

Implementation of optimized technology for segmentation of brain tumor using VLSI

N.J.R.Muniraj¹ and Surya Prabha²

Tejaa Sakthi Institute of Technology, Coimbatore, TamilNadu.

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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 gray scaling, edge detection, contrast enhancement, watershed segmentation and finally marking the region of interest. Comparison 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 can successfully segment a tumor. 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.

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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

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

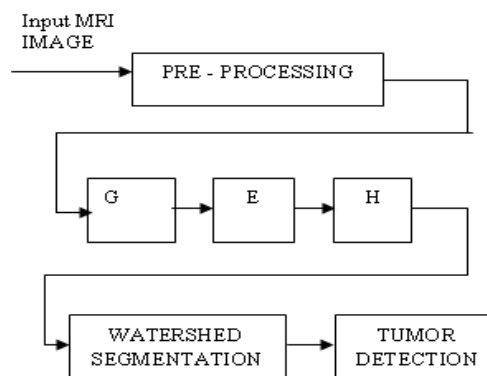


Fig.1. Methodology

In this instance, this three specific features: the edges (E), gray values (G), and local contrast (H) of the pixels in the block being analyzed.

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. In Preprocessing the first step is to load the MRI image data set on to the MATLAB workspace and after loading they will be processed in such a way that instead of processing 128 images in one direction a whole clip of 128 images is processed by one command, otherwise it would have been very hectic situation for processing each and every image independently. Thus after this processing there are only three clips instead of 384 separate images, i.e. one clip for axial images, one clip for sagittal images and one clip for coronal images. After that all the clips are combined to get the single clip for further processing.

Gray parameter

Gray parameter[b] avoids the need to scale the data-to color mapping, which would be required if we used a color map of a

different size[e].The gray parameter (G) for each block of the brain is accumulated, and controlled by a binary image (IT) using the GD value as a threshold(1). GD value is calculated using the average pixel value (Iavs) of each image slice (S) for total image slices (T) of an image dataset

$$I_{avs} = \frac{1}{65536} \sum_{x,y} I_p(x,y) \tag{1}$$

$$G_D = \frac{\sum_{S=0}^T I_{avs}}{T} \tag{2}$$

$$G_{(r,c)} = \sum I_p(x,y), \forall I_T(x,y) = 1 \tag{3}$$

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.

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

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

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

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.

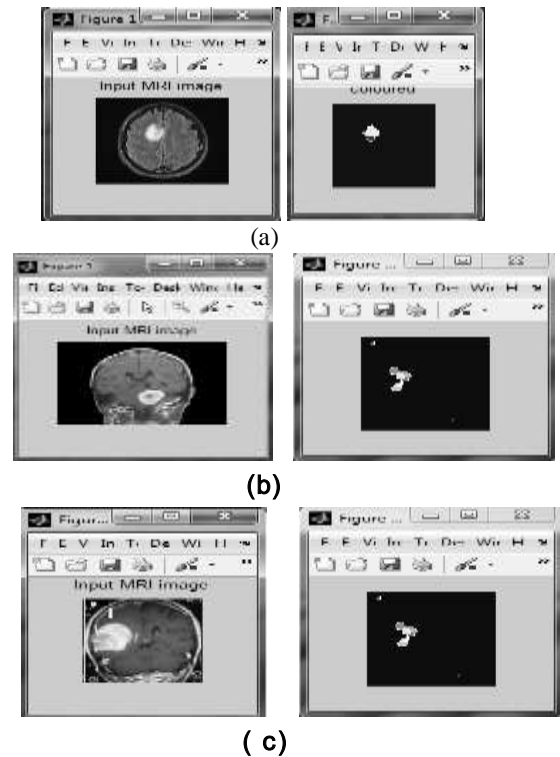


Fig. 2. Input MRI Images along with their watershed segmented output:(a)image 1,(b)image 2(c) image 3

Objective methods are used in this experiment by calculating SNRpeak and erms between the edge detection images and the original ground truth image. Table I shows the peak signal to noise ratio and the Table II shows erms

Table I Summary of snrpeak measurement

Operators	Image 1	Image 2	Image 3
Sobel	4.4018	3.6717	6.8231
Prewitt	4.3710	3.6769	6.7879
Roberts	4.3685	3.6242	6.6390
Canny	4.3752	3.6739	6.3565
LOG	4.6817	3.8506	7.0388

Table II Summary of erms measurement

Opeartors	Image 1	Image 2	Image 3
Sobel	0.6024	0.6553	0.4559
prewitt	0.6046	0.6549	0.4577
Roberts	0.6048	0.6589	0.4656
Canny	0.6043	0.6551	0.4810
LOG	0.5876	0.6419	0.4447

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 objective evaluation of edge detection results as in Table II agrees that 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.

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. In the present technique, the computational program analyses the differences, especially in instances of strong dissimilarity, between entities or objects in an image I(x,y). We adopt the minimum/maximum stretch algorithm for the 8-neighborhood connectivity, where min H and max H represent the minimum and maximum intensity values of the neighbourhood pixel C8(IH), as written in(6). In the previous studies, tumor cells are often associated with higher value of contrast (H) parameter [9]. Hd is obtained by totalling the contrast of a supervised block (7)

$$I_H(x,y) = \frac{I(x,y) - \min H}{\max H - \min H} \times \max H \quad | \quad H \in C_g(H) \quad (6)$$

$$H_{d(r,c)} = \sum_{(x,y) \in B} I_H(x,y) \quad (7)$$

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.

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 is often carried out on images with bimodal distributions. 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.

The three modules edge detection,thresholding and high pass modules are simulated in Xilinx environment and their outputs are shown in Fig.6.

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.

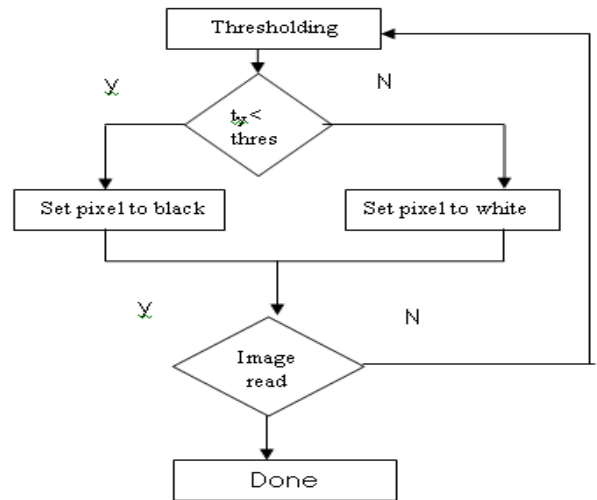


Fig.5. Thresholding Flowchart

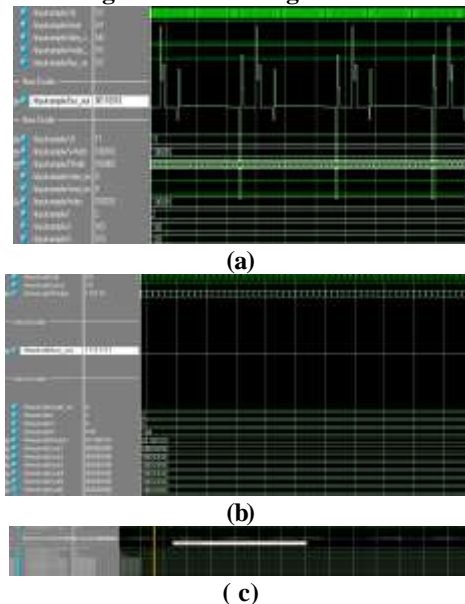
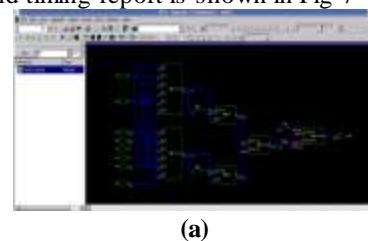


Fig..6.simulation results (a)edge detection module (b)threshold module (c)high pass module

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 7



(a)

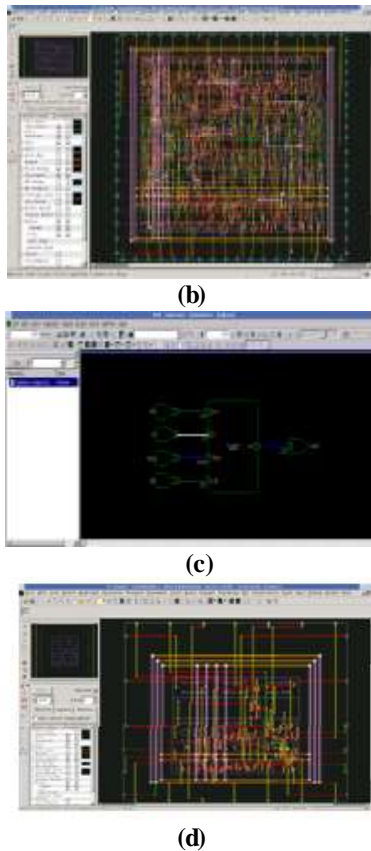


Fig.7 synopsis simulation results (a)schematic of edge detection module (b) layout of edge detection module(c)schematic of high pass filter module (d)layout of high pass filter module

Table III Comparison 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

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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