

An Optimised VLSI Approach for the Tumor Detection

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Abstract-Image segmentation is the process of dividing images according to its characteristics like color and objects present in the images. The general segmentation problem involves the partitioning of a given image into a number of homogeneous segments, such that the union of any two neighbouring segments yields a heterogeneous segment. This can further be used for surgical planning, to avoid open surgery.

The techniques used are namely image registration, edge detection, contrast enhancement, watershed segmentation and finally wavelet decomposition to find the tumor growth. Comparision of different edge detection techniques based on peak signal to noise ratio and root mean square error is performed. Finally Watershed segmentation uses the intensity as a parameter to segment the whole image data set. The results show that Watershed Segmentation found to have minimum bit error rate. All the mentioned modules and techniques have been implemented in MATLAB environment for the brain tumor detection using input MR images and the part of modules like edge detection, thresholding and high pass filter are also implemented in FPGA using Verilog in Xilinx environment, the advantage being speed enhancement and re-configurability.

Keywords: Brain tumor, Magnetic resonance Imaging (MRI), Image segmentation, Watershed segmentation, wavelet decomposition, MATLAB, XILINX

I. INTRODUCTION

The body is made up of many types of cells. Each type of cell has special functions. When cells lose the ability to control their growth, they divide too often and without any order. The extra cells form a mass of tissue called a tumor. Tumors are benign or malignant. There are three methods of segmentation. These are Snakes (Gradient Vector Flow), Level Set Segmentation and Watershed Segmentation [a]. The aim of this work is to design an automated tool for brain tumor quantification using MRI image data sets., More specifically the aim for this work is to segment a tumor in a brain. This will make the surgeon able to see the tumor and then ease the treatment. The instruments needed for this could be ultrasound, Computer Tomography (CT Scan) and Magnetic Resonance Imaging (MRI). In this Paper, the technique used is Magnetic Resonance Imaging(MRI).

Medical image segmentation is the process of labeling each voxel in a medical image dataset to indicate its tissue type or anatomical structure. The input to a segmentation procedure is gray scale digital medical imagery, for example the result of a CT or MRI scan.

The following paper deals with: section 2 presents methodology for segmentation and shows their corresponding result. Section 3 explains image processing in fpga. Section 4 summarizes and concludes the paper. References are given in section 5

2. METHODOLOGY FOR SEGMENTATION

A conceptually simple supervised block-based and image-based (shape, texture, and content) technique has been used to analyze MRI brain images with relatively lower computational requirements. The process flow of the methodology is shown in Fig.1

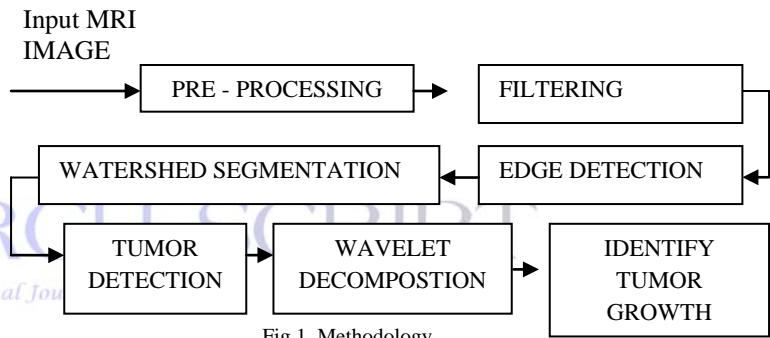


Fig.1. Methodology

In this instance, image is processed and segmented to detect the tumor, later the image is decomposed to find the tumor growth.

A. Preprocessing

The Preprocessing is used for loading the Input MRI images to the MATLAB Environment and also it removes any kind of noise present in the input images[a]. In Preprocessing the first step is to load the MRI image data set on to the MATLAB workspace. First image is converted into double image for mathematical calculations. Edge is detected using various edge detection method and noise is removed using filtering methods and the image is segmented to detect the tumor location. To make the image to display it is again converted into unsigned image. image Registration is made in order to be able to compare or integrate the data obtained from different measurements. Knowing the correspondence between a number of points in images, a transformation is then determined to map the target image to the reference images, thereby establishing point-by-point

correspondence between the reference and target images. Image registration is made as shown in Fig.7

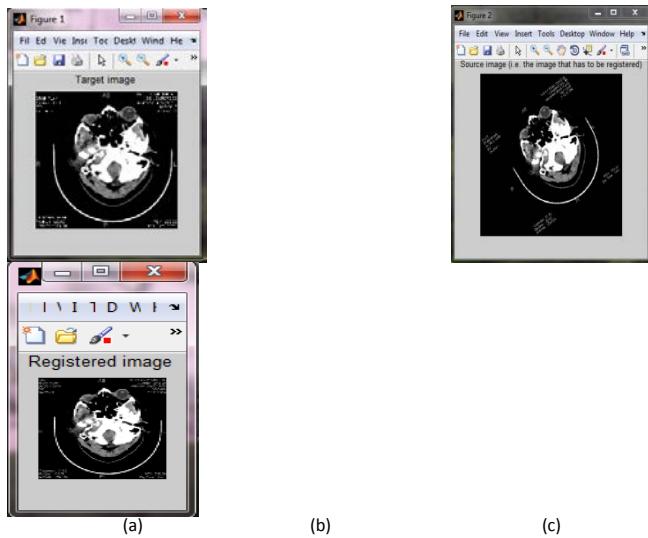


Fig. 1. Input MRI image: (a)target image (b)source image (c)registered image

B. FILTERING

Preprocessing is an important task since the segmentation will be better if there is minimal image noise. weiner filter is used to eliminate the speckle noise and to keep the most significant edges of the volumes

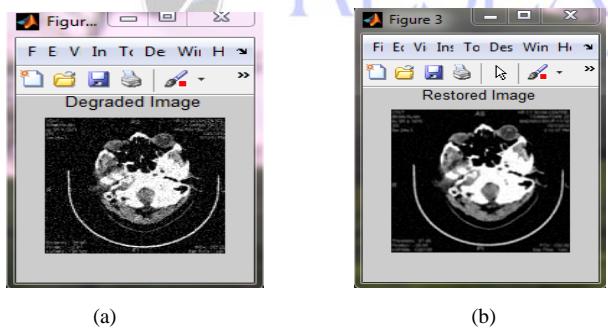


Fig. 2. weiner Filtered image: (a) Degraded image (b) Restored image

C. Edge Detection

Edge information is often used to determine the boundaries of an object. This is mainly used for analysis to derive similarity criterion for a predetermined object[b].

1) *Edge Detection operator* :An edge operator is a neighbourhood operation which determines the extent to which each pixel's neighbourhood can be partitioned by a simple arc passing through the pixel where pixels in the neighbourhood on one side of the arc have one predominant value and pixels in the neighbourhood on the other side of the arc have a different predominant value. Usually gradient operators, Laplacian operators, zero-crossing operators are

used for edge detection. The gradient operators like sobel, prewitt and Roberts compute some quantity related to the magnitude of the slope of the underlying image gray tone intensity surface of which the observed image pixel values are noisy discretized sample.

2) *Methods of the evaluation of performance for edge detectors:* The objective methods use to measure the performance of edge detectors using signal to noise ratio and mean square error between the edge detectors images and the original one[d]. The objective methods borrowed from digital signal processing and information theory, and provide us with equations that can be used to measure the amount of error in a processed image by comparison to known image. For instance, an image with a low error as determined by an objective measure may actually look much worse than an image with a high error metric. Commonly used objective measures are the root-mean-square error and the peak signal-to-noise ratio

$$e_{rms} = \sqrt{\frac{1}{MN} \sum_{r=0}^{M-1} \sum_{c=0}^{N-1} [E(r,c) - O(r,c)]^2} \quad (4)$$

$$SNR_{PEAK} = 10 \log_{10} \frac{(L-1)^2}{\frac{1}{MN} \sum_{r=0}^{M-1} \sum_{c=0}^{N-1} [E(r,c) - O(r,c)]^2} \quad (5)$$

Where $O(r, c)$ is the original image, $E(r, c)$ is the reconstructed image and L is the number of gray level equal to 256.

3) *Experiment of Edge detection:* In this paper, the images displaying different tumor location are chosen as shown in Fig.2.These images are subjected to the different edge detection techniques.

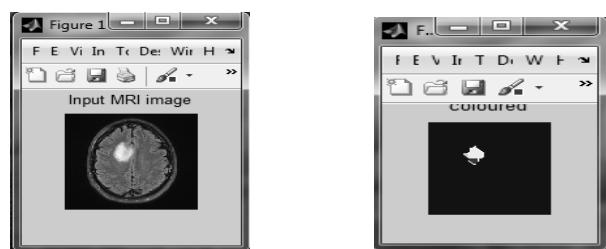


Fig. 3. Input MRI image :watershed segment output

Objective methods are used in this experiment by calculating SNR_{peak} and e_{rms} between the edge detection

images and the original ground truth image. Table I shows the peak signal to noise ratio and e_{rms}

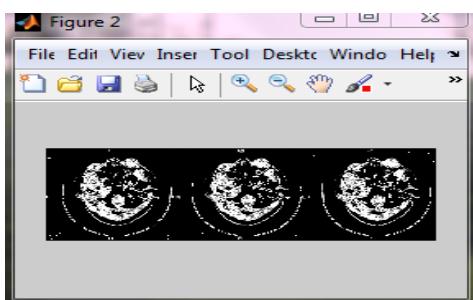
TABLE I
SUMMARY OF SNR_{peak} AND e_{rms} MEASUREMENT

parameter	sobel	prewitt	roberts	canny	log
SNR	4.4018	4.3710	4.3685	4.3752	4.6817
e _{rms}	0.6024	0.6046	0.6048	0.6043	0.5876

In this paper, evaluation of edge detection result images show that Canny, LOG, Prewitt, and Sobel exhibit better performances respectively under noisy conditions. According to Table I in case of input MRI image, the Prewitt, Roberts, canny and Sobel have poor quality. Laplacian of Gaussian has fair quality. LOG are better than Prewitt and Sobel. the root mean square error of LOG less than Sobel and Prewitt. On the other hand the peak Single to Noise Ratio of LOG is greater than Sobel and Prewitt. LOG exhibit better performances. This is because the Gaussian edge detectors are symmetric along the edge and reduce the noise by smoothing the image.

D. Contrast (H) Parameter

An intensity image is a data matrix, I, whose values represent intensities within some range [c]. MATLAB stores an intensity image as a single matrix, with each element of the matrix corresponding to one image pixel. The matrix can be of class double, uint8, or uint16. While intensity images are rarely saved with a color map, MATLAB uses a color map to display them. In essence, MATLAB handles intensity images as indexed images. Contrast (H) is often used to characterize the extent of variation in pixel intensity as shown in Fig. 4


Fig. 4. Contrast image output

E. COMPARISON OF DIFFERENT SEGMENTATION TECHNIQUES

The objective method is used to measure the BER(bit error rate)of different segmentation method. For instance, an image with a low error as determined by an objective measure may actually look much worse than an image with a high error metric. The histogram of different segmented images shows out the watershed segment proved to be

better compared to other segmented methods. Table II shows the bit error rate of different segmentation methods.

TABLE I
SUMMARY OF BER MEASUREMENT

PARA METER	fuzzy segmentation	GRAY IMAGE SEGMENTATION	k means clustering	watershed
BER(BIT ERROR RATE)	r = 8.5423 g = 0.7071 b = 8.5251	r = 8.2595 g = 7.6374 b = 7.2572 k = 6.3248	r = 0.6356 g = 8.5246	0.4563

From the table II it is proved that watershed segmentation constitutes low bit error rate compared to other segmentation methods

E. WATERSHED SEGMENTATION

The term watershed refers to a ridge that divides areas drained by different river systems [f]. A catchment basin is the geographical area draining into a river or reservoir. Watersheds and catchment basins related to analyzing biological tissue, studying galaxies, or researching new semiconductor technology because the connection is through computer analysis of objects in digital images. The objects could be anything: blood cells, stars, toner spots on a printed page, DNA microarray elements, or even quantum semiconductor dots, as in this image. Computer analysis of image objects starts with finding them-deciding which pixels belong to each object.

The different segmented output are stored in database and the resultant output is compared with database to know the details of the tumor. The tumor growth is identified and is differentiated into malignant and benign tumor. Fig 5 shows the watershed segment output and the histogram result. The histogram shows that there is a only one peak point which has high energy which means there is an existence of occurrence of tumor at that point

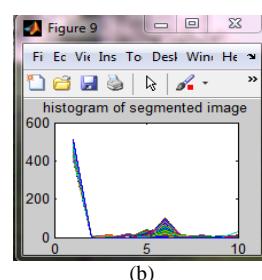
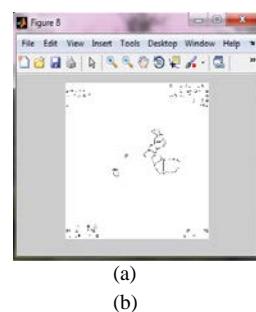


Fig. 5. watershed image (a) segmeted output (b) histogram of segemented output

F.WAVELET DECOMPOSITION

Wavelet is useful for denoising, enhancement, and image analysis. Successive lowpass/highpass filtering and downsampling on different level are obtained by capture transitions of different frequency bands and on the same level capture transitions at different locations

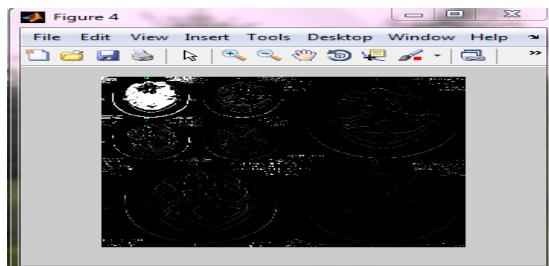


Fig.6.wavelet decomposition of an image

The Fig.6. shows wavelet decomposition which gives the complete details about the image. by comparing the image with the image obtained after period of time using wavelet decomposition we can obtain the tumor growth.tumor growth may be also due to blood clotting so the clear analysis is obtained only using wavelet decomposition

3.IMAGE PROCESSING IN FPGA

A simple segmentation technique that is very useful for scenes with solid objects resting on a contrasting background. All pixels above a determined (threshold) grey level are assumed to belong to the object, and all pixels below that level are assumed to be outside the object as shown in Fig.5. The selection of the threshold level is very important, as it will affect any measurements of parameters concerning the object.

Thresholding as shown in Fig.7. is often carried out on images with bimodal distributions[e]. This is explained by vlsi programming. The best threshold level is normally taken as the lowest point in the trough between the two peaks (as above) alternatively, the mid-point between the two peaks may be chosen. It clearly identifies the objects of interest in the image, and removes any noise present.

The highest and lowest intensity values with a peak are stored. The threshold value is calculated as the average of these points. This is a fairly basic method of thresholding, but is effective with the majority of images.

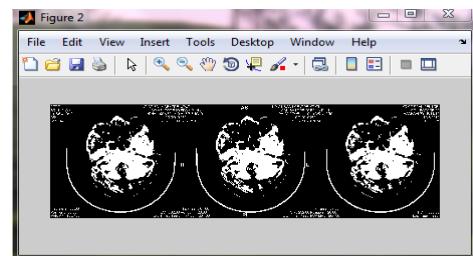
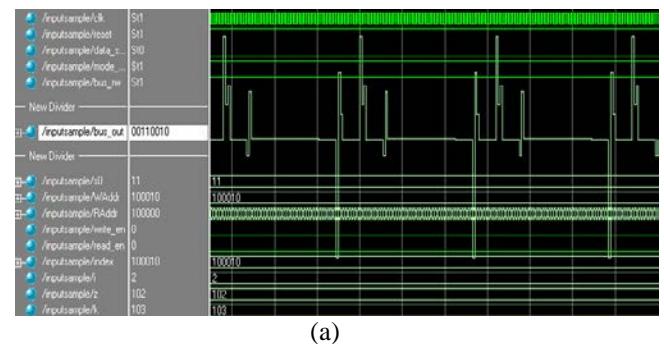
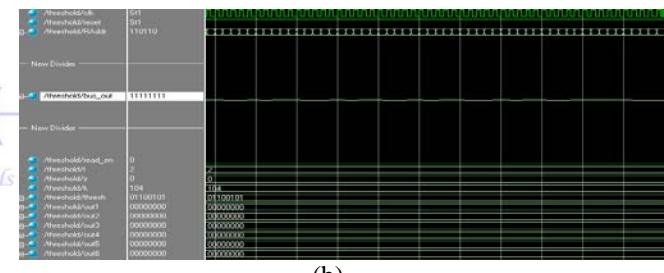


Fig.7 .MATLAB simulation results of thresholding

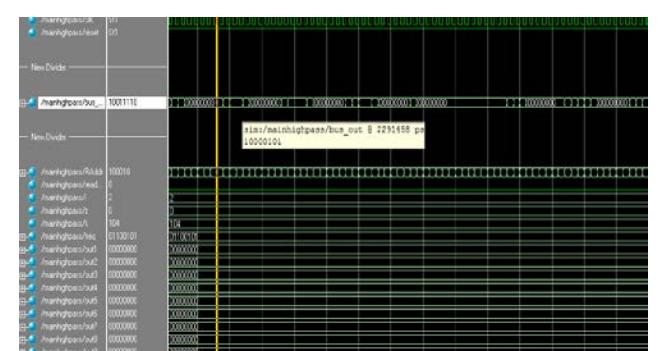
The three modules edge detection,thresholding and high pass modules are simulated in Xilinx environment and their outputs are shown in Fig.8.



(a)



(b)

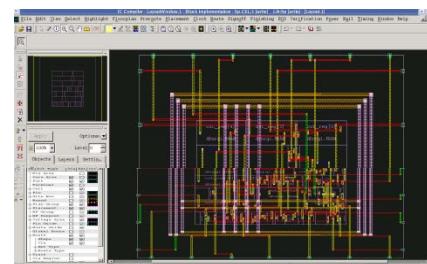
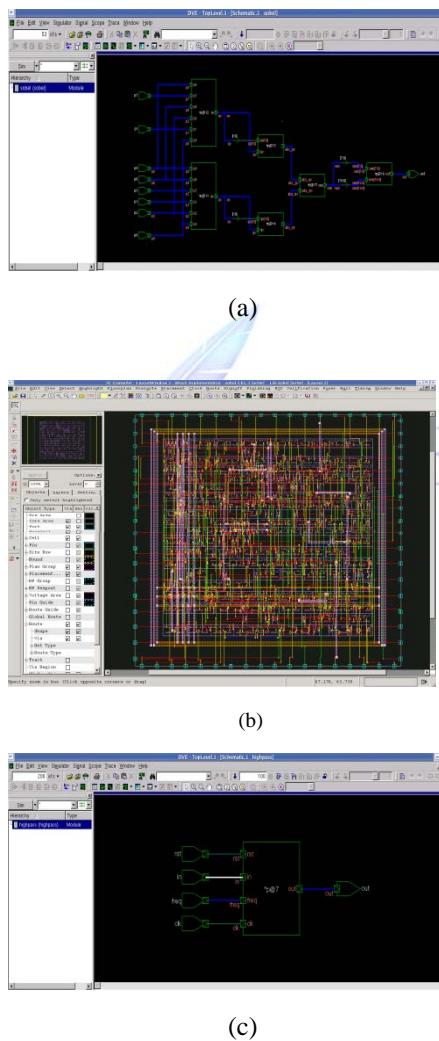


(c)

Fig..8.simulation results (a)edge detection module
(b)threshold module (c)high pass module

For edge detection technique, RAM modules are employed to get data from the MATLAB. Three RAM modules each of size 3X34 are employed for storing the data from computer. The contents of the RAM modules are reset

before initiating computation. When the control signals ‘write_en’ and ‘bus_rw’ are both asserted LOW, firstly the RAM module in the third row is loaded with 34 bytes of pixel values transferred from the text file to the temporary register. Then placing a value of 100010 in the data bus. Then the entire rows are shifted one upwards. Then the third row is filled with next set of data values. The process is repeated until the three rows are filled with image information. Consecutive three elements of each row will be the input to each of the 32 Sobel Modules. The edge detection module and the high pass module are simulated using synopsis to obtain the area, power and timing report is shown in Fig 9.



(d)

Fig.9 synopsis simulation results (a)schematic of edge detection module (b) layout of edge detection module(c)schematic of high pass filter module (d)layout of high pass filter module

TABLE III

COMPARISION OF DIFFERENT MODULES

Specification	Edge detection	High pass
Total Cell Area	643.250000 Previous: 720.00000	80.000000
Total Area	693.119120	85.616268
Total Dynamic Power	2.2485 mw Previous: 2.6284mw	2.7899 μ w
Cell leakage power	45.2166 μ w Previous: 153.4724mw	430.260 nw

The above TABLE III provides the comparison of different modules based on power and area. It found that the proposed method provides less Power and occupy less area compared to previous methods

4. CONCLUSION

We have made three technical contributions in this paper. The main contribution is the detection of brain tumor using watershed segmentation. Second we compare the different edge detection techniques based on peak signal to noise ratio and root mean square error. From the measurement we identify that laplacian of Gaussian edge detection provide better performance. Third contribution is performing the operation of thresholding, edge detection and high pass filter to improve the performance..The hardware implementation of the operation improves speed enhancement and mainly reconfigurability.The future work is to enhance the segmentation to automatic.

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