A BRAIN TUMOR DETECTION USING K-MEANS, FUZZY C MEANS AND WATERSHED SEGMENTATION

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ABSTRACT

Brain tumor is one of the serious diseases so it is necessary to have accurate detection. Generally by using CT-scan and MRI techniques visual examination is done by doctors for detection of part of brain having tumor. In this paper three algorithms are used to perform brain tumor segmentation of MRI image. In first stage image pre-processing is performed to remove file artifacts, skull removal and median filter is applied for noise reduction. In second stage segmentation is performed on preprocessed image by k-means and FCM and watershed segmentation methods which partition the image into different regions. In third stage, thresholding and morphological operators are used to separate the part of brain having tumor from MRI image. At the end of the process the tumour is extracted from the MR image and its exact position and the shape also determined.

Keywords : Tracking Algorithm, Median Filter, K-Means, Fuzzy C Means, Watershed Segmentation, Thresholding, Morphological Operator's

I INTRODUCTION

Tumour is an abnormal growth of cells in body which forms a mass of tissues. It can be cancerous i.e malignant or non-cancerous i.e. Benign. Malignant tumour involves abnormal cell growth which spread to other parts of the body. Benign tumors do not spread to other parts of the body. Normally brain tumour affects CSF (Cerebral Spinal Fluid). It causes strokes. The physician gives the treatment for the strokes rather than the treatment for tumour. So detection of tumour is important for the treatment. MRI, computed tomography (CT), digital mammography, and other imaging processes give an efficient means for detecting different types of diseases. From the MRI images the information such as tumors location provides radiologists, an easy way to diagnose the tumour and plan the surgical approach for its removal. MRIs use radiofrequency and magnetic field without ionized radiations. This MRI Magnetic resonance imaging is used to visualize the internal structures of the body which gives different opinions between doctors .Therefore, the brain tumor diagnosis in an appropriate time is very necessary. To overcome this problem image segmentation is applied to MRI images. Image segmentation technique partitions a given image into a finite number of non-overlapping regions to accurately identify tissue structure and perform correct diagnosis.

S Zhu et al paper presents an image segmentation method using thresholding technique This is based on the assumption that adjacent pixels whose value lies within a certain range belong to the same class[1]. Manoj K Kowar and Sourabh Yadav describe Brain Tumor Detction and Segmentation Using Histogram Thresholding. If the histograms of the images corresponding to the two halves of the brain are plotted, symmetry between the two histograms should be observed along its central axis and if any asymmetry is observed, tumor is detected. This makes image histogram the choice for object delineation and finding an appropriate threshold between object and background fulfils the task of object identification [2]. Victor Chen et al proposed that Graph based detection of tumor is one of the segmentation technique where tumor is detected based on graph. Graph cut leads to over partitioning of the image[3]. From the above discussion, it can be said that, there is no such technique which is perfect. To get best results we have to minimize the limitation of the individual methods for this segmentation processes are used in this paper. Here proposed algorithms are based on k-means, fuzzy c means and combination of watershed segmentation and morphological operator's.

II PROPOSED METHOD

The proposed method mainly divided into two stages as preprocessing and combination of image segmentation and classification. The preprocessing is done by tracking algorithm and median filter. Segmentation is carried out by K-means, Fuzzy c means followed by thresholding performed for classification. and watershed segmentation methods followed by morphological operators which separate the tumor part from brain MRI. The block diagram of proposed method is given below:

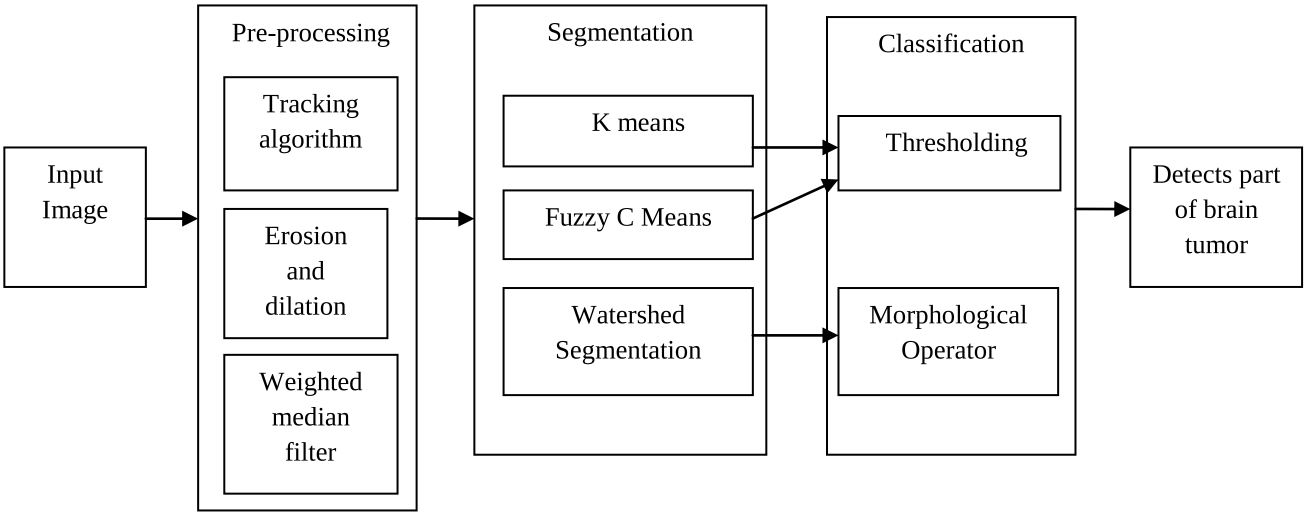

Fig.1 Block diagram of proposed method

Fig.1 is a block diagram for proposed method. It is having a combination of three segmentation methods from that image segmented by k means and fuzzy c means is classified by thresholding. Morphological operators are used to classify watershed segmented image. The entire proposed system consist of mainly three modules under that different algorithms are used. Each module and its function is explained below:

2.1 Pre-processing

MRI image is taken as input image. For getting accurate results preprocessing is performed on MRI image. Fisrt MRI image is converted into gray scale image which gives all the intensity values from 0 to 255. Then preprocessing is done using tracking algorithm, erosion and dilation and also median filter. The algorithms and results for each method are explained below:

2.1.1 Tracking algorithm

Film artifacts such as patients name, labels are removed using tracking algorithm.Here, starting from the first row and first column, the intensity value of the pixels are analyzed and the threshold value of the film artifacts are found. The threshold value, greater than that of the threshold value is removed from MRI. The high intensity value of film artifacts are removed from MRI brain image [4].

1. Read the input image and store it in a two dimensional matrix.
2. Select the peak threshold value for removing white labels
3. Set flag value to 40.
4. If the intensity value is less than or equal to 40 then, then that pixel is set to zero and thus the labels are removed from the image.
5. Otherwise skip to the next pixel.

2.1.2 Skull removal algorithm

Removal of skull part using erosion and dilation morphological techniques which is an effective and fully automated but inefficient way of stripping skull. Erosion and Dilation are two basic operators in the area of mathematical morphology. These typically applied to binary images, but there are versions that work on grayscale images. As erosion is a technique which uses background and the foreground for the processing. In Brain MRI there is a particular intensity of the back-ground that appears before brain image. Unfortunately in brain MRI, the same intensity is appeared as a part of the brain. And this appearance is a false background. So in this scenario that algorithm would be unable to distinguish between the original back ground and the false background. Eventually the area around the false background will also be eroded, which causes distortion in the brain tissues along with the skull.

1. Convert the film artifacts removed image into binary image.
2. Set the disk value to 7.
3. Apply the erosion followed by dilation.
4. Map the result obtained with input image.

2.1.3 Median filter algorithm

For removal of unwanted part median filter is applied to remove noise from an image. It is used for removing high frequency components such as salt and pepper noise. Median Filter can remove the noise without disturbing the edges. This technique calculates the median of the surrounding pixels to determine the new value of the pixel. A median is calculated by sorting all pixel values by their size, then selecting the median value as the new value for the pixel. For each pixel, an 3*3, 5*5, 7*7, 9*9, 11*11 window of neighborhood pixels are extracted and the median value is calculated for that window. The intensity value of the center pixel is replaced with the median value. This procedure is done for all the pixels in the image to smoothen the edges. Then using this preprocessed image segmentation is performed to detect tumor part [5].

1. Read the image and store it in a 2 dimensional matrix.
2. Extract matrix of size 3*3 from the given image and apply median filtering.
3. Intensity values of 3*3 matrix are compared with the given range of values.
4. Calculate median value for the above 3*3 matrix.
5. Replace the center intensity value of the 3*3 matrix by the median value that was calculated.

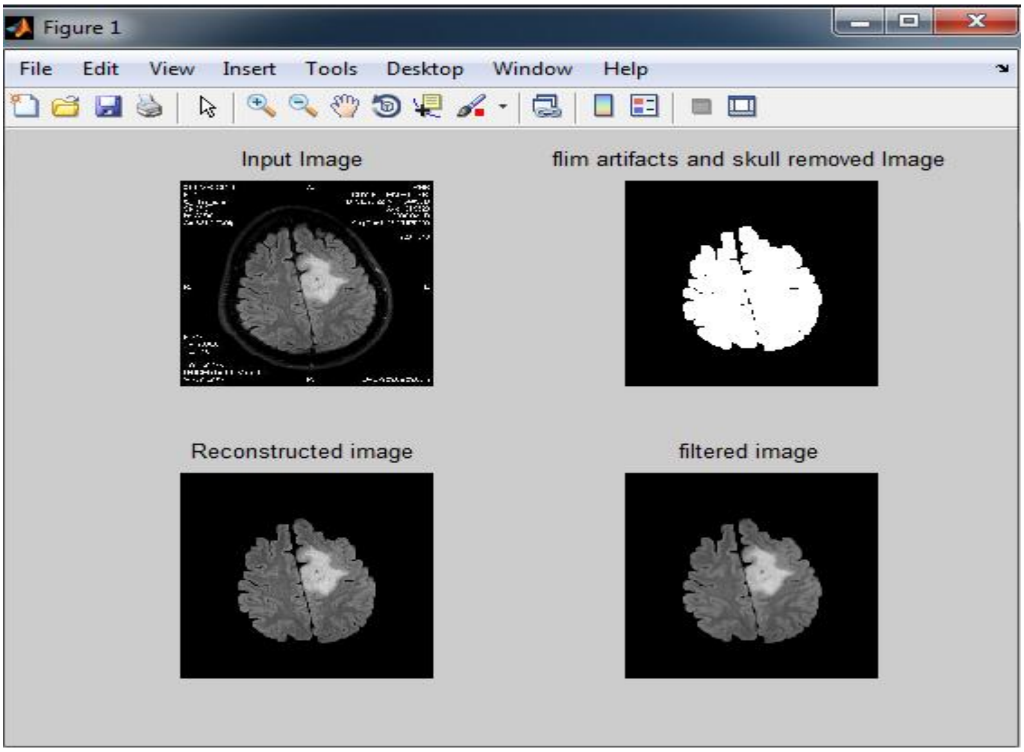

Fig.2Screenshot for Output of pre-processing stage

Fig.2 shows the output of preprocessing stage from that first image is input MRI image. Then film artifacts and skull part is removed using tracking algorithm and erosion dilation techniques respectively. Hence the reconstructed image is obtained at output. Then to remove noise median filtering is applied.

2.2 Image segmentation

Image segmentation is a method of partitioning the image into different region and each region contains the pixels of similar intensities. The goal of Magnetic Resonance (MR) image segmentation is to accurately identify the principal tissue structures in these image volumes. However in MRI images, the amount of data is far too much for manual interpretation and analysis and this has been one of the biggest problems in the effective use of MRI. In the specific case of brain MRI, the problem of segmentation is particularly critical for diagnosis and treatment purposes. In this paper three image segmentation algorithms are applied to perform segmentation of MRI image which are explained in detail below:

2.2.1 K-means method

K-means is a pixel-based methods. A natural objective function can be obtained by assuming that we know there are k clusters, where k is known. Each cluster is assumed to have a center; we write the center of the ith clusteras ci. The jth element to be clustered is described by a feature vector xj .If we were segmenting an intensity image x might be the intensity at a pixel. Notice that if the allocation of points to clusters is known, it is easy to compute the best center for each cluster. However, there are far too many possible allocations of points to clusters to search this space for a minimum. Instead, we define an algorithm which iterates through two activities first is to assume the cluster centers are known, and allocate each point to the closest cluster center and second is to assume the allocation is known, and choose a new set of cluster centers. Each center is the mean of the points allocated to that cluster. We then choose a start point by randomly choosing cluster centers, and then iterate these stages alternately. This process will eventually converge to a local minimum of the objective function.

The process uses K-means algorithm for solving clustering problem this algorithm aims at minimizing an objective function, in this case a squared error function. Mathematically, this objective function can be represented as:

$$J = \sum_{j=1}^{k} \sum_{i=1}^{x} \mathrm{P} x_i^j - c_j \mathrm{P}^2 \qquad (1)$$

where J is a chosen distance measure between a data point x(i) and the cluster centre cj, is an indicator of the distance of the n data points from their respective cluster centers. Image is read from database. The image contains the skull tissues. These tissues are non brain elements. Therefore, they should be removed in the preprocessing step. The presence os these tissues might lead to misclassification [6].

2.2.1.1 Algorithm of K-means method

1. The initial partitions are chosen by getting the gray values of the pixels.
2. Every pixel in the input image is compared against the initial partitions using the Euclidian distance and the nearest partition is chosen and recorded.
3. Then, the mean in terms of gray scale of all pixels within a given partition is determined. This mean is then used as the new value for the given partition.
4. Once the new partition values have been determined, the algorithm returns to assigning each pixel to the nearest partition.
5. The algorithm continues until pixels are no longer changing which partition they are associated with or until none of the partition values changes by more than a set small amount.

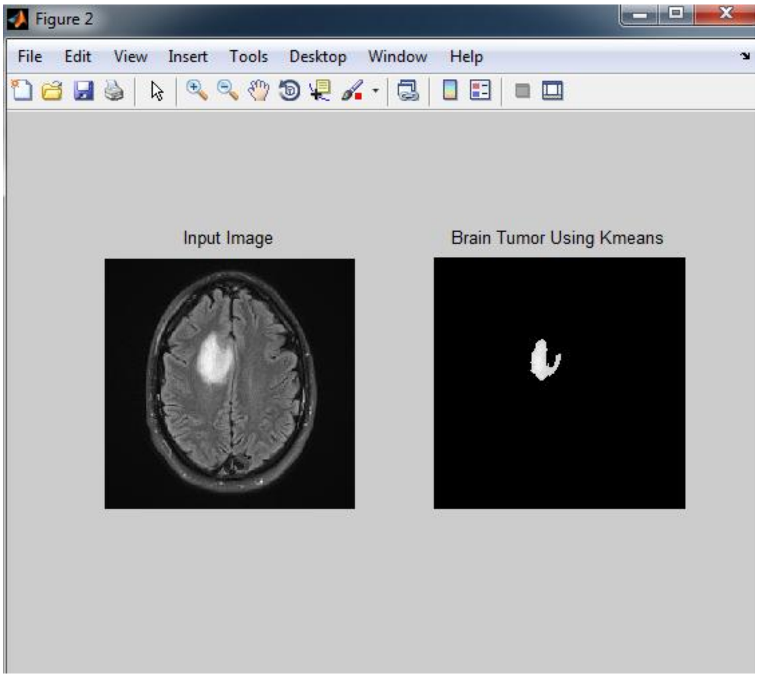

Fig.3 Output of K-means algorithm

Fig.3 shows the output of K-means method. This method can separate the exact tumor part from MRI image by dividing the preprocessed image into number of clusters having same or nearby intensity values. The results are shown after performing the thresholding.

2.2.2 Fuzzy c means method

The aim of FCM is to find cluster centers (centroids) that minimize dissimilarity functions. In order to accommodate the fuzzy partitioning technique, the membership matrix (U) is randomly initialized. In the first step, the algorithm selects the initial cluster centers. Then, in later steps after several iterations of the algorithm, the final result converges to actual cluster center. Therefore a good set of initial cluster is achieved and it is very important for an FCM algorithm. If a good set of initial cluster centers is chosen, the algorithm make less iterations to find the actual cluster centers.

The Fuzzy C-Means algorithm is an iterative algorithm that finds clusters in data and which uses the concept of fuzzy membership. Instead of assigning a pixel to a single cluster, each pixel will have different membership values on each cluster. The Fuzzy C Means attempts to find clusters in the data by minimizing an objective function shown in the equation below:

$$J = \sum_{i=1}^{n} \sum_{j=1}^{c} u_{ij}^{m} (X_i - C_j)^2 \quad (2)$$

J is the objective function. After one iteration of the algorithm the value of J is smaller than before. It means the algorithm is converging or getting closer to a good separation of pixels into clusters. N is the number of pixels in the image, C is the number of clusters used in the algorithm, and must be decided before execution, is the membership table – a table of NxC entries which contains the membership values of each data point and each cluster, m is a fuzziness factor (a value larger than 1), xi is the ith pixel in N, cj is jth cluster in C and difference between (xi - cj) is the Euclidean distance between xi and cj [7-8].

2.2.2.1 Algorithm of fuzzy c means method

The input to the algorithm is the N pixels on the image and m, the fuzziness value. The fuzziness value of 2 is used in this system.

1. Initialize with random values between zero and one; but with the sum of all fuzzy membership table elements for a particular pixel being equal to 1 – in other words, the sum of the memberships of a pixel for all clusters must be one.

2. Calculate an initial value for J using,

$$J = \sum_{i=1}^{n}\sum_{j=1}^{c} u_{ij}^{m}(X_i - C_j)^2$$

3. Calculate the centroids of the clusters cj using,

$$C_j = \frac{\sum_{i=1}^{n} u_{ij}^{m} \, |x_i|}{\sum_{i=1}^{n} u_{ij}^{m}}$$

4. Calculate the fuzzy membership table using,

$$u_{ik} = \frac{1}{\sum_{i=1}^{n}\left(\frac{|X_i - C_j|}{|X_i - C_k|}\right)^{\frac{2}{m-1}}}$$

5. Recalculate J.

6. Go to step 3 until a stopping condition was reached.

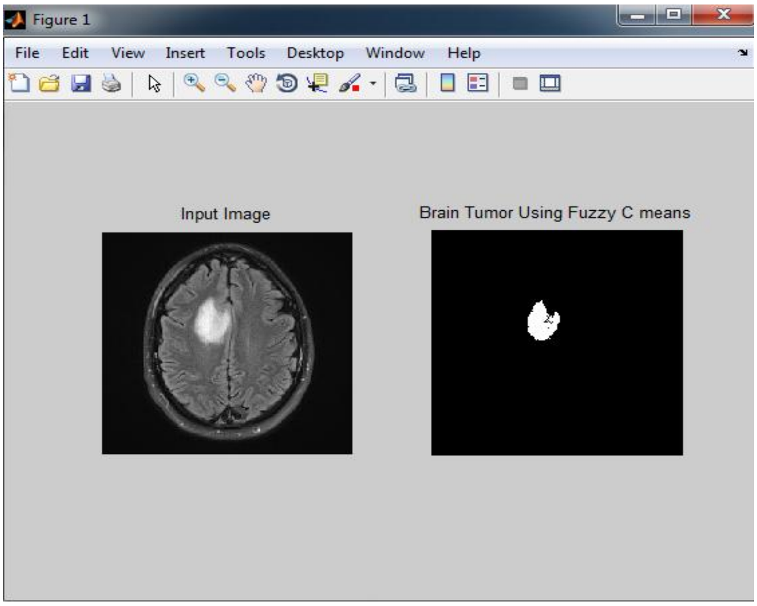

Fig.4 Output of fuzzy c means algorithm

Fig.4 shows the output of fuzzy c means method. At the end of the execution of the algorithm we have, for each pixel, the membership values for that pixel in each cluster. Traditionally the algorithm can then defuzzing its results by choosing a "winning" cluster. Hence we get exact part of tumor from MRI image.

2.2.3 Watershed segmentation

A grey-level image may be seen as a topographic relief, where the grey level of a pixel is interpreted as its altitude in the relief. A drop of water falling on a topographic relief flows along a path to finally reach a local minimum. Intuitively, the watershed of a relief corresponds to the limits of the adjacent catchment basins of the drops of water. In image processing, different watershed lines may be computed. In graphs, some may be defined on the nodes, on the edges, or hybrid lines on both nodes and edges. Watersheds may also be defined in the continuous domain . There are also many different algorithms to compute watersheds.

If we consider a plain surface with places having few drenches and then if we spill water in it then we can easily understand that it will fill the deeper gradient first then the lighter gradient. This is how the watershed transformation came into existence. For a gray scale image black is considered to be the deepest gradient and lighter gradients are considered as we move through gray sheds toward white. Since it is highly sensitive to local minima and a watershed is created, if we have an image with noise, this will influence the segmentation. To get accurate results erosion and dilation is performed on segmented image. results by choosing a "winning" cluster.

2.2.3.1 Morphological operator's

The term morphology means deforming or reconstructing the structure or shape of an object. Morphological operations are applied on binary images. They are used in pre or post processing steps such as filtering, watershed segmentation for getting a representation or description of the shape of objects or regions. The major morphological operations are erosion, dilation, opening and closing [9-11].

2.2.3.1.1 Erosion

The erosion process is similar to dilation, but we turn pixels to 'white', not 'black'. As before, slide the structuring element across the image and then follow these steps:

1. If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel.

2. If the origin of the structuring element coincides with a 'black' pixel in the image, and at least one of the 'black' pixels in the structuring element falls over a white pixel in the image, then change the 'black' pixel in the image (corresponding to the position on which the center of the structuring element falls) from 'black' to a 'white'.

2.2.3.1.2 Dilation

The dilation process is performed by laying the structuring element B on the image A and sliding it across the image and then follow these steps:

1. If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel.

2. If the origin of the structuring element coincides with a 'black' in the image, make black all pixels from the image covered by the structuring element.

2.2.3.2 Algorithm of watershed segmentation method

1 .Read input image.

2. Calculate gradient of an image.

3. Perform watershed segmentation.

4. Perform erosion followed by dilation on segmented part of an image.

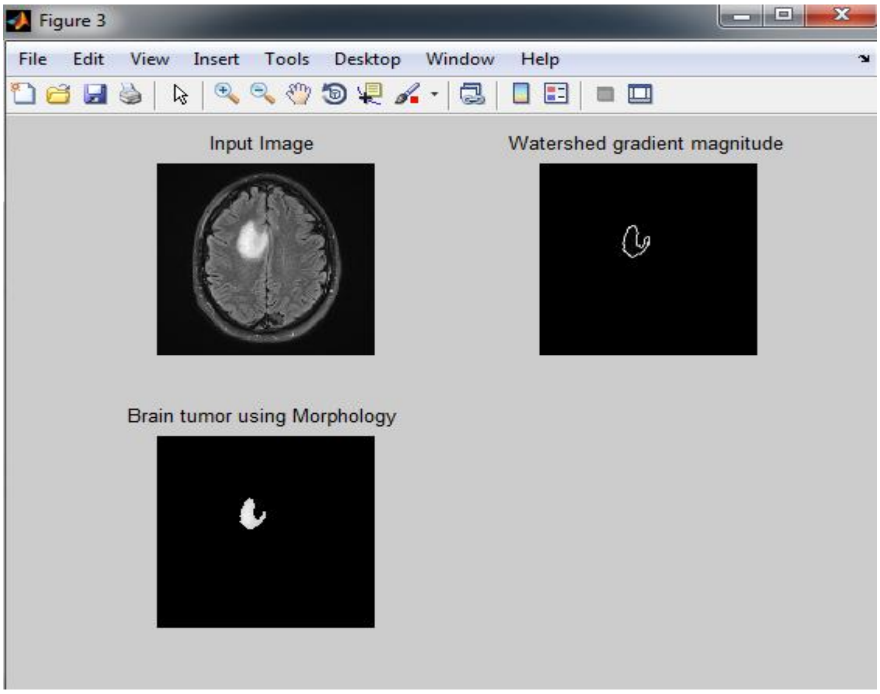

Fig.4 Output of watershed segmentation algorithm

Fig.4 shows the output of watershed segmentation method. It is like edge detection method which finds the boundary between tumor part and other part of brain MRI. It divides the image into two catchment basins and examines the intensities from lower value for accurate segmentation. The boundary is called as watershed line. The erosion followed by dilation is performed to reconstruct the tumor part region.

III CONCLUSION

In this paper, we have performed image segmentation techniques viz., K-Means, Fuzzy c means and watershed segmentation for detection of brain tumor from sample MRI images of brain and detect the area of the tumor. The output image clearly shows the tumour cells. The parameters used in thresholding is very difficult to determine because the factor used for one image may not work for other image. This parameter may be different for different images. The watershed method has the disadvantage that it is highly sensitive to local minima, since at each minima, a watershed is created. If we have an image with noise, this will affact the segmentation. so we have not used it directly on our input images. The use of median filter in preprocessing stages removes noise from the MRI image which was then passed for further processing. Morphological operations are applied on the segmented image for smoothening the brain tumor part. and fuzzy c-means also gives accurate result for identifying the brain tumor.

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