Performance Evaluation of Various Segmentation Methods for Brain Tumour Images using Raspberrypi Processor

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Abstract:In recent years, automatic segmentation of brain tumour from the MRI images using medical image processing is really a challenging task. This work describes the comparison of the performance of various image segmentation algorithms with the help of a Raspberrypi processor. The best segmentation approach is identified after applying different methods to the standard publicly available datasets and the evaluation of the performance is done by measuring the parameters like similarity criteria, execution time, sensitivity and specificity. At first, the input MRI images are taken from the public datasets. These images may be affected with Gaussian noise, impulse noise, and speckle noise. So, in order to remove these noise and to improve the contrast, a pre-processing technique is applied to the input images. Once the images are enhanced, it is then enhanced using various segmentation algorithms like a watershed, thresholding technique, mean shift algorithm, distance transform, Active Contour Model, K-means clustering and Fuzzy C-Means clustering technique. On the basis of the obtained results, it is found that the Fuzzy C-Means clustering technique achieves more segmentation accuracy but at the same time, it takes more execution time.

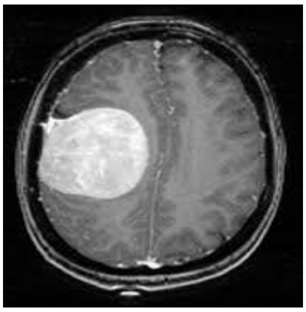
1. Introduction

Tumour, an abnormal growth of cells, can occur in various parts of the human body. But the entire system of our body will get collapsed if it occurs in the brain.A brain tumour is a mass of tissue which is formed by a gradual addition of anomalous cells with different shape and size [1]. The train tumour can be classified as primary or metastatic. The primary type of brain tumors occur mostly in older adults and children and do not spread to other parts of the human body. It will stay within the brain. Whereas, the metastatic tumour, which occurs commonly in older adults than in children, will spread to other parts of the body also [2].

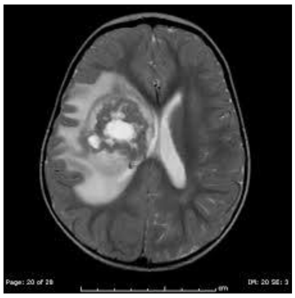
Brain tumors can be characterized into two types as Benign or malignant. It is reported by the American Brain tumour association that nearly 78,000 new cases of primary brain tumour were diagnosed in the year of 2015. Among them, 25,000 patients belong to primary malignant.

National Brain tumour foundation found that the number of patients having BT and the number of people dies outof BT are increasing every year [3]. Therefore, early diagnosis of the disease using imaging method is very essential for prevention and further treatment.A typical Brain tumour image illustrating the category of benign and malignant is shown in the figure 1.

Various Imaging techniques like CT, MRI and PET are available which provides a lot of information about the tissue in the brain. As MRI Imaging has high spatial resolution with no harmful radiation, it is considered as an efficient method, in BT detection while compared with all other techniques.



a



b

Fig. 1.*MRI Brain Image*

(a) Benign Image

(b) MalignantImage

Although, the detection of tumour with the help of human is existing, when a large number of brain MRI images are examined, it may create a misclassification problem and consumes more time since it is a laborious process [4]–[5].

Therefore, there is a need of an automated Computer-aided diagnosis system which helps to detect the brain tumourwith helps to detect the brain tumour with accurate classification in almost no time. This proposed method exploits the accurate segmentation of tumour in the brain MRI images with the help of Raspberry pi processor, which in turn helps to prevent the progression of disease.

The rest of this paper is organized as follows Section II reviews related work on segmentation of brain tumour. The details of the proposed method are discussed in section III. The experimental results of various segmentation are explained section IV. Finally, the conclusion is drawn in section V.

2. Overview of state of art

A number of studies have investigated the automatic segmentation and classification of brain tumour. Early detection of Brain tumour using MRI images is an interesting and intense research area.

Gordillo et al [6], proposed a method for the segmentation of Brain tumour using Global and local thresholding technique. The author identified that global thresholding is more suitable if an image contains more homogeneous intensity region. But if the tumour is present in more than one region, then the local thresholding works good for the segmentation process.

In [7], an approach for the segmentation of tumour using improved edge detection algorithm is proposed by Aslametal. Initially, an automatic image thresholding in combination with sobel operator is applied to extract the edges of the brain tumour. The brain tumour is then segmented with the help of closed contour algorithm.

Gholipour et al [8] have developed an automatic segmentation method based on multi-atlas, multi-shape strategy. This method achieved a better value in comparison with solid anatomic variability.

The work in [9] discussed the optimized segmentation of tumour from MRI images using Genetic algorithm. The main advantage of this work is that it produced high efficiency. Tandoori et al in [10] proposed an approach for the extraction of brain and non-brain regions using active contour model. The vector field convolution (VFC) more external forces to the edges of the images. The brain and non-brain regions are then classified effectively with the help of Support Vector Machine (SVM) classifier.

In [11], an artificial neural network (ANN) based method for the accurate segmentation of brain tumour is proposed by Dahab et al. The tumour region is classified with the help of probabilistic neural network and Linear Vector Quantization (LVQ) process. A set of features are extracted from the required Region of Interest (ROI) and then each ROI is assigned a weight vector. These vectors are then used for modeling the PNN with LVQ.

Havaei et al in [12] implemented a method to segment tumour using deep neural network. This approach used both local and global conceptual features to segment tumour. In [13], the authors presented an approach for classification of normal and abnormal Brain tumour images using Support Vector Machine (SVM) classifier. The distinguishable features were extracted from the ROI using dominant grey level run length matrix method, wavelet based method and spatial grey level dependence matrix method. The best features that help the classification process are selected using Genetic Algorithm (GA). Finally the images are classified with the help of SVM classifier.

Bauer et al in [14] modeled a mesh-free method to diagnose healthy and disease images. The author employed mesh free method for healthy images and a modified atlas for diseased images. The growth and position of tumour which stimulate the tumour may are meshed into the atlas to improve the accuracy of the method.

Based on the motivation and the review of the above works, an efficient method for the segmentation of Brain Tumour is proposed. This approach discusses the segmentation of tumour from MRI brain images with various segmentation algorithms. All the process explained in this approach is carried out with the help of a Raspberry pi processor. The important reason for selecting this is that is easily portable as it is of very small size and consumes very less power. Implementation of this proposed work with raspberry pi processor will definitely aid the doctors mainly whenever they are going for a large screening process. He doctor can diagnose the disease quickly and accurately.

3. Proposed Methodology

The overall schematic flow of the proposed methodology is shown in fig 2. The input MRI brain images are captured from the human. As there images may be affected with unknown noise or may have poor illumination, these images are pre-processed with different types of filters and pre-processing algorithms. Once the images are pre-processed, the brain tumour images are segmented with the help of different segmentation algorithms. Finally, the performances of the different algorithms are compared by measuring the performance parameter.

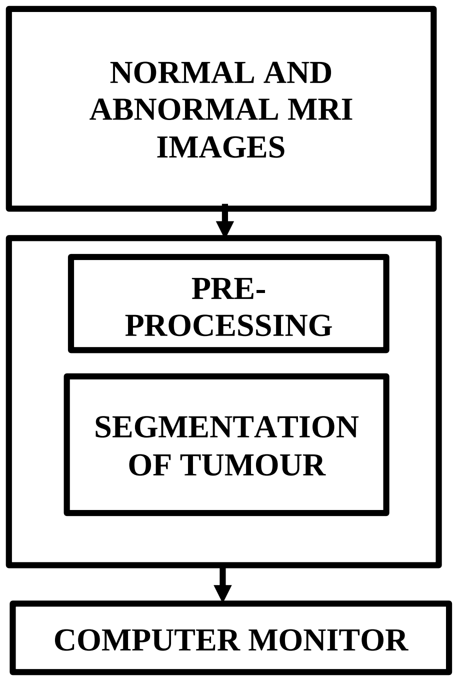


Fig. 2.*Schematic representation of the proposed method*

3.1 Image Acquisition

To diagnose the brain tumour, several imaging techniques are available around the world. CT, MRI, PET and multimodal techniques provides a lot of information about the brain tissues which is turn helps to detect the disease accurately. In this proposed work, MRI brain images are used for the early prevention of the disease. MRI images are mainly preferred as it contributes various useful features such as tissue characteristic, multiplanar characteristics, and no bone and teeth artifacts. It provides high quality spatial resolution and it doesn't produces any harmful radiation. So this is usually considered as an efficient imaging technique compared to CT and PET [15]-[16].

3.2 Pre-processing of Input MRI Image

The input MRI brain images taken from the patients may be degraded by noise and may have poor contrast and illumination. If these images are segmented, it may in our low accuracy and give poor results. So these images are pre-processed before the application of segmentation process.

The steps involved in the pre-processing stage is illustrated in fig3.

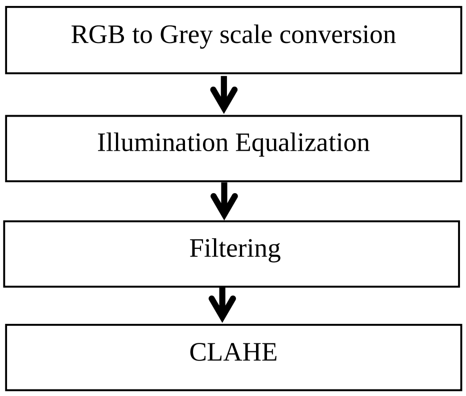


Fig.3.Preprocessing of MRI Image

3.2.1 RGB to Grey scale Conversion:

Initially, the MRI brain images are in primary RGB colour space. It is converted into grey scale as it will be more useful for processing.

3.2.2 Illumination Equalization:

The grey Scale image may have poor illumination that occurs during capturing. So these images are illumination equalized [17], [18] and it is given by

$$G_{IE} = G\,(r,c) + m\text{-}G_w(r,c) \qquad \text{---(1)}$$

Where, $G_{IE}$is the illumination equalized image and $G_w(r,c)$ is the mean intensity value of the pixel within a window of size 3x 3.

3.2.3 Filtering:

Though there are lot of filters are existing. In this work, the authors employed three different types of filters like mean filters, median filters and Gaussian filters. As Gaussian noise are mostly present in medical images, the output of Gaussian filter is used for further Processing.

3.2.4 Contrast Limited Adaptive Histogram Equalization (CLAHE):

The Filtered output is then enhanced in contrast by applying CLAHE algorithm [19]-[20]. The output obtained at this stage is used for the segmentation process.

3.3 Segmentation of MRI brain Images

The Segmentation is the process of dividing an entire image into small region that have similar characteristics. In this work, the different tumour tissues are separated from the normal tissues with the help of different segmentation algorithms. The various segmentation algorithms employed in this approach are thresholding, Watershed Segmentation, K-means clustering, distance transform algorithm and Mean shift algorithm.

3.3.1 Segmentation using thresholding:

Segmentation of MRI images using thresholding is the simplest and easiest method of tumour segmentation. As normal and tumour tissues have different intensities, this method segments the tumour region from normal tissues by comparing the intensity of each pixels with a threshold intensity. This method will take less execution time as the complexity of this algorithm is very less.

3.3.2 Segmentation using Watershed Algorithm:

When the object to be segmented contains a closed contour, then it is better to empty a watershed segmentation. This algorithm is a flexible and robust method for segmentation. The watershed algorithm can be explained with the analogy of behaviour of water on the landscape. The landscape is divided into different disjoint regions. The dam is built at the point where water from different basins flows together. When water reaches the top level, the building of dam is stopped. Each region in landscape represents a dam. Thus a contour of region is formed. The function cv2. watershed() in OpenCV library helps to compute the watershed segmentation of the enhanced image.

3.3.3 Segmentation using K-means clustering:

Next, the enhanced image is segmented with the help of K-means clustering algorithm. This algorithm is the simplest and the easiest way to cluster the region. Clustering is a way to separate group of objects [21]. The algorithm finds partition such that region within each cluster are close to each other as possible and as for from other clusters as possible. K-initial clusters are randomly identified. The objects that are close to each other are assigned to the centre. This process is continued until all objects are converged in a single cluster. When compared to thresholding algorithm, which segments the image into two clusters, k-means can segment into K-different clusters.

3.3.4 Segmentation using distance transform algorithm:

Distance transform algorithm is an important tool in machine learning and computer vision [22]. The output of the pre-processed image is in grey scale form. It is then converted into binary form before being applied to distance transform algorithm. This transform measures the distance of each object from the nearest boundary. Euclidean distance norms, city block distance norms or mahalanobis distance norms can be used. In this work, the author employed Euclidean distance norms for the image segmentation.

3.3.5 Segmentation using Mean shift algorithm:

Mean shift is one of the powerful iterative algorithm used to segment the tumour in MRI brain images. The algorithm takes the pre-processed image in grey space and consider it as a probability density function. If there is a group of tumour in the image, then they correspond to the mean shift of the probability density function. Usually, the mean shift is calculated by the window and after each iteration, the window shift to the next region containing tumour.

3.3.6 Segmentation using Fuzzy C-Means Clustering (FCM) algorithm:

The segmentation of MRI brain images using Fuzzy C-Means is a useful research work as it produces more accurate results compared to others. FCM algorithm divides a group of data into two or more clusters based on a membership function. The important pros of this segmentation algorithm is that it assigns the data points to more than one cluster centre and it produces encouraging results for overlapped data sets. The pathological tissues are accurately segmented from the raw MRI images using this algorithm. The segmentation of brain tumour by FCM can act as an excellent tool in clinical labs for studying virtual brain endoscopy.

3.3.7 Segmentation using Active Contour Model (ACM) algorithm:

Active Contour Model, which was first proposed in 1988, can also be called as snake model. It is a widely used algorithm for the detection of brain tumour boundaries as it has considerable sensitivity. The performance of the ACM is highly comparable to canny, sobel and Laplacian edge detectors. In this proposed work, a Gradient Vector Flow (GVF) snake is proposed to segment the tumour from the MRI brain images. This model can track the boundary even at its concavity and also eliminates the issue of short capture range. The only pitfall of this method is that it sometimes require to locate the initial position manually in order to avoid incorrect boundary detection.

4. Results and Discussion

The proposed approach is tested on normal and abnormal images from BITE Database [23]. This database consists of both pre- and post- operative T1-weighted MR images which are captured from 14 brain tumour patients at Montreal Neurological Institute, Canada. These images are preprocessed with various filters and CLAHE. The output enhanced image is segmented using different algorithms lite thresholding, watershed, K-means clustering, distance transform, Mean-shift algorithm, Fuzzy C-Means and Active Contour Model algorithm.

The proposed method is executed on a RaspberryPi3 processor with python and open CV tool as programming language. The RaspberryPi is a credit- card sized single board computer which runs on Linux OS. It consumes very less power compared to normal processor. As it is of small size, it can be easily portable and very useful for screening process in the urban areas.

The performance parameters such as accuracy and execution time are computed for the different algorithms and they are compared and tabulated in table 1.

The accuracy of the algorithm is calculated using the formula

$$\text{Accuracy} = \frac{(TP+TN)}{(TP+TN+FP+FN)} \quad \text{--- (2)}$$

Where, TP, TN, FP, FN are true positive, true negative, false positive, false negative respectively.

Table 1. Comparison of Accuracy for various segmentation Methods.

S. No	Segmentation Algorithm	Accuracy (%)
1	Thresholding	76.14
2	Watershed	84.22
3	K-means Clustering	94.61
4	Distance transform	70.54
5	Mean shift algorithm	79.21
6	Fuzzy C-Means Clustering	95.37
7	Active Contour Model	85.20

The execution time of different segmentation algorithms are shown in Table 2 and it is compared in fig 6.

Table 2. Comparison of Execution time for various segmentation Methods.

S. No	Segmentation Algorithm	Execution time (sec)
1	Thresholding	0.06
2	Watershed	0.47
3	K-means Clustering	3.26
4	Distance transform	0.09
5	Mean shift algorithm	1.90
6	Fuzzy C-Means Clustering	3.47
7	Active Contour Model	2.16

(Fig 6)

On Comparison, the authors found that among the seven different algorithms, Fuzzy C-Means (FCM) segmentation produces high accuracy with a high execution time.

5. Conclusion

An automatic segmentation of brain tumour by different segmentation algorithm using Raspberrypi processor is proposed and validated. Though different types of imaging techniques are available, MRI based tumour segmentation is employed as it have good tissue contrast and good spatial resolution. Manual segmentation of tumour are suited but it takes more time and sometimes provides poor results when a large number of people are gathered in a large screening process. So, this work proposed an automatic segmentation of brain tumour from MRI images. The performance of different algorithms are compared and it is found that Fuzzy C-Means segmentation algorithm outperforms well against different algorithms. In future, the images can be classified as normal or tumour with the help of some classifier using an IoT platform.

6. References

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