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Implementation of Edge Detection Technique for Identification and Evaluation of Brain Tumor Metrics in MR Image through Lab VIEW

S. Sunita Ratnam[1], D. Suresh Kumar[2], K. Madhukar[2]

[1]Department of Physics and Electronics, Shadan Degree College for Women, Hyderabad, Telangana, India

[2]Department of Physics, Osmania Universiy, Hyderabad, Telangana, India

Abstract : ***In this paper the authors present the development of an algorithm based on the Edge Detection Technique for Automatic Detection of Brain Tumors in MR Images of the Brain and their Quantification. The basic Edge detection technique is primarily based on the abrupt changes in the intensities between the tumor and the brain regions, identified through gradient operations. This is implemented through Vision Assistant tool box in Lab VIEW 12. The authors have proposed an algorithm which is implemented through Canny Edge Detector. The results of the measurements of maximum width, maximum length and the areas of the tumor and the brain obtained by the algorithm on the Ground truth image are in good agreement within ± 3% error, establishes that the proposed algorithm by the authors yields reliable results. Hence, this algorithm is implemented on 12 different patients through Lab VIEW. The results of the analysis are automatically evaluated and metricized.***

Keywords: Edge detection technique, Ground Truth Image, Image Segmentation, Brain Tumor Detection, Quantification, Lab VIEW, Vision Assistant.

1. Introduction

As per the statistics released by the American Brain Tumour Association, several millions of people world over are affected by Brain Cancer [1-3]. The conditions of other developing and under-developed countries are pathetically alarming. Hence, there is a dire necessity for faster, accurate and automatic diagnostic system for the identification and evaluation of brain tumors. Early detection of brain tumor is important for a radiotherapy planning. As the MRI images exhibit complex characteristics it is indeed necessary to perform the image enhancement and segmentation process [4-5]. Recently, computerized methods in the area of nuclei detection segmentation and classification are extensively being used [6-8].

Medical image segmentation had inherited complex problems for the proper diagnosis of brain disorders [9]. The Digital Image Processing has provided the means to overcome these limitations in the analysis [10]. This is extensively used for identification of Brain Tumors in MR Images [11]. Considering these aspects, the authors have taken up the task for developing highly reliable algorithms for this proposed analysis.

The present research work is carried out by making use of Vision Assistant Tool in LabVIEW software with Edge Detection and segmentation methods [12]. The algorithm detects the edge patterns and segmentation of tumor and brain are efficiently. This is usually identified through local linear gradient operators like Canny, Sobel, Laplace, etc [13]. In the present investigation, the authors have incorporated Canny Edge Detector [14] into their algorithm for automatic identification of Brain Tumours in MR Images and for the evaluation of their metrics of the physical parameters like the maximum width, maximum length and the areas of the tumor and the brain.

2. Methodology and Analysis

In medical diagnosis the segmentation of the MRI images is preferred for quality segmentation [15]. The process of a portioning a digital image into multiple segments is called segmentation. By segmentation the image can be converted into a finite number of non-overlapping regions with respect to some characteristics (gray value, texture etc.,). Some tumors may deform surrounding structures in the brain because of the mass effect or oedema. The presence of artifacts and noise in the brain tumor images increases the difficulty in segmentation process [16]. Most of the segmentation algorithms depend on one of the two basic properties of intensity values: Discontinuity and Similarity. The segmentation process is mainly used to locate objects and the boundaries of different regions of an image and it is implemented using Edge detection technique.

Edge based methods are focussed on detecting the contour of the image [17]. Canny Edge Detector [18] is used in the present investigation for this purpose. Lab VIEW based methods are being extensively used in the area of Digital image processing for automatic detection, segmentation and quantification [17] of brain tumors. Digital image processing enables faster and precise detection of the tumors. Edge extraction based schemes provide an efficient detection result against variations in the illuminations. The Edge Detection is achieved by Spatial Gradient Operation on pixel intensities of Red, Green and Blue components in the image plane defined by equations (1, 2 & 3).

$$U_x = \frac{\partial R}{\partial X}.\mathbf{r} + \frac{\partial G}{\partial X}.\mathbf{g} + \frac{\partial B}{\partial X}.\mathbf{b} \quad \text{..... (1)}$$

$$V_y = \frac{\partial R}{\partial Y}.\mathbf{r} + \frac{\partial G}{\partial Y}.\mathbf{g} + \frac{\partial B}{\partial Y}.\mathbf{b} \quad \text{..... (2)}$$

$$g_{x,y} = \mathrm{U.V} = \left[\frac{\partial R}{\partial X}.\frac{\partial R}{\partial Y}.\right] + \left[\frac{\partial G}{\partial X}.\frac{\partial G}{\partial Y}.\right] + \left[\frac{\partial B}{\partial X}.\frac{\partial B}{\partial Y}.\right] \ldots\ldots \quad (3)$$

For smoothening the image the relation (4) & (5) are employed [15].

$$g(x,y) = \frac{1}{c} e^{\frac{-(x^2+y^2)}{2\sigma^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where $c = \sqrt{2\pi\sigma^2}$

$$f(x,y) = g(x,y) * f(x,y) \quad \ldots\ldots (5)$$

The intensity gradient –**' g'**, the magnitude –**'m'** and the direction **'α'** of the edge pixels in the image plane. They are presented in equations (6) & (7).

$$|M(x,y)| = \sqrt{g_x{}^2 + g_y{}^2} \quad \ldots\ldots\ldots\ldots (6)$$

$$\text{angle } \alpha\,(x,y) = \tan^{-1}\left[\frac{g_y}{g_x}\right] \quad \ldots\ldots\ldots\ldots (7)$$

The Canny Edge detector achieves low error rate as the edges detected are as close to the true edges. The Edge points are also well localized with respect to the centre of the true edge. It also avoids the detection of multiple edges. The Canny Edge detection algorithm is presented in Figure 1.

The work of the edge detection decides the result of the final processed image. Although many edge detection and evaluation methods have been developed in the past it is still a challenging task. Conventionally edge is detected according to some forward algorithms like Sobel, Prewitt and Robert, but in theory they all belong to the high pass filter [19] category. Hence, they are not suitable for analysing noisy medical images. Hence it may be difficult to distinguish the exact edge from noise or trivial geometric features. Hence Canny, presented the well known three criteria of edge detectors namely accurate detection, excellent localization, low spurious response and showed that the optimal detection for an isolated step edge. Based on these criteria the Canny edge detector first smoothens the image to eliminate the noise [20] and then locates the edges.

3. Implementation of Algorithm through Vision Assistant

3.1 Pre-processing

The multi modal MRI images used by the radiologists cannot provide complementary data on tumors. Hence image enhancement [21, 22] operation improves the quality of the images such as contrast, brightness characteristics, reducing the noise level and by sharpening the image to extract the fine detail of the tumor for further processing. It also reduces noise of the image. This improves the quality of the image and accuracy in detecting the tumor [23]. It performs filtering of noise and other artifacts in the image and sharpens the edges in the image.

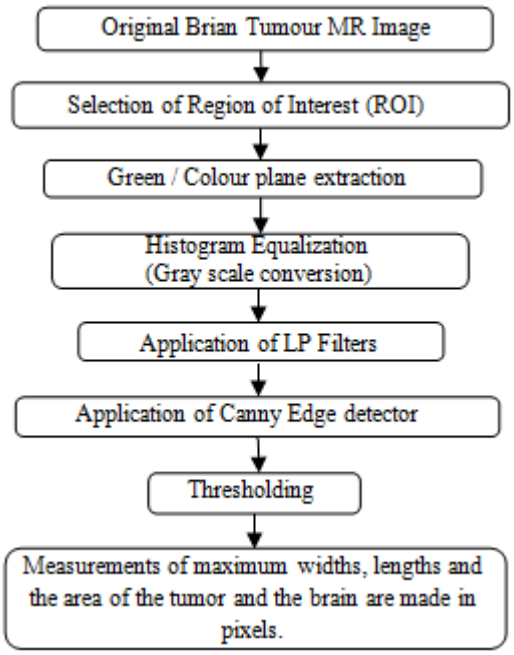


Figure 1: Edge Detection Technique Algorithm

3.2 Color Plane (Green Plane) Extraction

In bio-medical applications Red color interacts with the human blood and may not yield good result. Similarly, as Blue color is a darker shade, some of the information may hide-out. So Blue is not preferred. Hence, the green color plane [11] is selected, because most of the image information is contained in the Green Plane.

3.3 Histogram

The Histogram [24] is a graphical representation of the total intensity distribution in a digital image. One can judge the entire tonal distribution at a glance and can manually fix the threshold value.

3.4 Filters (Low Pass)

The image enhancement is carried out in spatial domain. A low pass linear filter is used to eliminate the low frequency noise. This filter produces smoother, softer looking images from a sharper original image. Thus smoothens skin lines, blemishes and noise pixels [20].

3.5 Canny Edge Detector

Canny Edge detector plays an important role to obtain the detailed information about the infected area of the brain. It identifies the contour of the region of interest (ROI) which is highly advantageous to identify the location of the tumor. This is most efficient edge detector. The advantageous is based on smoothening the image through the Gaussian filter to reduce the noise and then apply the local gradient operation in X and Y directions. The edge point is defined as the point of maximum strength in the direction of the gradient (magnitude).

3.6 Thresholding

Thresholding is a very simple approach for segmentation [24] in computer vision and image analysis. As the computational complexity is low thresholding based scheme is considered for real time computer vision systems. Thresholding scheme is broadly classified into two categories as Contextual and non-contextual, depends on the gray level distribution of the image. The Contextual thresholding, depends on the second order gray level statistics or co-occurrance matrix of the image and the non-contextual threshold depends on the Gray level distribution of the image. The input gray image is converted into a binary format. The selection of a threshold value from the image using Histogram is important for segmentation. The vision assistant script for identification of the tumor is shown in Figure 2. The Lab VIEW block diagram generated for the Canny Edge Detector is presented in Figure 3.

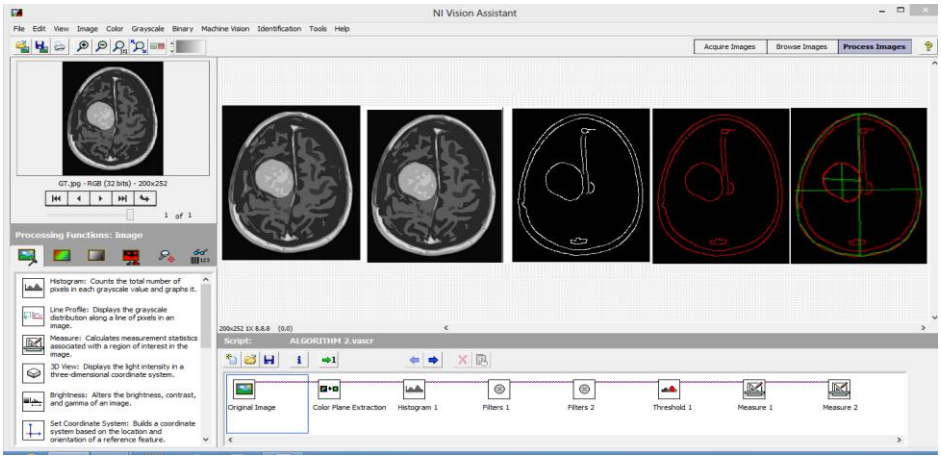


Figure 2: The Vision Assistant script (Edge detection)

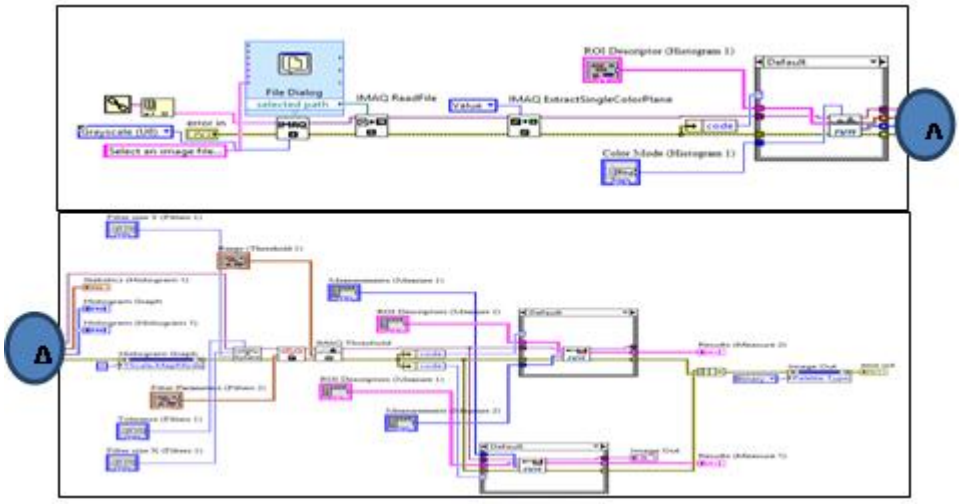


Figure 3: Lab VIEW Block Diagram

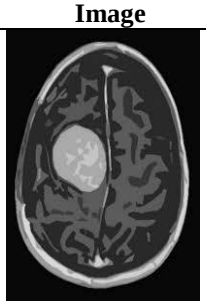
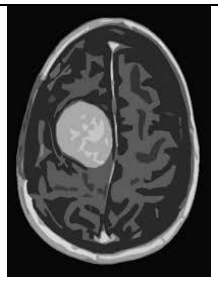
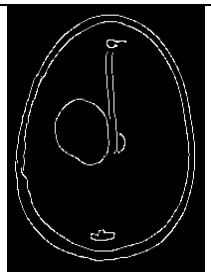
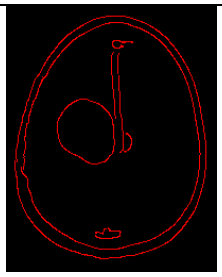
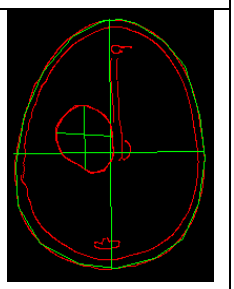
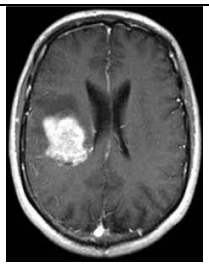
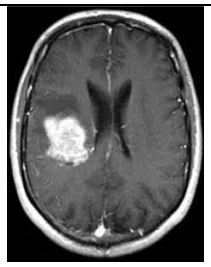
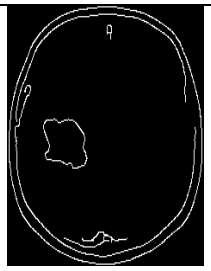
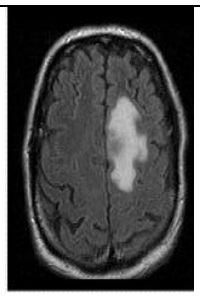
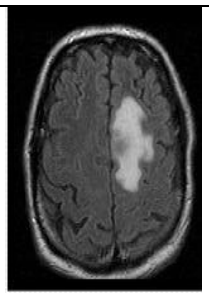
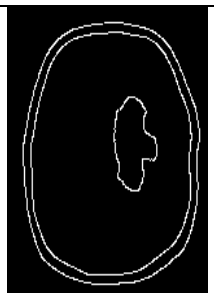
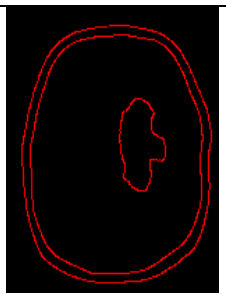
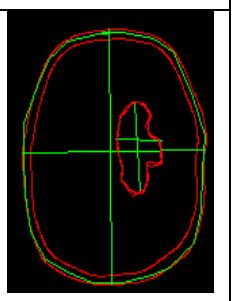
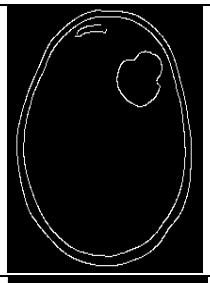
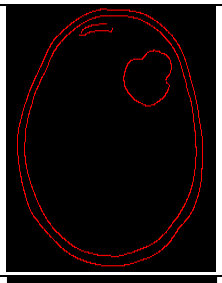
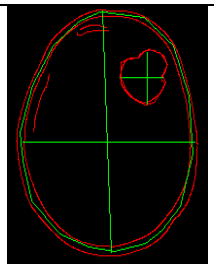
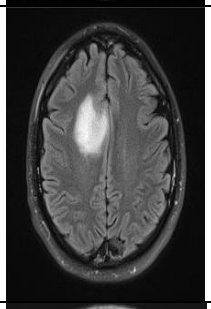
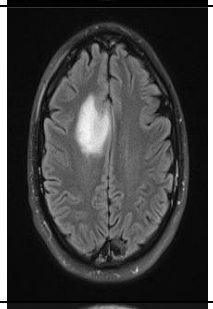
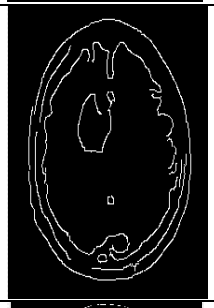
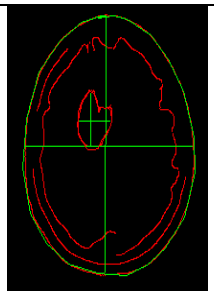
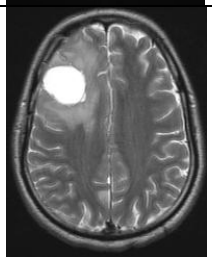
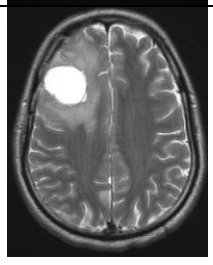
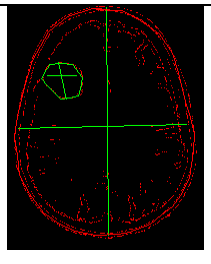
4. Measurements

Edge Detection Technique developed by the authors is implemented in the Lab VIEW using Vision Assistant toolkit. The maximum width, maximum length and the area of the tumour and the brain are automatically quantified [25, 26] by using the Polygon Tool in pixels. The Edge Detection algorithm yielded the results with a maximum error of ±4%.

5. Results

The algorithm developed is implemented on Ground Truth images [27] and the results of the measurements obtained are presented in Table 1. The algorithm is implemented for analyzing the MR Images of 12 different patients through LabVIEW. The results of this analysis are presented in Table 2 and the resulting output images are presented in Table 3 and also graphically presented in Figure 4.

Table 1: The resultant processed images of different patients

	Original MR Image	Color Plane Extraction	Filter	Thresholding	Measurements
GT					
P-1					
P-2					
P-3					
P-4					
P-5					

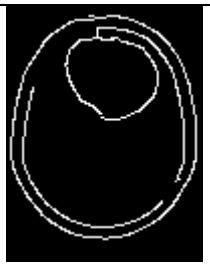
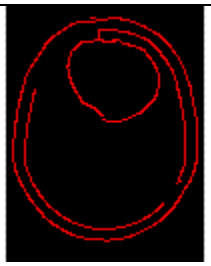
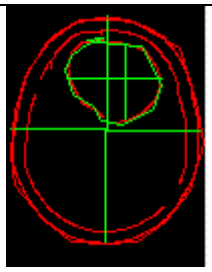
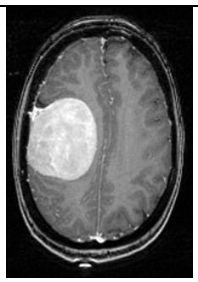
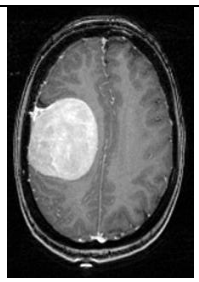
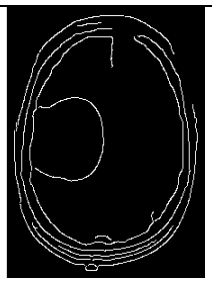
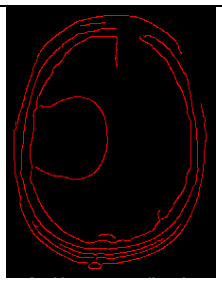
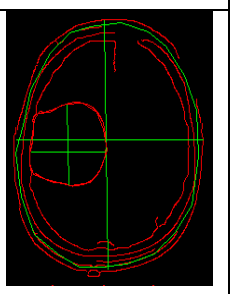
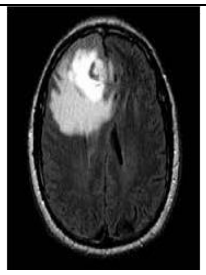
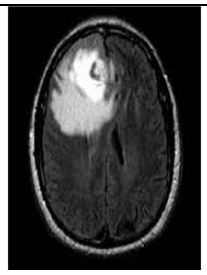
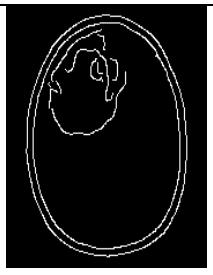
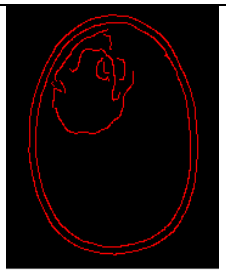
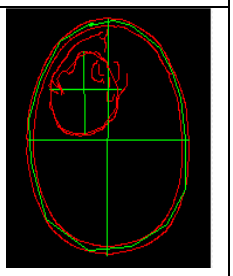
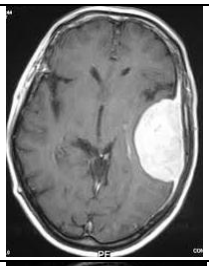
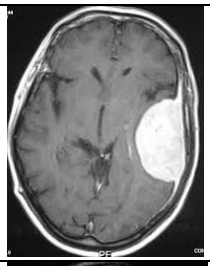
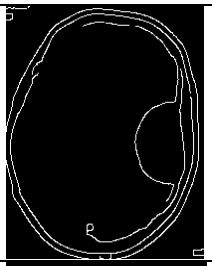
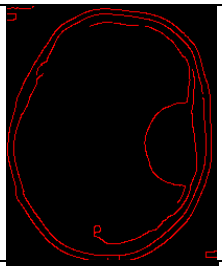
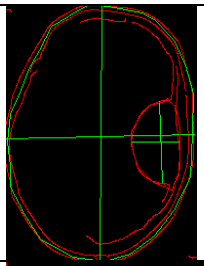
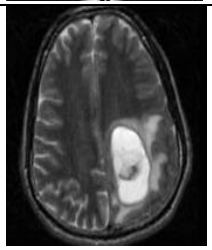
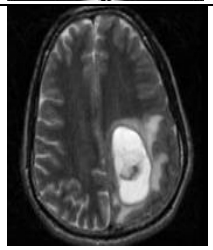
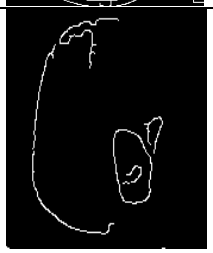
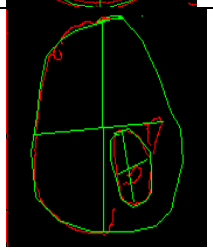
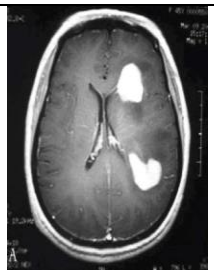
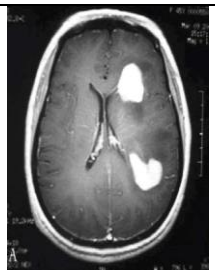
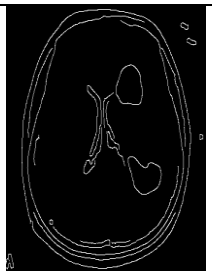
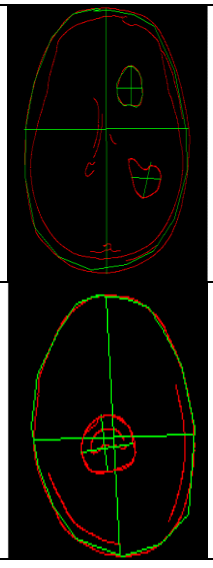
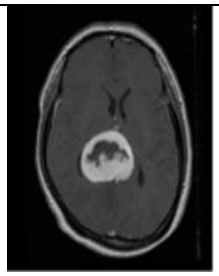
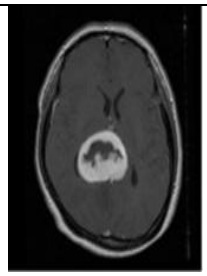
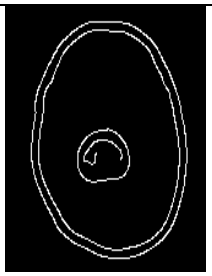
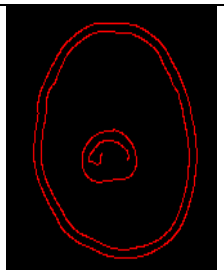
P-6					
P-7					
P-8					
P-9					
P-10					
P-11 Dual					
P-12					

Table 2A: Comparison of Tumor Index on GT with Edge Detection Algorithm

	Max. Width of Tumor (w)	Max. length of Tumor (l)	Tumor Area (a)	Max.Width of Brain (W)	Max. length of Brain (L)	Brain Area (A)	Ratio of widths (w/ W)	Ratio of lengths (l / L)	Ratio of Areas (a / A)
	pixels	Pixels	pixels	pixels	pixels				
GT	54	59	2497	172	225	31543	0.314	0.262	0.079
Algorithm	55	60	2639	182	229	32298	0.302	0.262	0.082

Table 2B: Estimation of Error in Tumor Index

GT			Algorithm			Error % (Width)	Error % (Length)	Error % (Area)
w/W	l/L	(a/A)	w/W	l/L	(a/A)			
0.314	0.262	0.079	0.302	0.262	0.082	**3.973**	**0**	**-3.659**

GT = Doctor's Data. Algorithm = GT analysed through Authors developed Edge Detection algorithm.
All the images taken for the present analysis are of high resolution of 32-bits.

Table 3: Estimation of Tumor Index for different patients

Patient code	Max. Width of Tumor (w)	Max. length of Tumor (l)	Tumor Area (a)	Max. Width of Brain (W)	Max. length of Brain (L)	Brain Area (A)	Ratio of widths (w/ W)	Ratio of lengths (l / L)	Ratio of Areas (a / A)
	Pixels	Pixels	Pixels	Pixels	Pixels	Pixels			
GT	55	60	2639	182	229	32298	0.302	0.262	0.082
P-1	52	40	1695	223	204	36849	0.233	0.196	0.046
P-2	35	59	1374	136	166	18321	0.257	0.355	0.075
P-3	43	49	1577	183	224	29882	0.235	0.219	0.053
P-4	38	49	1366	151	202	25728	0.254	0.243	0.053
P-5	122	112	10328	500	640	258083	0.244	0.175	0.040
P-6	45	40	1364	86	104	7306	0.523	0.385	0.187
P-7	80	79	5536	201	245	37623	0.398	0.322	0.147
P-8	62	64	2744	138	183	19105	0.449	0.350	0.144
P-9	51	76	3299	190	236	35669	0.268	0.322	0.092
P-10	28	49	1299	138	155	16603	0.203	0.316	0.078
P-11A	56	52	2369	356	349	97097	0.157	0.149	0.024
P-11B	65	50	2358	356	349	97097	0.183	0.143	0.024
P-12	43	32	1110	128	147	15152	0.336	0.218	0.073

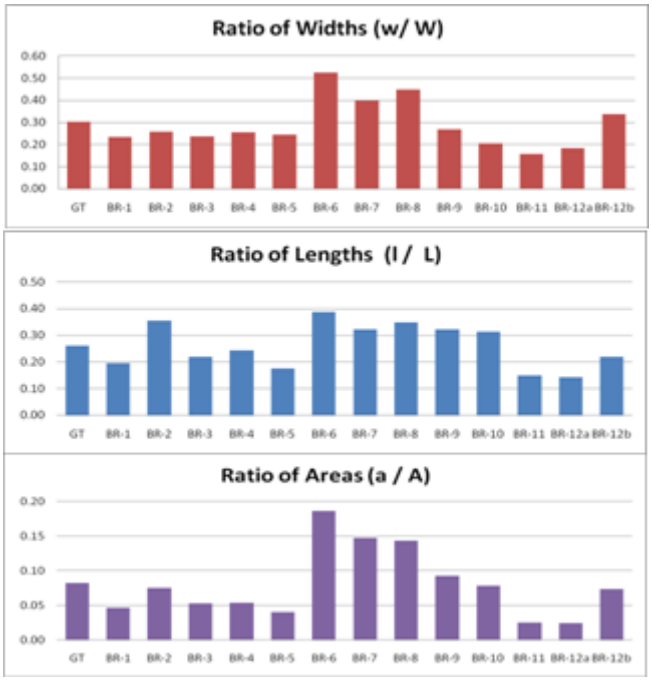


Figure 5: Metrics of the tumor and the brain

6. Conclusions

By analysing the MR Images of the brain, through the algorithm the authors could achieve the objective of Automatic Identification and Quantification of Brain Tumours. This greatly relieves the doctors from the work pressure of examining and interpreting the huge amount of brain tumor images which can be entrusted to the junior doctors equipped with the software developed by the authors. Only critical cases which require the guidance of the expert will be referred to them. This facilitates the expert doctors to concentrate on more important research.

7. Future Scope

The research can be further directed towards generating brief reports from the results obtained it can also can be extended to 3D Image processing.

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