorithm Results:
Matlab Results:



2(a) Filtered Image(b) Contrast Improved Image (c) Edge Detected Image

Simulink Results:



3(a) Filtered Image(b) Contrast Improved Image (c) Edge Detected Image
Figure 2: Edge Detection Results

V. SYNTHESIS REPORT:

From the Simulink model HDL and Xilinx logic cores are generated for each Xilinx block in the Simulink Model using Xilinx 14.1 System Generator as shown

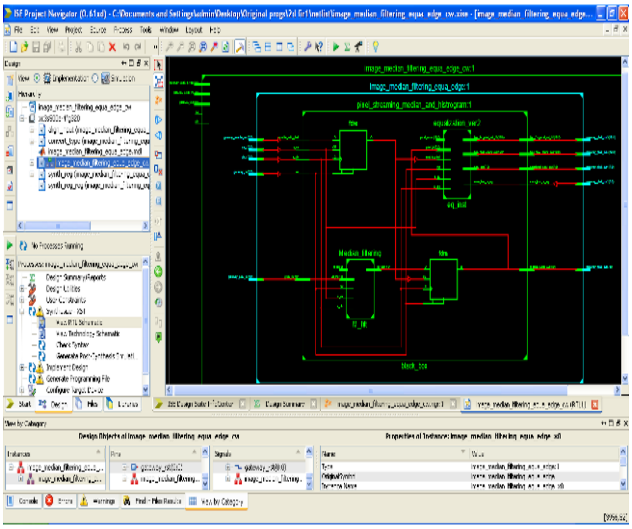


Figure 3: The RTL Synthesis Image

VI. CONCLUSION

In this paper, the edges of the Angiogram image are detected using various techniques such as median filtering, Histogram Equalization and 2D FIR filter. It is observed that the edge detected image of the Image Enhancement Algorithm is more clear and accurate than the Canny edge detected output by overcoming the thresholding problem. The results obtained from the Xilinx/Simulink model are faster. In our model, the interfacing of Matlab and XSG is done through the workspace of Matlab to obtain better results with high speed. The Image Enhancement Algorithm is performed on Matlab as well as Simulink Model and it has been verified on Spartan-3E FPGA.

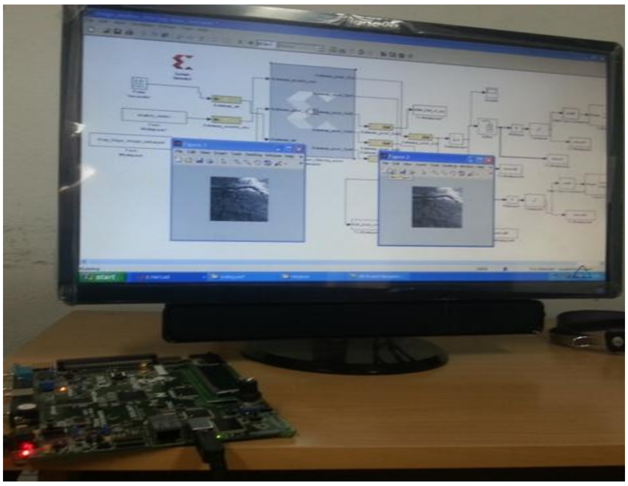


Figure 4: Implementation On FPGA

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