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Computer Aided Diagnosis Tool for Identification of Tumors in Brain MRI Images and Performance Evaluation

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Abstract: In recent years, technical advances and enhancements in Magnetic resonance imaging (MRI) have aggravated increasing interest in the clinical role. The Computer Aided Diagnosis (CAD) framework helps the radiologists in researching the irregularities and helps radiologists to distinguish inconspicuous variations from the normal to the more critically, potential brain diseases at the prior stages. The CAD tool acts like a checker for therapeutic image and helps radiologists by highlighting regions that warrant a second examination. The development of computer aided detection technology which laid foundation for solving early diagnosis of brain tumor. The CAD tool for medical image processing is proposed in this paper. The tool is developed in MATLAB to read images of different formats like tif, jpg, DICOM etc. The tool fits for showing data about the loaded image of selected format, read and spare images form and to work space. This paper also aims at extracting the meaningful objects lying in the image and goes for extricating significant objects in the image In this paper, K-Region based Clustering and watershed segmentation has been proposed. K-means is one of the prominent methods of its simplicity and computational efficiency, whereas watershed segmentation is one such dependable way to deal with homogeneous regions in the image. It is simple, can be parallelized and dependably produces a complete division of the image. The four parameters, such as Probabilistic Rand Index (PRI), Variation of Information (VOI), Global Consistency Error (GCE), Peak signal to noise ratio (PSNR), and Structural similarity (SSIM) have been utilized to evaluate the performance. The performance is evaluated by taking the Brain MRI images as the input and GUI based CAD tool has been used to evaluate the performance.

Keywords: Brain MRI image, computer Aided Diagnosis, Image segmentation, k-means, Watershed segmentation.

I. INTRODUCTION

Brain is the most entrancing and the slightest comprehended organ in human body. For hundreds of years, researchers and logicians have considered over the relationship among conduct, feeling, memory, thought, awareness, and the physical body. The study of brain function advanced in the late nineteenth century through work including the stimulation of the cortex of creature brains utilizing electrical streams. This prompts the mapping of engine capacity in creatures and later in people. It comes about however contained numerous irregularities. Typically the Anatomy of the Brain can be seen by the MRI scan or CT examine. In this paper the MRI examined image is taken for the whole process. The MRI output is more agreeable than CT examine for determination. It won't influence the human body. Since it doesn't utilize any radiation [3]. It depends on the magnetic field and radio waves. There are different types of algorithms were produced for brain tumor location. On the other hand, brain tumor is one of the main sources of death among people. It is proof that the chance of survival can be expanded if the tumor is recognized accurately at its initial stage. Much of the time, the physician gives the treatment for the strokes instead of the treatment for the tumor. Accordingly, detection of the tumor is crucial for the treatment. The lifetime of the individual who affected by the brain tumor will increase the chance that it is distinguished early [4]. Hence, there is a requirement for a productive therapeutic image segmentation strategy with some preferred properties, for example, quick computation, precise, and robust segmentation [5].

Computer Aided Diagnosis framework has been created for Automatic Detection of Brain Tumor through MRI.Improving the capacity to recognize early-stage tumors is an imperative objective for doctors, on the grounds that early location of lung malignancy is a key element in delivering effective medications. PC supported determination (CAD) includes the utilization of PCs to bring suspicious territories on a therapeutic picture to a radiologist's consideration. Computer aided design for growth identification in restorative pictures begins with a computerized picture. The PC filters and stamps suspicious are looking territories in the picture. Radiologists can then concentrate on those regions and choose if a biopsy or further assessment is required. Segmentation plays a crucial role in the diagnosis and considered as a difficult because the medical images have poor contrasts and diffusive boundaries and suffered by different noises [2].

In general the segmentation algorithms are based on two properties of image intensity values i,e discontinuity and similarity based[6]. In the formal classification, the segmentation methodology depends on dividing the processed image in view of changes in intensity, for example, edges and corners [1]. The second one depends on partitioning a image into areas that are similar because of an arrangement of predefined criteria. Subsequently, there are numerous segmentation methods which can be comprehensively utilized, for example, histogram based strategies, edge-based techniques, neural system based segmentation techniques, physical model based methodologies, region based methodologies(splitting, growing and merging), and Clustering methods(Fuzzy , K-means clustering) and expectation Maximization[7-9]. Image processing is a procedure where input image is handled to get output as an image or attributes of the image. All images processing procedures aim is to perceive the image easier visually. Segmentation of image holds a crucial role in the field of image processing. In medical imaging, segmentation is vital for feature extraction, image estimations and picture display. Tumors grow without any control of normal forces so that in the field of medical processing real time diagnosis is given an important role for detection of brain tumors using MRI and CT scan images. Segmentation is the partition of image in to similar regions, so that the image is more meaningful and easier to analyse visually. The challenging issues faced by segmentation are the development of an approach which can be applied to all the types of images. The selection of an technique for a particular kind of image is also a difficult problem during segmentation. Hence there is no universal method for segmentation of image. It remains a challenging problem in vision fields and image processing [10].

The partition of data into groups of related objects is defined as clustering. The algorithms based on clustering are mainly divided into two techniques: Hierarchical algorithms and division algorithms. A hierarchical algorithm partition the given data set into smaller subsets. A partition clustering algorithm partitions the data set into preferred number of sets in a single step. Several methods have been projected to solve clustering problem. The most accepted clustering method is K-Means clustering algorithm. This algorithm is more prominent to cluster enormous data rapidly and efficiently. So it can be used in image processing techniques especially in the field of segmentation. Whereas in the grouping, the pixels are collected together based on some assumptions that determine how to group preferably [11]. Many clustering algorithms are developed during the segmentation process such as K-means clusters, and Fuzzy clustering. Cluster analysis serves as a pre-processing step for other algorithms, such as classification that would then operate on detected clusters [12, 20].This paper is organized as follows. In Section 2, the current research in medical image segmentation is introduced. Section 3 presents the description of the methods used in this work. It describes the image algorithms used in this work based on clustering and water shed segmentation. Section 4 depicts the experimental results obtained from the evaluation of the segmentation methods using. Finally, conclusion and future work are drawn in Section 5.

II. RELATED WORK

This section deals with the works related to the brain tumor detection and segmentation in medical image.

Koley.s [13] proposed Brain MRI segmentation for tumor detection using cohesion based self merging algorithm. The CSM has involved much consideration as it gives efficient result as a self merging algorithm compared to other merging processes and the noise effect is also less and the chance of obtaining the exact location of tumor is more. They proposed that their approach is much simpler and computationally less complex and computation time is very less. J. Selva kumar [14] had developed Brain tumor segmentation and its area calculation in Brain MRI images using K-Means and Fuzzy C-means algorithm. This paper deals with the implementation of Simple Algorithm for detection of range and shape of tumor in brain MR images. The suggested approach deal with computer aided method for segmentation (detection) of brain tumor based on the combination of two algorithms. This method allows the segmentation of tumor tissue with accurateness and reproducibility equivalent to manual segmentation. In addition, it also reduces the time for analysis.

J.Vijay and J.Subhashini [15] had developed an efficient brain tumor detection methodology using K-means algorithm. This paper describes an efficient method for automatic brain tumor segmentation for the extraction of tumor tissues from MR images. In this method segmentation is established out using K-means clustering algorithm for improved performance. This enhances the tumor boundaries more and is very prompt when compared to many other clustering algorithms. The proposed technique produces appreciative results.

Vrji, K.S.A et al [16] 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&3D visualization for surgical planning and assessing tumor.

Xianoyan zhang, Yongshan [17] had proposed an image segmentation method based on improved watershed algorithm .In this paper to overcome the shortcomings of traditional watershed segmentation, this paper presented an improved watershed image segmentation method. Firstly, the morphological opening/closing reconstruction filter is useful to remove the image noise. Secondly, multi-scale structure elements are used to compute morphological gradient. Furthermore, the morphological gradient is modified by morphological operators which can remove the most irregular local minimums.

Bandhyopadhyay and Paul [18] had proposed “segmentation of brain tumor from MRI image-Analysis of K-means and DBSCAN clustering”. These algorithms had applied to the problem of clustering and segmentation of brain tumor from MRI human brain. They observed that

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the results of K-means were noisy and many of clusters could be used for further analysis and the result of DBSCAN is more satisfactory. Meena and Raja [19] proposed an approach of Spatial Fuzzy C-means (PET-SFCM) clustering algorithm on Positron Emission Tomography (PET) scan image datasets. The algorithm is joining the spatial neighbourhood information with classical FCM and updating the objective function of each cluster. They calculated the weighting function based on the statistics and applied into the membership function. Their algorithm is tested on data collection of patients with Alzheimer's disease.

Gopi karnam, Ramashri Thirumala [21] has proposed a Design and development of a computer aided diagnosis (CAD) system for segmentation of brain tumor. In this paper a segmentation approach namely k means segmentation is implemented and this tool has provision for quantification of the segmented region.

Vijay kishore [22] 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 and evaluation of the segmentation approaches.

EL.Sayed A.El-Dahshan [23] has projected computer aided dianosis for human brain tumor through MRI. In this paper the recent publised segmentation and classification tecchniques and thier state of the art for the human brain MRI .In the light of this review a anticipated hybrid intelligent machine learning technique for computer aided detection system for automatic detection of brain tumor through Magnetic resonance images.

Two famous segmentation techniques: K-means, watershed segmentation. We made a comparison between The four parameters, such as Probabilistic Rand Index (PRI), Variation of Information (VOI), Global Consistency Error (GCE), Peak signal to noise ratio (PSNR), and Structural similarity (SSIM) have been utilized to evaluate the performance. The tested algorithms were applied on MRI images of the brain contain tumor cells.

III.THE PROPOSED GUI BASED CAD MEDICAL IMAGE SEGMENTATION SYSTEM

A. Reading an image

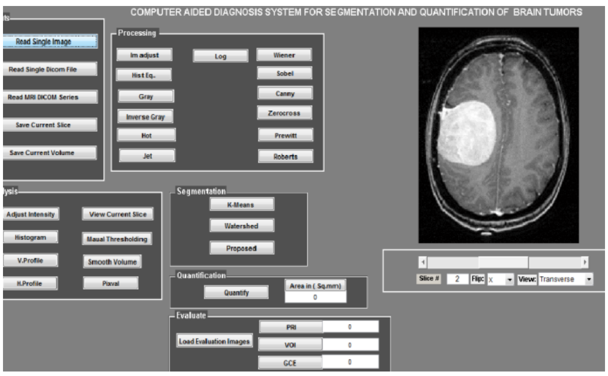

Fig.1. GUI for reading a brain MRI image

The tool will read single image of various formats like tiff, jpg, DICOM etc. It additionally has the choice of saving the image to the current work space , read from current space and additionally it will give information regarding the image details like File mod date, format version, file name, bit depth, color type , image type ,study time, series time, modality, patient name, rows-columns etc. Figure 1 shows the GUI for reading an image.

B.Image Smoothing

The aim of image upgrade is to enhance the observation or interpretability of information present in the picture for human viewers or to give better information to other computerized image processing techniques. The aim of image smoothing is to either scale back noise among the image or to produce less pixilated image. The image smoothing is also used for noise reduction and for blurring in some applications. In some applications blurring a picture may be a pre-processing step to fill gaps in lines or curves and to get rid of small detail from a picture before object extraction. Reduction may be achieved by introducing blurring with a liner or nonlinear filter.MRI images captured typically are unit liable to Gaussian noise, salt and pepper noise etc., Image filtering algorithms are applied over the noisy pictures to get rid of the noise and preserve the image details. During this work a hybridisation of adaptive median filter with wiener filter is employed for denoising the multiple noises within the magnetic resonance imaging pictures. The figure2 shown is graphical user interface for smoothing a picture once reading by the tool.

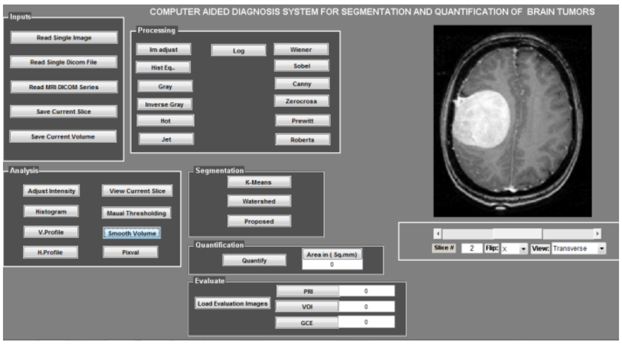

Fig.2. GUI for image smoothing of brain MRI image

C.K-means segmentation

K-Means calculation is an unsupervised algorithm that characterizes the input information into various classes in view of their inherent separation from one another. The calculation accept that the information highlights frame a vector space and tries to discover normal grouping in them. The points are clustered around centroids.

A cluster is a gathering of objects which are similar between them and are not at all like the objects having a place with different groups. clustering is an unsupervised learning system which manages discovering a structure in a gathering of unlabeled information. K-means clustering is a algorithm to gathering objects in view of attributes/features into k number of gatherings where k is a positive integer. The gathering (clustering) is finished by

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minimizing the Euclidean separation between the information and the comparing cluster centroid.
For a given For a given image, compute the cluster means m

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

Calculate the distance between the cluster center to each pixel

$$D(i) = \arg\min \|x_i - M_k\|^2, \quad i=1,\ldots\ldots,N \tag{2}$$

1. In the image let D be the data points
2. Partition the data points into k equal sets.
3. Take the middle point in each set as initial centroid.
4. Calculate the distance between each data point ($1 \le i \le n$) to all initial centroids ($1 \le j \le k$).
5. For each data point di, find the closest centroid cj and assign di to cluster j.
6. Set $c[i] = j$.
7. Set $Nea[i] = d(di, cj)$.
8. For each cluster ($1 \le j \le k$), recalculate the centroids.
9. for each data point di, (i) compute its distance from the centroid of the present nearest cluster. (ii) The data point stays in the same cluster If this distance is less than or equal to the present nearest distance, Otherwise compute the distance (di, cj) for every centroid ($1 \le j \le k$).
10. Repeat from steps 5 to 9 until convergence is m.The Fig.3 shows the Graphical user interface for K-means segmentation of brain MRI image.

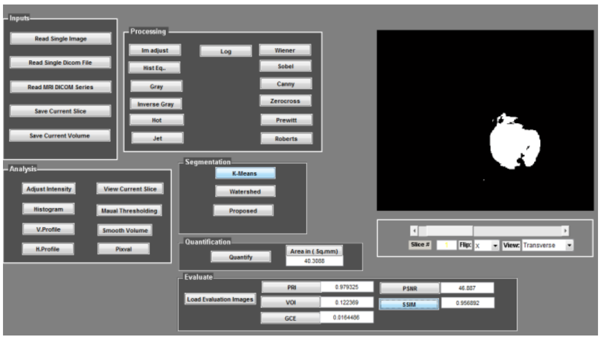

Fig3. GUI for K-Means segmentation of brain MRI image

D.Watershed Transform
Watershed segmentation is a most efficient segmentation originating from the field of numerical morphology. The instinctive thought of this transform is quite simple: if we consider the image as a scene or topographic relief, where the height of every point is directly identified with its gray level, and consider rain gradually falling on the territory, then the watersheds are the lines that separate the "lakes" really called catchment basins that form. The watershed transform is computed on the gradient of the original image, so that the catchment bowl limits are situated at high inclination points. This transform has been generally utilized as a part of numerous fields of image processing, including medicinal MR image segmentation, because of the advantages that it possesses. it is very simple, instinctive, quick, parallelized strategy and produces a complete division of the image in separated regions regardless of the fact that the complexity is poor, along these lines staying away from the requirement for any sort of contour joining. Some essential disadvantages related to the watershed transform are the over segmentation and poor detection areas with low contrast that commonly results in MRI brain images.
Marker Controlled Watershed Segmentation Touching objects detachment in an image is the one of the most difficult works in image processing. The watershed transform is often applied to this issue.
Marker Controlled Watershed Segmentation Touching items partition in a picture is a standout amongst the most troublesome works in medicinal picture handling. The watershed change is frequently connected to this issue. The watershed transform discovers catchment basins and watershed edge lines in a image by treating it as a surface where light pixels are high and dark pixels are low. Segmentation utilizing the watershed transforms works better, if you can identify or mark foreground objects and background locations.

Marker-controlled watershed division takes after this essential methodology

1. Compute a segmentation function. This is a image whose dark regions are the items you are attempting to segment.
2. Compute frontal area markers. These are joined blobs of pixels inside of each of the objects.
3. Compute background markers. These are pixels that are not a portion of any object.
4. Change the segmentation function so that it just has maxima at the foreground view and background marker areas.
5. Compute the watershed transform of the altered segmentation capacity.

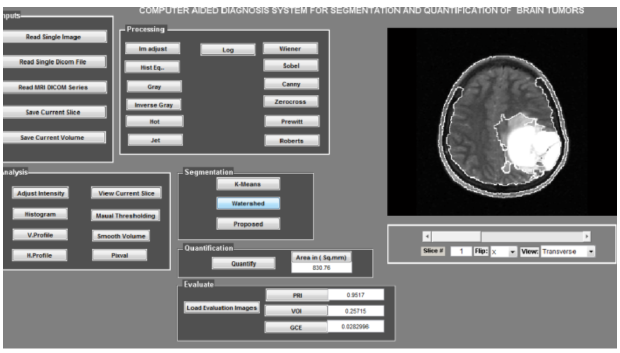

Fig.4. GUI for watershed segmentation of brain MRI image

The fig.4 provides the detailed view of graphical user interface for watershed segmentation of brain MRI images.

The detailed view of watershed transform with all processing images as shown below in fig. 5

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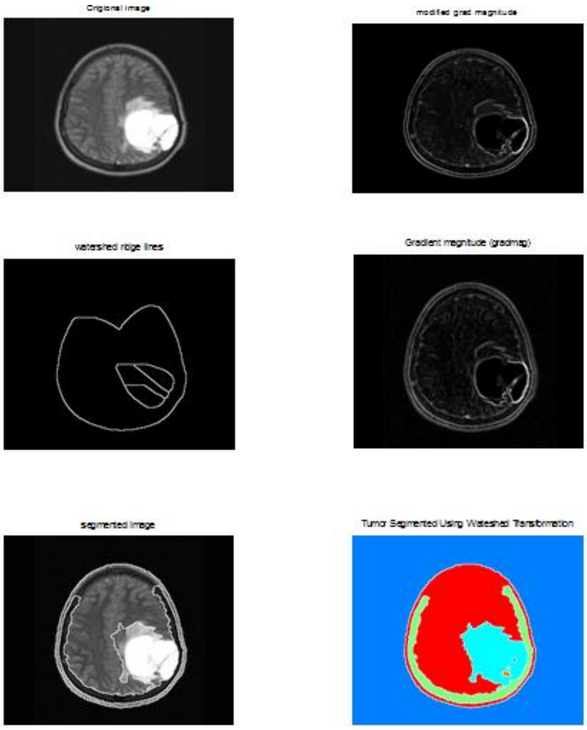

Figure5. Results of watershed segmentation of brain MRI image

IV. EXPERIMENTAL RESULT ANALYSIS AND DISCUSSIONS

Two sorts of experiments are done to assess the execution of the proposed approach qualitatively and quantitatively. The performance measures used to analyze the execution are PRI (Probabilistic Rand Index), VOI (variation of information) &GCE (global consistency error). PRI assesses the pair wise connections between pixels of divided result and numerous ground-truth divisions and takes values in the reach (0, 1). Hence higher PRI esteem shows a superior match between the sectioned result and the ground-truth information. VoI, GCE are error measures that have to be reduced by the good segmentation algorithm.

A. Rand Index (RI)

The Rand Index (RI) checks the part of pairs of pixels whose marking are reliable between the computed segmentation and the ground truth averaging over numerous ground truth segmentations. The Rand measure is a measure of the similitude between two data clusters. Given a set of n components and two partitions of S to look at, and, we characterize the following:

a. The quantity of pairs of elements in S that are in the same set in X and in the same set in Y
b. The quantity of pairs of elements in S that are in different sets in X and in distinctive sets in Y
c. The quantity of pairs of elements in S that are in the same set in X and in diverse sets in Y
d. The quantity of sets of elements in S that are in different sets in X and in the same set in Y

The Rand Index (RI) defined as

$$R = (a + b)/(a + b + c + d) = (a + b)/((n/2)) \qquad (3)$$

Where a + b as the number of agreements between X and Y and c + d as the number of disagreements between X and Y. The Rand index has a value between 0 and 1, with 0 indicating that the two data clusters do not agree on any pair of points and 1 indicating that the data clusters are exactly the same.

B.Variation of Information (VOI)

The Variation of Information (VOI) metric characterizes the distance between two segmentations as the average conditional entropy of one segmentation given the other, and in this manner measures the measure of randomness in one segmentation which can't be clarified by the other. Assume we have two clustering (a division of a set into a several subsets) X and Y where

$$X = \{X1, X2... Xk\},\ pi = |\ Xi\ |/n,\ n = \Sigma k\ |\ Xi\ |. \qquad (4)$$

At that point the variety of information between two clustering is:

$$VI(X; Y) = H(X) + H(Y) - 2I(X, Y) \qquad (5)$$

Where, H(X) is entropy of X and I(X, Y) is mutual information between X and Y. The common data of two clustering is the loss of uncertainty of one grouping if the other is given. Consequently, shared positive and limited by {H(X),H(Y)}_log2(n).

C. Global Consistency Error (GCE)

The Global Consistency Error (GCE) measures the degree to which one segmentation can be seen as a refinement of the other. Segmentations which are connected are thought to be steady, since they could represent to the same image segmented at distinctive scales.

Segmentation is essentially a division of the pixels of a picture into sets. The portions are sets of pixels. If one segment is appropriate subset of the other, then the pixel lies in an area of refinement, and the error should be zero. If there is no Subset relationship, then the two regions overlap in an Inconsistent manner.

$$\tau = \sum_{j=1}^{K} \sum_{i=1}^{x} = 1 \parallel X^{(j)} - Cj \parallel^2 \quad \text{where} \parallel X^{(j)} - Cj \parallel^2 \ (6)$$

Where, segmentation error measure takes two divisions S1 furthermore, S2 as input, and produces a genuine esteemed output in the reach [0::1] where zero signifies no error. For a given pixel pi consider the segments in S1 and S2 that contain that pixel.

D.Calculation the tumor region

The tumor area region is calculated by the following equation:

Tumor area = A total number of pixel in the tumor region

$$A = V \times H \qquad (7)$$

Where, A=the area of each pixel
H=horizontal dimension of the image
V=vertical dimension of the image

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E. Peak signal to noise ratio (psnr)

The Peak Signal to Noise Ratio (PSNR) is used to find the deviation of segmented image from the ground truth image. Equation (8) represents the PSNR. In this equation mean squared error (MSE) for two M * N monochrome images f and z and it is given by Equation (9). MaxBits gives the maximum possible pixel value (255) of the image.

$$PSNR = 10X\log_{10}\frac{MaxBits^2}{MSE} \quad (8)$$

$$MSE = \frac{1}{MxN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}((f(x,y)-z(x,y))^2 \quad (9)$$

F. STRUCTURAL SIMILARITY

Structural Similarity Index (SSIM) is a method for measuring the similarity between two images. The SSIM is measured between two windows X and Y of common size N*N on image using Eq. (3).

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \quad (10)$$

The amount of quantitative information available on medical images is enormous. Computer quantification may hold more potential than computerised detection. The main reason that most radiolilogic scoring systems are not used routinely in clinical pratcie that they are too time consuming and cumbersome to apply. For effective and wide sped use of any cad system it should be integrated in to through workflow of radiologist and interaction should bbe intuitive and the results should availabe instantelysly. Current systems for computer aided detection have been intruded as complementary tools that draw the radiologist attention to certain image areas that need further evaluation. The proposed calculations have been implemented utilizing MATLAB. The execution of different image segmentation methodologies are analyzed and talked about. The measurement of image segmentation is hard to measure. There is no regular algorithm for the image segmentation. The measurable estimations could be utilized to measure the nature of the image segmentation [21]. The rand index (RI), global consistency error (GCE) & VOI are utilized to assess the execution. The detailed description with formulae of RI, GCE, VOI parameters are clarified in point of interest as follows.

TABLE1. Performance evaluation

Methods	PRI	VOI	GCE	PSNR	SSIM
K-Means	0.9796	0.126	0.01663	46.88	0.9568
Water Shed	0.5847	1.02	0.0782	27.94	0.3387

The experiment is conducted over the Brain tumor MRI images using the algorithms k means, watershed and their outcomes appeared in Fig.3 and Fig.4 with required measurable parameters and their outcomes are exhibited in Table 1The estimation of RI,PSNR, SSIM is higher and GCE, VOI are lower than the segmentation methodology is better.

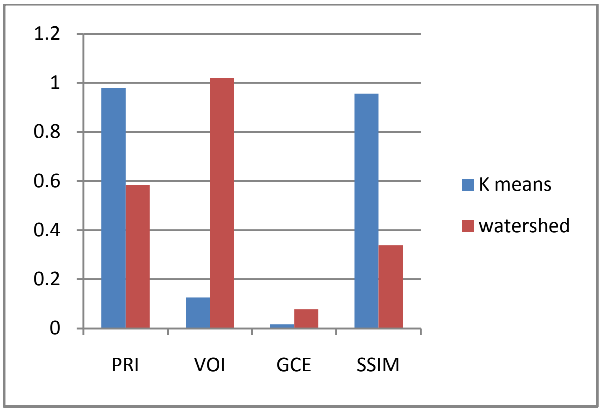

Fig. 6 The performance analysis chart

The fig. 6 performance analysis chart revieals that the PRI, SSIM values are higher and VOI and GCE values are lower for K means algorithm compared to water shed algorithm. We observed that the k means algorith outperformances compared to watershed algorithm.

V. CONCLUSION

In this paper a GUI based CAD interactive image processing tool for medical images is proposed. The tool is developed in MATLAB and is user friendly. The aim of the paper is to describe and develop a technique which provides various functions like image smoothing, reading a medical image of different format. In this paper, the unsupervised method i.e. cluster based algorithms and waterhsed segementaion were proposed for image segmentation. These algorithms were tested on BRAIN MRI images. The performance of these algorithms is measured using segmentation parameters RI, GCE, VOI, and PSNR, SSIM. Thecomputational results showed that the K means image segmentation consumes less time and it performs better than the watershed.Accordingly, we compare the segmentation performance in brain tissue. To say that actual results are consistent with the results obtained on synthetic images .

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BIOGRAPHIES

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