

# Medical Image Analysis on Software and Hardware System

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**ABSTRACT:** Biomedical Engineering is one of the main areas where in the image processing plays a wide role. Medical imaging and its processing is a topic of interest which helps for easier diagnosis and analysis of the medical issues. Detection of the areas affected is the basic step in the processing. In this work, Prewitt edge detection and Sobel edge detection of a Computed Tomography image of brain with tumour is considered. The process is carried out on Software and Hardware system for different sizes of the image and the time taken are analysed.

**KEYWORDS:** Biomedical Engineering, Image Processing, Medical Imaging, Edge Detection, Computed Tomography, Software and Hardware system

## I. INTRODUCTION

Biomedical Engineering is the field which bridges the medical field to many other fields like engineering, applied mathematics, physics and so on [1]. The advancements brought in the technology is now being effectively used in medicine. One such area which brings improvement in the medical diagnosis is the medical imaging and its processing. Images of various parts of the body are obtained from various techniques like Computed Tomography (CT), X-Rays, Magnetic Resonance Imaging (MRI), endoscopy, ultrasonic imaging etc. These obtained images are to be processed for better identification of the problems. In that stage, image processing comes into picture. Image features detection, extraction, segmentation, colour enhancement and many more criterions are achieved through image processing.

Brain is the central system of a human body. It controls all the activities. Growth of abnormal cells in the tissues of brain are the tumours. These tumours could be either cancerous (malignant) or non-cancerous (benign) [2]. Detection of these tumours and immediate treatments are essential. The size of the tumour and its location are to be identified [3]. To achieve this segmentation of the image is to be carried out. Segmentation is mainly achieved by techniques based on edge detection or based on thresholding or region based [4].

Edge detection is the fundamental step in most of the image analysis methods. Changes in the intensity is obtained through edge detection. Derivatives helps in the finding the changes in intensity of the image and thus help in detection of edges. Edge detection are basically classified as Classical or Gradient based edge detectors (first derivative), Zero crossing (second derivative), Laplacian of Gaussian (LoG), Gaussian edge detectors, Coloured edge detectors [5]. The classical or gradient based methods include Roberts, Prewitt, Sobel and Canny edge detections.

First derivative is defined by the magnitude of gradient. The gradient of an image  $I$  at  $(x, y)$  is given,

$$\nabla I = \text{grad}(I) = [G_x, G_y] = \left[ \frac{\partial I}{\partial x}, \frac{\partial I}{\partial y} \right] \quad (1)$$

where  $G_x$  and  $G_y$  are the gradients of the image  $I$  in horizontal and vertical directions respectively.

$$G_x = \frac{\partial I}{\partial x} = \frac{f(x+1, y) - f(x-1, y)}{2} \quad (2)$$

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$$G_y = \frac{\partial I}{\partial y} = \frac{f(x, y + 1) - f(x, y - 1)}{2} \quad (3)$$

The magnitude of the gradient is given by,

$$G = \sqrt{G_x^2 + G_y^2} = |G_x| + |G_y| \quad (4)$$

where  $G$  is the value of rate of change in the gradient vector direction.

Edge detection is done by convolution of original image with the coefficient of gradient along  $x$  and  $y$  direction.

## PREWITT EDGE DETECTION

In Prewitt edge detection method, equal weights are assigned to the neighbourhood pixels of the pixel whose edge strength to be detected. The mathematical equation given in equation (5) is used to design the kernel.

$$|\nabla I| = |(I_7 + I_8 + I_9) - (I_1 + I_2 + I_3)| + |(I_3 + I_6 + I_9) - (I_1 + I_4 + I_7)| \quad (5)$$

where  $I_i$  is the coefficient of gradient operator.  $i$  is the coefficient place value of mask pixels.  $|\nabla I|$  is the gradient operator. Prewitt operator convolution mask is given in Figure 1.

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

$G_x$

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

$G_y$

Figure 1: Convolution mask of Prewitt edge detection [6]

## SOBEL EDGE DETECTION

In Sobel edge detection algorithm, pixel weights assigned to the pixel in neighbourhood of the candidate pixel are not equal like in the case of Prewitt edge detection. Operations are similar to that practised in case of Prewitt edge detection. The mathematical equation defining the kernel is given in equation (6).

$$|\nabla I| = |(I_7 + 2I_8 + I_9) - (I_1 + 2I_2 + I_3)| + |(I_3 + 2I_6 + I_9) - (I_1 + 2I_4 + I_7)| \quad (6)$$

where  $I_i$  is the coefficient of gradient operator.  $i$  is the coefficient place value of mask pixels.  $|\nabla I|$  is the gradient operator. The convolution mask of Sobel edge detection is given in Figure 2.

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

$G_x$

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

$G_y$

Figure 2: Convolution mask of Sobel edge detection [6]

## II. RELATED WORK

Computer aided technologies have great influence on medical processing. Introduction to some of the basic concepts and techniques used is presented by Zhu [1]. One such processing is the CT image processing. Brain CT images are to be processed for proper analysis in case of any disease. Brain tumour detection helps in finding the size of the tumour and the location of it. Mustaqeem et al. proposed an efficient algorithm for tumour detection based on segmentation and morphological operator [3]. Al-Ashwal et al. performed brain tumour extraction and histogram analysis of CT image of brain [7]. Ge and Shen [8] designed an algorithm for feature extraction based on the chart transferring tree in tree structure. Uemura et al. [9] performed segmentation based on edge detection using boundary code. Contrast Enhancement of the CT image is carried out in [10].

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Segmentation is one of the significant step in these image processing application. Various methods of segmentation is discussed in [4]. Edge detection is one of the methods for segmentation of image. Various methods of edge detection for segmentation is given in [5], [11], [12] and [13]. In [6], [14] and [15] edge detection techniques are implemented on various platforms like Xilinx System Generator (XSG), Vivado HLS and on FPGA boards.

## III. METHODOLOGY

### SOFTWARE IMPLEMENTATION

Edge detection is implemented on Matrix Laboratory (MATLAB) software by writing a MATLAB code. The Prewitt and Sobel edge detected images are obtained. The time taken for the execution of the code and to obtain the results is got by the 'tic' and 'toc' functions.

Edge detection is also carried out on MATLAB Simulink platform. The block sets present in the Simulink library are used to detect the Prewitt and Sobel edge detected images. The time taken is measured by the 'tic' and 'toc' functions and execution of the Simulink model is performed through the MATLAB command prompt.

The above procedures were carried out on a Intel core i7 processor and in MATLAB 2012a platform.

### HARDWARE IMPLEMENTATION

Field Programmable Gate Array (FPGA) is used to implement Prewitt edge detection and Sobel edge detection on hardware. Very High Speed Hardware Description Language (VHDL) code is written for edge detection. The image details are converted to coefficient file (.coe) using MATLAB. This .coe is used to generate an Intellectual Property (IP) core of a Single Port Block Random Access Memory (RAM). From the RAM, the image pixel details are buffered and the edge detection is carried out using VHDL code. The image and the edge detected images are then displayed on the Video Graphics Array (VGA) by interfacing FPGA with VGA monitor. The flowchart given in Figure 3 explains the steps involved in edge detection of image in FPGA and display of it in the VGA monitor.

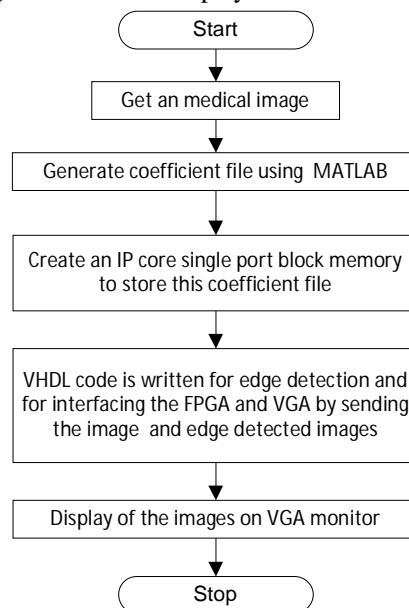


Figure 3: Flowchart showing the steps involved in edge detection in FPGA and display of images on VGA monitor

Virtex 2 Pro FPGA board (xc2vp30-7ff896), Xilinx 9.2i software was used to carry out the hardware implementation.

#### IV. RESULTS

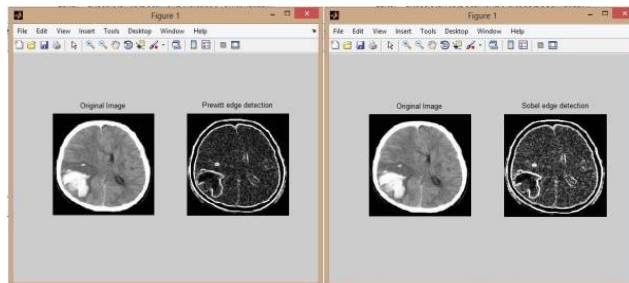
A brain with tumour CT image [7] is considered for the work which is shown in Figure 4. The white patch in the figure is the tumour. This is to be detected.



**Figure 4: CT image of brain with tumour [7]**

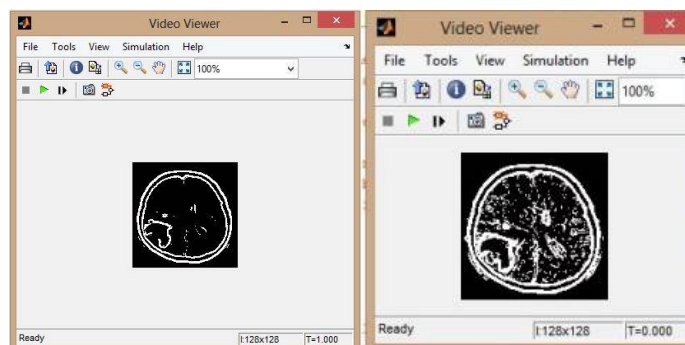
#### SOFTWARE IMPLEMENTATION

The output obtained from the Prewitt edge detection and Sobel edge detection MATLAB codes is given in Figure 5. Prewitt edge detection implementation output is to the left side. Sobel edge detection implementation output is to the right side. In both of them the original image and the edge detected images are present.



**Figure 5: Output of Prewitt and Sobel edge detection in MATLAB**

Figure 6 shows the output obtained for Prewitt and Sobel edge detections in MATLAB Simulink. Left part is the Prewitt edge detection output and the right part is the output obtained from Sobel edge detection.



**Figure 6: Output of Prewitt and Sobel edge detection in MATLAB Simulink**

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Vol. 5, Special Issue 9, May 2016

## HARDWARE IMPLEMENTATION

Figure 7 shows the Prewitt and Sobel edge detection techniques implemented on FPGA and its result displayed on the VGA monitor.



Figure 7: Output of Hardware implementation of Prewitt and Sobel edge detection

Table 1 shows the logic utilization for Prewitt and Sobel edge detection implementation on FPGA Virtex 2 Pro for the image sizes 128\*128, 160\*160 and 200\*200.

Table 1: Logic utilization for Prewitt and Sobel edge detection implementation on FPGA

Logic Utilization	Available	Prewitt edge detection			Sobel edge detection		
		128*128	160*160	200*200	128*128	160*160	200*200
Total No. of slice registers	27392	265	272	282	265	272	282
Number of slice flipflops		201	208	218	201	208	218
Number of latches		64	64	64	64	64	64
Number of 4 input LUTs		378	455	457	374	451	453
Number of occupied slices		355	412	451	353	410	449
Total number of 4 input LUTs	27392	607	718	802	605	716	800
Number used as logic		378	455	457	374	451	453
Number used as route thru		93	95	81	95	97	83
Number used for 32x1 RAMs		128	160	256	128	160	256
Number used as shift registers		8	8	8	8	8	8
Number of bonded IOBs	556	30	30	30	30	30	30
IOB latches		8	8	8	8	8	8
Number of block RAMs	136	8	13	20	8	13	20
Number of GCLKs	16	3	3	3	3	3	3
Total equivalent gate count for design		546999	879541	1350829	546983	879505	1350793
Additional JTAG gate count for IOBs		1440	1440	1440	1440	1440	1440

Table 2 shows the time taken for executing the Prewitt edge detection on different platform - MATLAB, MATLAB Simulink and on FPGA Virtex 2 Pro. Image sizes 128\*128, 160\*160 and 200\*200 are considered.

Table 2: Time taken for the execution of Prewitt edge detection on various platform for different image sizes

Image Sizes	MATLAB	MATLAB Simulink	FPGA-Virtex 2 Pro
128*128	0.16s	0.30s	6.14ns
160*160	0.19s	0.34s	6.62ns
200*200	0.24s	0.42s	6.39ns

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(An ISO 3297: 2007 Certified Organization)

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Table 3 shows the time taken for executing the Sobel edge detection on different platform - MATLAB, MATLAB Simulink and on FPGA Virtex 2 Pro. Image sizes 128\*128, 160\*160 and 200\*200 are considered.

**Table 3: Time taken for the execution of Sobel edge detection on various platform for different image sizes**

Image Sizes	MATLAB	MATLAB Simulink	FPGA-Virtex 2 Pro
128*128	0.16s	0.36s	6.07ns
160*160	0.18s	0.36s	6.63ns
200*200	0.21s	0.39s	6.20ns

## V. CONCLUSION

Prewitt edge detection and Sobel edge detection algorithms were implemented on Software and Hardware system for a CT image of brain with tumour. The time taken for the execution of edge detection on these platforms for different image sizes (128\*128, 160\*160 and 200\*200) is noted. It is observed that the hardware implementation is faster in this case compared to the software implementation.

The edge detection can be further used for segmentation, feature extraction, measuring size or volume of the tumour etc. The methods can be implemented for any medical images or videos.

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