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DESIGN AND DEVELOPMENT OF A COMPUTER AIDED DIAGNOSIS (CAD) SYSTEM FOR SEGMENTATION OF BRAIN TUMOR

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ABSTRACT

Application of image processing for diagnosis is a very crucial link in having effective treatment modalities. Different imaging modalities have resulted in accumulation of huge volume of information and has subsequently increased the burden on radiologist. There is an ever pressing need for having a tool for aiding the radiologist in diagnosis. The Magnetic Resonance Imaging is particularly a important tool for diagnosis of brain tumor. The image processing techniques can be off immense help in identifying the tumors in analyzing the tumor. In this paper we have presented a tool for aiding the diagnosis of Brain Magnetic Resonance Images (MRI).The tool is presented in the form of a Graphical User Interface (GUI) that is capable of processing, analyzing and segmenting MRI images. Two segmentation approaches namely K means segmentation and Watershed are implemented as a part of this tool. The tool also has provision for quantification of the segmented region and evaluation of the segmentation approaches.

Keywords: computer aided detection (CAD), brain tumors, K-Means segmentation and watershed segmentation, medical informatics, MRI, Segmentation.

INTRODUCTION

Image processing is a tool for diagnosis has come to occupy a centre stage in the arena of health infrastructure. Advancement in the domain of medical imaging has resulted in enormous volume of medical data that has to be analysed, interpreted and comprehended. Multiple imaging modalities coupled with advancements in the computing power of systems together with the availability of storage devices has wide open the implications of image processing has applied to clinical diagnosis. Human visual interpretation of images is result of millions of years of evolution supported with a cognitive and large data base in the form of memory. Researchers have long tried to mimic the functionalities of human systems and one of the most widely exploited areas of research is in the domain of image processing.

The primary objective of visual image interpretation is to identify the objects and judge their significance. The goal is to optimize the visualisation of the particular schematic data set. The type of the method and strategy for image processing is broadly influenced by the objectives and application for which the processing is carried out. With the huge volume of the image data there is always a risk of clinical practitioner getting overloaded and overwhelmed by the sheer volume of the data. Computer aided diagnosis tools can be effective and efficient tolls that can aid the radiologist and help in the process of decision making. These tools can provide authentic secondary opinion in identifying and classifying e images specific features in an image. The use of automated computerized algorithm to aid the image interpretation process is commonly referred to as CAD. By virtue of this structure these are as such complex because of the intrinsic nature of the systems are capable of providing image interpretation with improve accuracy and consistency necessitated by radiological diagnosis. The increased computational ability of systems with their allied software is making CAD computer aided diagnosis a viable and valid option for interpretation and analysis.

The necessities to develop such specialised systems are growing by the day. Increased consumer awareness coupled with medical legal issues and the need to provide health care at the once door step are all imposing stress on health care delivery mechanisms. Any miss interpretation or miss diagnosis has both clinical implications as well as medical legal issues. An able tool that can help the radiologist in eliciting the valid secondary opinion can go a long way in having effective diagnosis and accurate prognosis. This research work is an endeavour to design one such tool that can help the radiologist in delivering better health care. The preliminary stage for any computer aided diagnosis tool is segmented of medical images. The quality of segmentation defines the quality of medical images, and in more ways than one segmentation of medical images is such complex because of the intrinsic nature of these images. Segmentation of brain images poses serious challenges because of the complicated structure and the need for having precise segmentation.

The outcome of any CAD is purely related to the outcome of segmentation procedures. The plehothre of image segmentation approaches have been proposed in the literature for segmentation of brain Magnetic Resonance images. Since Magnetic resonance imaging is considered the most widely used modality for human brain the wide variety of these approaches are specifically targeted towards the segmentation of human brain Magnetic Resonance images [10]. Many of these approaches typically fall under the categories of thresholding, region growing and clustering owing to the complex distribution of tissue intensities in human brain, thresholding methods suffer from inaccurate determination of thresholds. Typically thresholding methods are combined with other methods and are seldom used individually for segmentation of MRI images. The development and an extension of thresholding method is region growing where connectivity conditions or region homogenetic criteria are combined with thresholding. Automated brain disorder diagnosis with MR images is one of the challenging medical image analysis methodologies [2].

Clustering is also popular method for medical image segmentation .The typical issue with medical image segmentation is loss of information is unacceptable and may result in loosing potential diagnostic information. Even though CT can be used for brain studies, MRI poses good contrast resolution for different tissues and because of its superior contrast properties majority of research in medical image segmentation concern with magnetic resonance images (MRI). Magnetic resonance (MR) images are a very useful tool to detect the tumor growth in brain but precise brain image segmentation is a difficult and time consuming process [5].Any segmentation procedure should preserve the structural intensity of the image during the process. Image morphology is an very important assert in medical image is unacceptable and unviable. Successful segmentation approaches should be capable of providing precise anatomical information. The image is visually examined by the physician for detection and diagnosis of brain tumor. However the method of detection should resists the accurate determination of stage and size of tumor [6].

This paper presents a tool that is designed to automatically segment brain tumour in MRI images. The proposed tool is developed in the form of a graphical user interface that is capable of reading the image, performing necessary interpretation and presents the processed results. Multiple arrays of functional elements are embedded in the tool to provide the clinical practiosioner with options and flexibility. The proposed tool is capable of reading MRI images in standard image formats like JPEG, BMP, and TIFF and also in the DICOMM format. In order to segment the brain tumors three well known segmentation procedures are implemented as a part of this tool. These procedures are K Means clustering and watershed clustering. This paper is organized in the following sections. The section 2 provides the brief review of literature with specific emphasis on recent trends. The section 3 explains Different methods and methodologies while the graphical user interface and its functionalities and features are elaborated in section 4. Section 5 provides the Results and discussions about the usage of the proposed tool, Followed by conclusions in section 6.

Literature Review

Ozyurt O *et al* [1] has developed Brain MR Image segmentation and using additional shape elements, he proposed a modification on the standard method by taking in to account the voxels in the neighbourhood and forming the shape elements in addition to the intensity of the voxel in interest. The resulting input vector is used with clustering technique and the proposed method was also tested with MR brain image with and without added synthetic noise.

Vrji, K.S.A *et al* [2] has presented an automatic detection of brain tumor using CAD system with watershed segmentation. In this article after manual segmentation procedure the tumor identification and investigations has been made for the potential use of MRI data for improving data tumor shape approximation and 2D and 3D visualization for surgical planning and assessing tumor.

V.Vijay kishore [3] has developed a Multi Functional Interactive Image processing tool for Lung CT images where the tool is capable of displaying information about the loaded image of the selected format read and save images from and to the workspace.

Robert. D. Ambrosini [4] has invented an computer Aided Detection (CAD) of Metastatic Brain Tumors using Automated 3-D Template Matching to demonstrate the efficacy of an automated 3-D template matching-based algorithm in detecting brain metastases on conventional magnetic resonance (MR) scans and the potential of our algorithm to be developed into a computer-aided detection tool that will allow radiologists to maintain a high level of detection sensitivity while reducing image reading time.

Akram, M.U [5], has made-up a computer aided system for brain tumor detection and segmentation. He proposed a method for automatic brain tumor diagnostic system for MRI. The system consists of three stages to detect and segment a brain tumor. The technique accurately identifies and segments the brain tumor in MR Images.

J. Selva Kumar *et al* [6] has developed brain tumor segmentation and its area calculation in brain MR images using K-mean clustering and Fuzzy C mean algorithm. The project uses computer aided method for segmentation of brain tumor based on the combination of two algorithms; this method allows the segmentation of tumor tissue with accuracy and reproducibility comparable to manual segmentation. The stage of the tumor is displayed based on the amount of area calculated from the cluster.

Woeibei Dou *et al* [7] Dou had developed a brain tumor segmentation through data fusion of T2 weighted image and MR spectroscopy. In this article a data fusion method is proposed to perform an automatic segmentation of brain tumor. The segmentation result represents Mrs-weighted structure image in tumor region and its

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performance is 99% correct detection for tumor only and 98% for tumor with potential edema and the false detection are 9% and 6%inside the VOI, respectively. The proposed method is a also a simple information fusion strategy.

Youssef, S.M. *et al* [8] has introduced a contour let based feature extraction for computer aided diagnosis of medical patterns. The designed architecture combines contour let transform and supervised neuro based classifier for tumor classification and brain tissues of medical images. Here an contour let based CAD model is proposed to adopt tumor diagnosis for abnormality detection in CT and MR Images by exploiting correlative information of suspicious lesions of brain sections. The experimental results demonstrated that the scheme can identify tumor regions and help the radiologists as a second reader in some medical images.

Ishita Maiti *et al* [9] has developed a new method for brain tumor detection using watershed method. The tumor detection algorithm uses MRI images of brain in HSV color space. Here the input image is converted three regions i.e. saturation, hue and intensity. Water shed algorithm is applied on each region of image and for the output image canny edge detector is applied.

DIFFERENT METHODS AND METHODOLOGIES

IMAGE SEGMENTATION

The partition of an image into different regions having high degree of similarity with objects of significance in the image is defined as segmentation. The image segmentation can be categorized into similarity based and discontinuity based segmentation [11]. If the image is divided on the basis of abrupt change in intensity then it is discontinuity based segmentation. The segmentation type includes the edge detection which segments an image by detecting the edges or pixels that have abrupt variation in intensity. If the image is divided into regions which are similar depending on a set of predefined criteria then it is similarity based segmentation. This includes the techniques like region growing, thresholding and clustering. The region based segmentation is simple and has higher noise immunity [11]. The Unsupervised learning algorithm which identifies a finite set of class known as clusters. These techniques train themselves by making use of the available data.

CLUSTERING

The technique which groups a set of objects in such a way that objects in the same cluster have higher degree of similarity to each other than to those in the other clusters. In the image analysis the process of grouping pixels according to some characteristics such as intensity is called clustering,. In hard clustering the data elements belong to one cluster only, whereas in the soft clustering the data elements belong to more than one cluster and the value of membership of belongingness to a cluster range from 0 to 1.

K-MEANS CLUSTERING

The K-means is a type of hard clustering algorithm. It is the simplest unsupervised learning algorithms that solve the well known clustering problems. Given ‘n’ number of observations this algorithm groups these observations in to clusters [9]. The process involves of grouping data points with similar feature vectors into a single cluster and grouping data points with dissimilar feature vectors into different clusters.. In the K- means algorithm the grouping is done by minimizing the Euclidean distance between the data and the corresponding cluster centroid [9]. The k- means is an extensively used clustering algorithm to partition data into certain number of clusters. The procedure follows a simplest and easy way to classify a given data set through a certain number of clusters, fixed a priori. The clustering is done by minimizing the Euclidean distance between the data and the corresponding cluster centroid.

In the k-means algorithm initially we have to define the number of clusters k. Then k-cluster center are chosen randomly. The distance between the each pixel to each cluster centers are calculated. The distance may be of simple Euclidean function. Single pixel is compared to all cluster centers using the distance formula. The pixel is moved to particular cluster which has shortest distance among all. Then the centroid is re-estimated. Again each pixel is compared to all centroids. The process continuous until the center converges. For a given for a given image, compute the cluster means m

$$M= \frac{\sum_{i:c(i)=k} x_i}{N_k} \quad ,k=1, \ldots, K$$

Calculate the distance between the cluster center to each pixel

$$D(i) = \arg\min \left\| x_i - M_k \right\|^2, \ i=1,\ldots\ldots,N \qquad (2)$$

Repeat the above two steps until mean value convergence. Finally, this algorithm aims at minimizing an objective function, in this case a squared error function.

a) Give the no of cluster value as k.

b) Randomly choose the k cluster centers and calculate mean

c) Calculate the distance b/w each pixel to each cluster center

d) If the distance is near to the center then move to that cluster.

e) Otherwise move to next cluster, Re-estimate the center.

f) Repeat the process until the center doesn't move.

K-means uses an iterative algorithm that minimizes the sum of distances from each object to its cluster centroid, over all clusters. This algorithm moves objects between clusters until the sum cannot be decreased further.

WATERSHED SEGMENTATION

Watershed method comes under the edge based segmentation method. Watershed segmentation technique segregates any image as different intensity portions and also the numerous cells have high proteinaceous fluid which has very high density and hence very high intensity, therefore watershed segmentation is the best tool to classify tumors and high intensity tissues of brain [2]. Improved robustness can be gained by segmenting the blood vessels inside the brain during preoperative image analysis. With the use of image registration the vessels can be found in the operative images and eliminate them from the feature map used in tumor segmentation. Such an extension also contributes to added complexity and there is no guarantee the added feature will increase the robustness of the complete system. The watershed method did not require an initialization while the others require an initialization inside the tumor. In geography watershed line is defined as the line separating two catchment basins [7]. The image gradient can be viewed as terrain. The homogeneous regions in the image usually have a low gradient values. Thus, they represent valleys while the edges represent the peaks having high gradient values. The watershed transform is often preferred to separate the touching objects in an image. The basic watershed algorithm is well recognized as a watershed transformation is that it produces a large number of segmented regions in the image around each local minimum embedded in that image.

However, a major problem with the watershed transformation is that it produces a large number of segmented regions in the image around each local minima embedded in that image. Since every pixel has different intensities compared to each other, the Watershed segmentation is done on the intensity basis. In this type of image processing, different watershed lines can be computed. In graphs, some lines may be defined on the nodes, some lines on the edges, or some hybrid lines on both nodes and edges. Watersheds can also be defined on the continuous domain. A watershed is a basin-like landform defined by ridgelines and highpoints that descend into stream valleys and lower elevations. Experimental results for more patients with over multiple MRIs show the efficacy of the technique in automatic segmentation of tumors in brain MRIs [14].

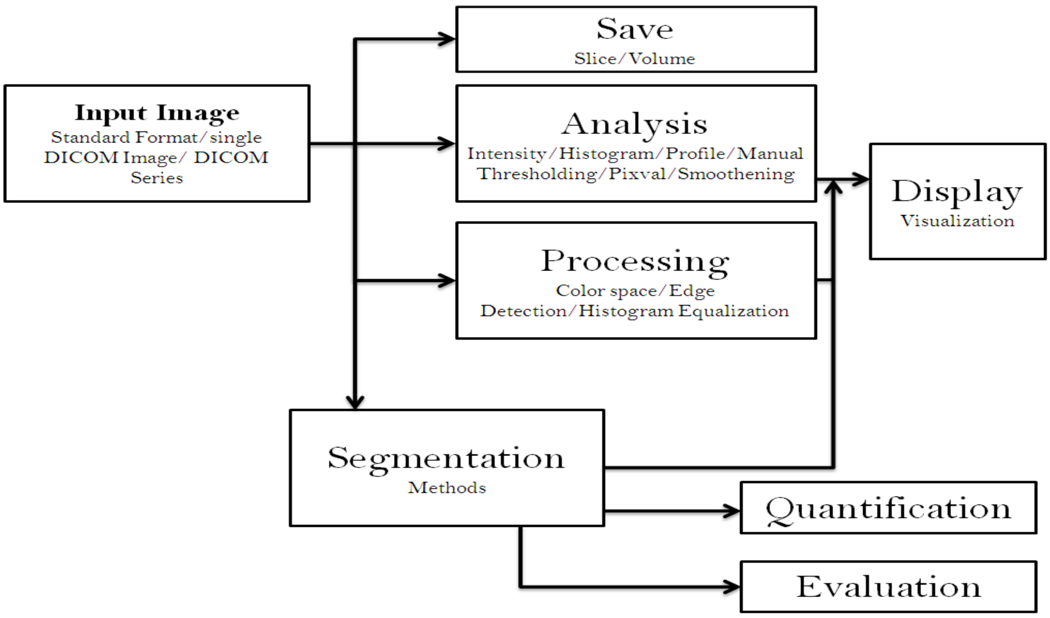

Figure-1. Functional structure of the tool.

The image should be pre-processed or the regions must be merged on the basis of a similarity criterion afterwards. The algorithm is as follows:

a) Choose the set of markers and pixels where the flooding should start. Each one will be having a Different label.

b) with a priority level use priority queue corresponding for the inserting neighbouring pixels of every marked area to the gray level of the pixel.

c) The pixel which is having highest priority level shall be extracted from the priority queue. If the Neighbours of the extracted pixel that have already been labelled all have the same label, then the Pixel is labelled with their

d) label. All nonmarket neighbours that are not still in the priority queue are put into the priority queue.

e) Repeat step 3 until the priority queue is completely empty. The non-labelled pixels are watershed lines.

PROPOSED METHOD

THE COMPUTER AIDED DIAGNOSIS (CAD) TOOL

Medical images contain valid diagnostic and clinical information which has to be analyses in detail. In order to aid in the diagnosis and interpretation they have to be presented in a form that is easy, flexible and comprehensive. A Computer Aided Diagnosis (CAD) tool serves this purpose and also helps in quantification of clinical / diagnostic information for better evaluation. In this paper, a CAD for Brain Magnetic Resonance imaging is presented, this tool is designed in the form of a Graphical User Interface (GUI) coded using Matlab. The functional structure of the tool is illustrated in the figure below.

The tool is capable of handling different file which includes the standard file formats and the DICOM format. In the standard image formats it can handle, .jpg, .bmp, .tiff formats. The tool is also capable of reading a single DICOM image or a series of DICOM images as may be required for volumetric analysis. The tool has the option for saving the image/ volume being displayed in the figure display window. This helps in storing the specific image under study for further retrieval and analysis. Another important point to be observed here is that a DICOM image can be read and saved in a standard image format. This will help the user in visualizing the image using standard image viewing tool and dispense the need for using DICOM image visualization tools.

The CAD has scope for primary analysis like visualizing the change in intensity, understanding the pixel intensity distribution by studying the histogram of the image and analyzing the pixel profile along a particular direction. The tool also has provision for performing manual thresholding and smoothing of a volume image. This smoothening may be necessary if the input image is corrupted with over exposure or sensor noises. The processing section of tool helps the user in performing different process like, histogram equalization. This section also helps in color space conversion of the image for better visualization. This section also has scope for identifying the edges using different edge enhancement operators.

The segmentation section includes different methods of segmentation; presently the tool supports K means and watershed segmentation techniques. Once the required region is segmented the quantification is done to have measure of the segmented region. Presently the tool calculates the area of the segmented region. The performance of the segmentation approaches is evaluated using different performance measures they are Probabilistic Rand Index (PRI), Variation of Information (VOI), Global Consistency Error (GCE). The Probabilistic Rand Index (PRI) counts the fraction of pairs of pixels whose labelling are consistent between the computed segmentation and the ground truth, averaging across multiple ground truth segmentations to account for scale variation in human perception. The Variation of Information (VoI) metric defines the distance between two segmentations as the average conditional entropy of one segmentation given the other, and thus roughly measures the amount of randomness in one segmentation which cannot be explained by the other. The Global Consistency Error (GCE) measures the extent to which one segmentation can be viewed as a refinement of the other. Segmentations which are related in this manner are considered to be consistent, since they could represent the same natural image segmented at different scales.

RESULTS AND DISCUSSIONS

In order to illustrate the function of the tool, images both standard and DICOM are analyzed and the results presented. The following Figure-2 illustrates the screen shot of the tool with an image loaded for analysis. The Figure-3 depicted below mentioned below illustrates the process when a DICOM series is read, the user is prompted to choose the first image in the series and the rest of the images in the series are automatically read and rendered. Image intensity adjustment is a great aid in better visualization of region of interest; the tool has the provision for adjusting the image intensity as depicted in the Figure-4.

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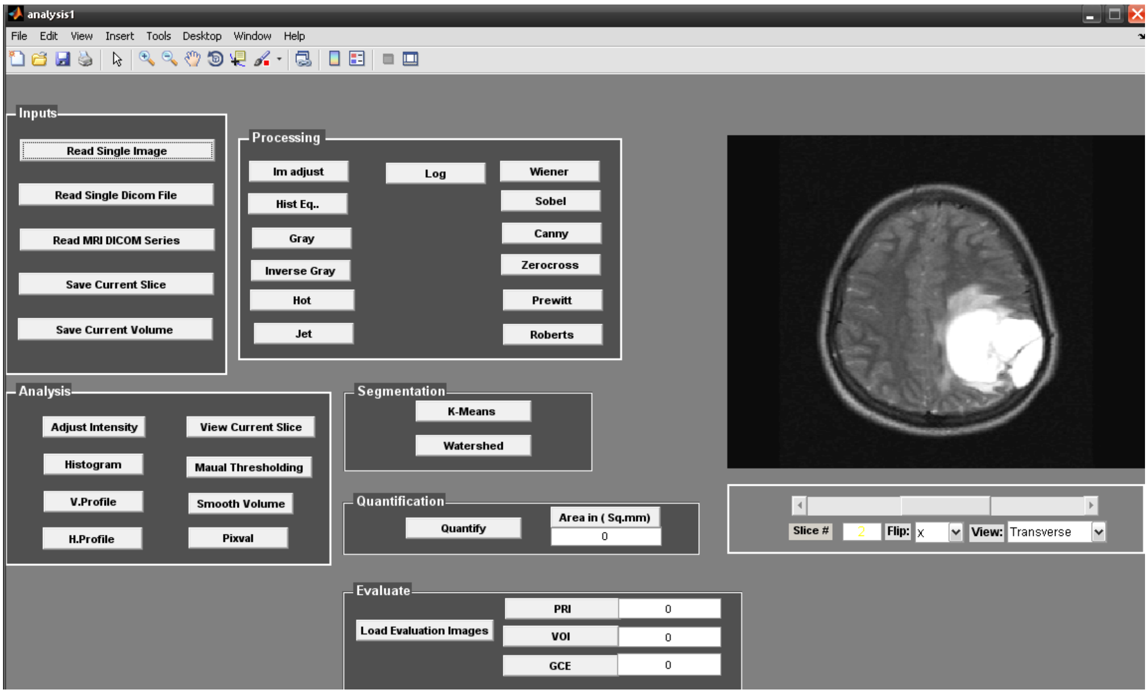

Figure-2. Screenshot of the Computer Aided Diagnosis Tool.

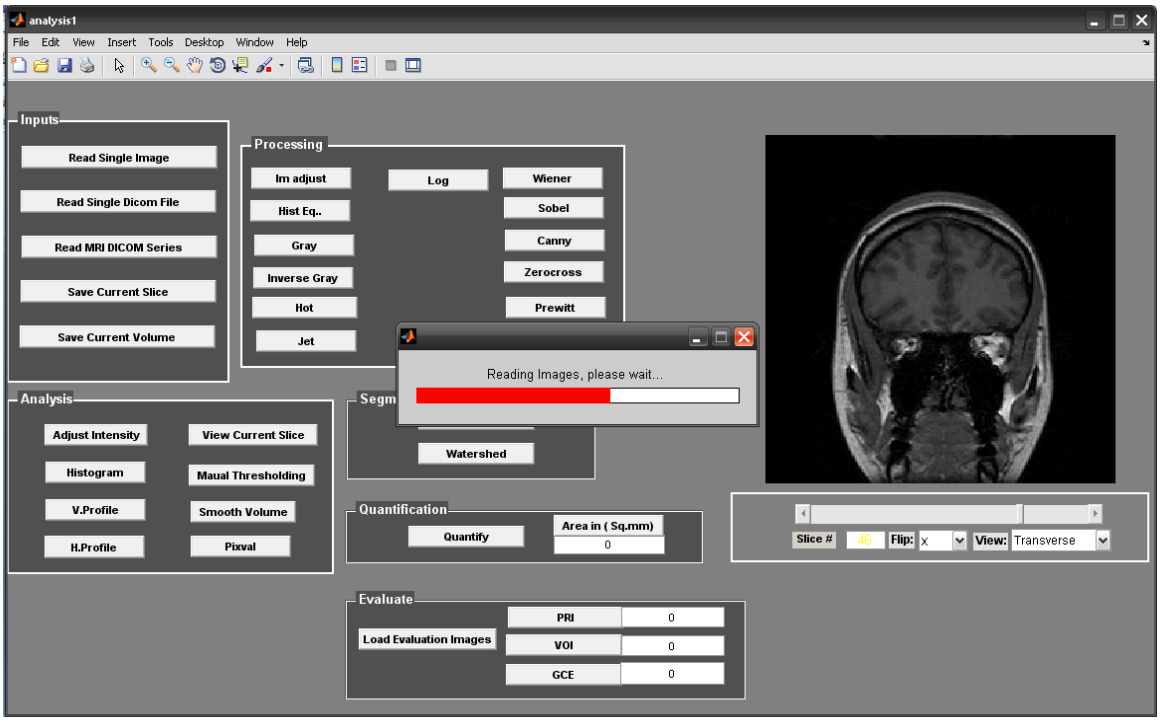

Figure-3. Screenshot of the DICOM MRI series images being Read.

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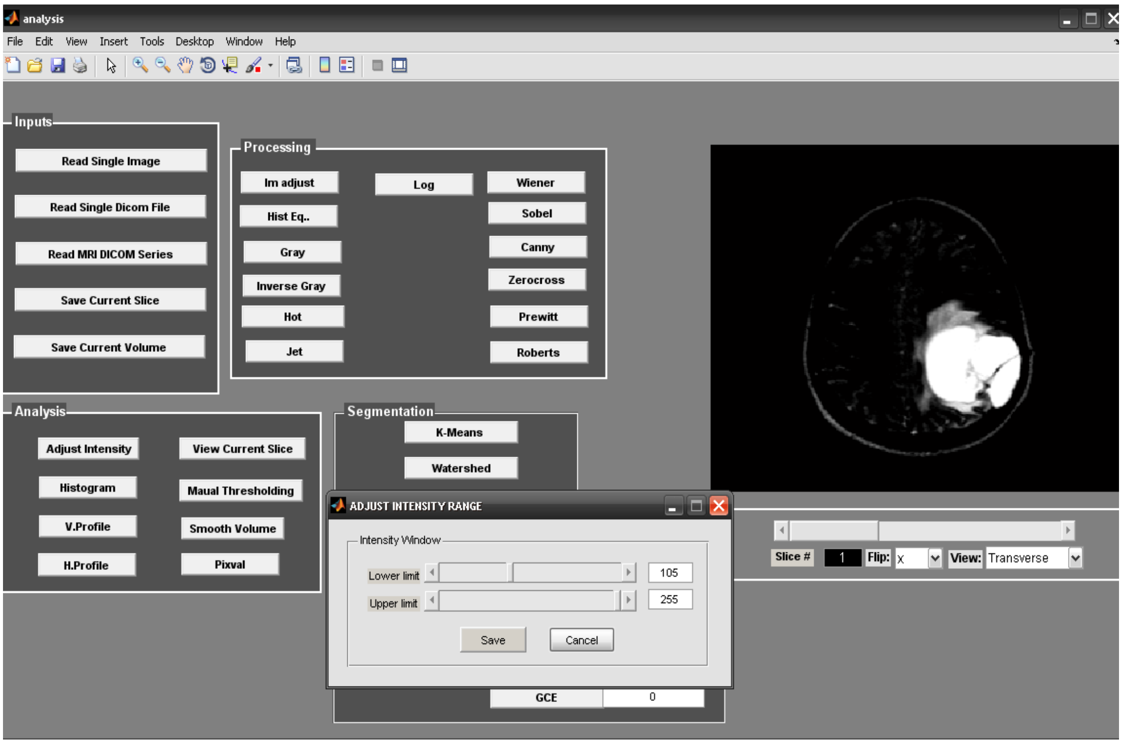

Figure-4. Screenshot of the tool used in adjusting the intensity.

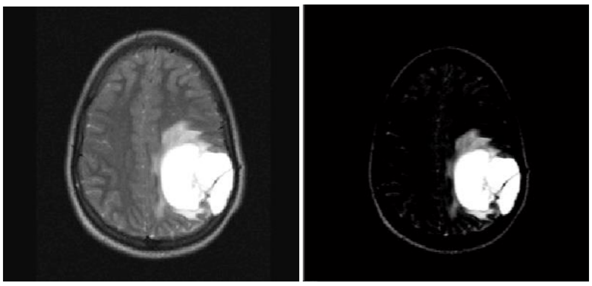

Figure-5. Original image and image after intensity adjustment.

The greater detail in the region of interest is visible once the intensity is adjusted as illustrated in the Figure-5. The distribution of pixel intensity is a pointer towards variation in structural composition and areas of different intensity in a medical image. This can be a pointer towards presence of structures of morphological significance. The Figure-6 depicts the vertical profile and horizontal profile of the image.

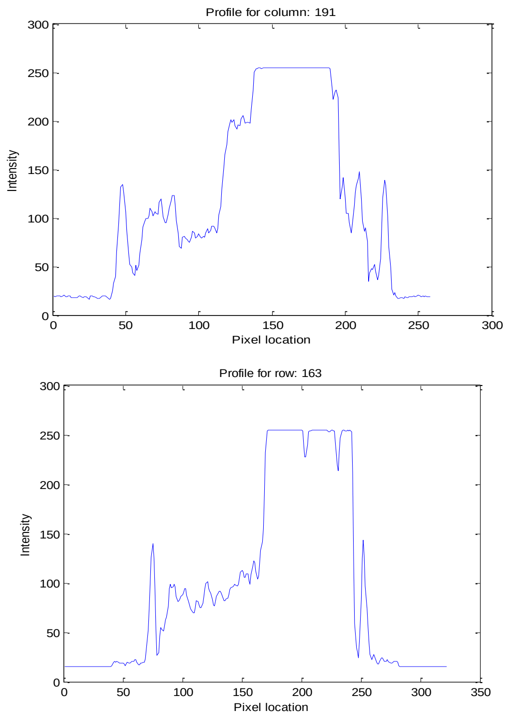

Figure-6. Vertical profile and Horizontal profile of image under study.

The vertical profile delivers the plot of differential pixel distribution along a particular column and horizontal profile of that in a particular row. It can be observed from the above figure a sudden intensity variation in the distribution of the pixel and it can be inferred to the presence of morphological structure. It can be inferred from the figure a plateau exist on either side of intensity variation and signifies the presence of a different intensity structure and in this case happens to be a tumor.

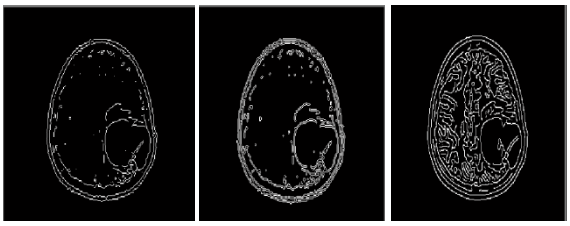

Figure-7. Sobel, Canny and Prewitt operators.

The tool has the capability of analyzing edges using different edge detection operators, these edges are a useful tool in differential diagnosis and helps in classification and segregation of structures. For the purpose of illustration three edge operators are illustrated in the following Figure-7 namely Sobel, Canny and Prewitt operators [12].

It can be observed from the figure different operators have different degrees of edge detection and choosing a particular operator is influenced by the type of image and the purpose of application. It can be inferred that using the Prewitt operator results in the predominant display of the edges.

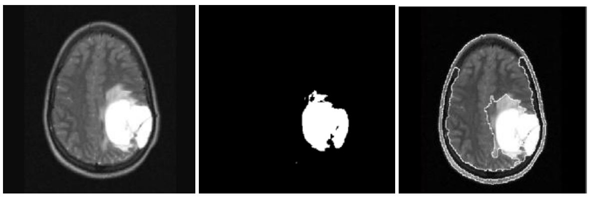

Figure-8. Original image, K-means and watershed segmented image.

Currently the tool supports segmentation using K-means and Watershed approaches, the results of which are illustrated in Figure-8.

It can be observed that the K means segmentation clearly segments the image and the watershed method provides a clear demarcation. The following table (1) provides the illustration of different evaluation parameters of segmentation for the K means segmentation method. The scope of this paper serves to illustrate the evaluation parameters for image segmentation, and the comparison of methods will be demonstrated in further work. The area of the tumor as quantified by the tool is also displayed along with parameter values used for the evaluation of image segmentation.

Table-1. Quantified segmentation evaluation parameters and area of Tumor.

Method	PRI	VOI	GCE	Area (Sq.mm)
K MEANS	0.9612	0.321	0.0346	40.308

CONCLUSIONS

India currently has one of the worst prognoses for cancer incidents. India is ranked number one i n the number of healty lost due to different cancers. Better diagnostic tools are very essential in this fight for survival against brain tumor. The tool we have designed is simple, flexible and the same time functionally efficient in segmenting tumors. The k means clustering is computationally less complex having acceptable computational time.

This tool has the potential to be an able ally in the hands of radiologist for better clinical practice specifically, in the fight against cancer.

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