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Detection of Brain Tumors from MRI images using Improved Fuzzy C means and K means template-based algorithm

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ABSTRACT

For decades even with the advancement of scanning and evolving imagery systems, the detection of tumors present in the brain has become increasingly challenging and is still one of the most sensitive areas in the field of medicine. In this research work, a enhanced model is proposed in which I have employed a combination of two algorithms. The first algorithm is the K Means Clustering which is a method of vector quantization. The second is the Fuzzy C-means clustering in which each data point can be attributed to more than one cluster. When used together the algorithms give an enhanced performance and is called the TKFCM algorithm. Here in this paper, first in order to initialize the segmentation the k-means algorithm is used and the template is selected based on the Gray level of the image. Then the membership that is updated is primarily determined using the distance from the centroid of the cluster to the data points of the cluster using the FCM algorithm. Next, the improved FCM clustering algorithm is fundamentally used to detect the position of the tumor based on the function that is obtained by different features that include energy, contrast, entropy, homogeneity, dissimilarity and also the correlation. The results of the paper indicate that the algorithm is capable of detecting tissues that are abnormal in a improved time window.

Keywords: *Gray Level Intensity, Entropy, TKFCM Algorithm, Extraction, Feature, Clustering of T Means, K Means Algorithm Based on Template, Homogeneity.*

1. INTRODUCTION

One of the most fast growing fields in medical science is the branch of digital image processing. Image processing is widely used in order to detect tumors, helping in identifying particular cancers and classifying the tumors based on extracted features

The human body is composed of a variety of different organs, tissues and bones. Among these, the most important system in the human body is clearly the brain as it oversees control of the entire nervous system in Human Beings. Clearly, the need for detection of tumors in the brain is a tremendously important factor for the survival of a human being.

The Human brain is one of the most complex organs. It contains blood vessels and nerves, including neurons and glial cells. The composition is such that sometimes tumors are easily overlooked and can go undiscovered for decades in a human. The occurrence and formation of tumors is sometimes linked to mutations or defects in genes. Environmental factor responsible for brain tumors is radiation exposure. Hence, the detection of tumors in the brain is not as straightforward as it seems. Primarily, computer aided diagnosis is used for the presence of detection in the brain.

A brain tumor is the development of an unnatural growth in the brain tissues it is also known as a central nervous system tumor. Some tumors are cancerous and some aren't. About a third of all detected tumors are cancerous. At present ,the detection of the brain can be done extremely fast and accurately through a Magnetic resonance imaging scan. MRI images are used to extract features and classify types of tumors based on various parameters such as size, shape, position and boundary.

In order to test brain tumors many kinds of scans are available but as of yet MRI stands out as the most accurate of the lot. Hence, MRI scans are by far the most popular and are great to look at since the images of the scans are extremely detailed and have a lot of depth and structure.

The major contribution in this paper is :
1) TKFCM algorithm proposed mainly detects brain tumors with more accuracy, even if the size of the tumor is extremely tiny.

2) The algorithm that is proposed will work quite accurately even if the images of MRI are filled with a lot of noise.
3) The execution time of this algorithm is minute when compared to other algorithms.

Based on the images taken different parameters are listed below

Parameters	Meaning
η	Accuracy
α	Sensitivity
β	Specificity
P	Pixel intensity
V	Cluster centroids
$P(x_i,y_{i,})$	Input Image
$B(x_i,y_{i,})$	Coarse Image
t	Computational time
K	Number of iterations
$d^2(x_{i,}v_{i,})$	Degree of fuzziness
P_{ij}	Binary image matrix
U_{ij}	Membership Function
C	Number of clusters
Jo	Squared error function
m	Any real number greater than 1
N	Number of feature vectors
Tmn	Template-based window
c	Number of cluster centers
G	Gray level co-occurrence matrix
K	Number of data points in clusters
$\|\|P_i = \|\|v_j\|\|$	Euclidean distance between x and v
v_i	Data in *i*-th points in *i*-th cluster Number of points in *i*-th cluster
c_i	Mean in the horizontal spatial domain
M_r	Mean in the vertical spatial domain
M_y	Standard deviation in the horizontal Spatial domain
σx	Standard deviation in the Vertical spatial domain
σy	Straightforward Euclidean distance or Mahalanobis distance

2. LITERATURE REVIEW

The features of the brain tumor extracted will help classify the MRI images into two sections. One section will consist of tumor cells and the other section will consist of normal cells of the brain.

1. Zanatony, a research scholar, proposed work on detection of brain tumors which is mainly based on an approach of hybrid type. Here it obtained an average segmentation of 90% .

2. Demi Rah, one of the scholars, worked on an algorithm based segmentation of neural networks which determined the number of tumors present in the images.

3. Vijay Kumar mainly introduced a work on segmentation of tumor and classification of tumor based on analysis of PCA and RBF based SVM which have a similar accuracy of the images with an index of 62.90% .

4. Aruna Devi proposed a method of machine learning for the classification of tumor cells. Here in this work a feature was extracted and then that feature accuracy was detected by the method of k means algorithm.

5. Weasel, a scholar, proposed a method to detect tumors from MRI images. In this work a deep learning methodology was introduced for the detection of 3D based images which gave an accuracy over around 45%.

3. PROPOSED ALGORITHMS

(a) Clustering algorithm for K means

It is one of the most simple learning algorithms. This algorithm will be given a very easy set of data that will be given to a number of clusters. Each set of data is classified as groups such as x 1, x2, and x3……….xn into k no of clusters. Very important and very basic idea of this algorithm is usually defining a k center for each no of clusters. By determining the number of clusters as determined.

The selection of the clusters is done randomly. One of the most important parameters that play an important role is measurement of distance. Measurements of these distances are different such as Euclidean distance, Chebyshev distance. Selecting a good distance is important and it depends upon the data.

Here we use Euclidean distance as one of the parameters as it is very fast and very easy to understand.

3. ALGORITHM

Assume that, x= $x_1 x_2, x_3 \ldots x_n$ be the set of data points and v= $v_1 v_2, v_3 \ldots v_c$ be the set of centers.
1.Define the number of clusters 'K'.
2. Randomly, define cluster centers 'c'.
3. Calculate the distance between each data point and cluster center.
4. Data point is assigned to the cluster center whose distance from the cluster center is minimum at all the cluster centers.
5.Then, new cluster is recalculated as follows

$$V_i = \frac{1}{c_i} \sum_{1=1}^{c_i} x_i$$

Where 'ci' is the number of data points in the *i*-th cluster.

6. Recalculate the distance between each data point and newly acquired cluster centers.

7. If no data point was reassigned then stop, otherwise repeat steps from 3 to 6.

The distance is calculated between the pixel of each and each cluster. Then all these pixels are compared individually and then the center is recalculated. Here this entire process will continue till the center converges and is calculated multiple times for maximum iterations.

This algorithm will provide an improvement in the efficiency and also it will support many vectors.
In this algorithm we can calculate the error function by

$$J_v = \sum_{i=1}^{c} \sum_{j=1}^{c_i} (||x_i - v_i||)^2$$

(b) Clustering Algorithm for Fuzzy C means

This algorithm is introduced in order to precede the pixels of each data into more clusters. Clustering or cluster analysis involves assigning data points to clusters such that items in the same cluster are as similar as possible, while items belonging to different clusters are as dissimilar as possible.

$$J_m(U,V) = \sum_{j=1}^{N} \sum_{i=1}^{C} (U_{ij})^m (||x_j - v_i||)^2 ; 1 \leq m \leq \infty$$

Here x= xl, x2, x3……xn
M= real number which is always greater than I
C= each feature dimension

The function membership is expressed as $J_{ij} = \sum_{k=1}^{c} \left(\frac{(||x_j - v_j||)}{(||x_j - v_k||)} \right)^{\left(\frac{-2}{m-1}\right)}$

In order to calculate the ith number of cluster

$$V_i = \frac{\Sigma_{j=1}^{N} (U_{ij})^m \times J}{\Sigma_{j=1}^{N} U_{ij}{}^{m}}$$

Algorithm

Assume that, X= $x_1 x_2, x_3 \ldots x_n$ be the set of data points and V= $v_1 v_2, v_3 \ldots v_c$ be the set of centers.
1.Fix the number of clusters c 2≤ c≤n. where n =number of data items. Fix, m where 1< m <∞.
Choose any inner product induced norm metric||. ||.
2. Initialize the fuzzy c partition $U^{(0)}$.
3. At step b,b = 0,1,2….
4.Calculate the fuzzy membership function U_{ij} using Equation (4)
5. Then compute the fuzzy centers 'U_i 'using Equation (5)
6. Repeat step 2 and 3 until the minimum 'J ' value is achieved or $|\ |U_{ij}{}^{(k+1)} - U_{ij}{}^{(k)}|\ | < \epsilon$

(c)TKFCM Algorithm

The implementation done in the project is TKFCM algorithm that is proposed. This algorithm is a combination of both the algorithms: Fuzzy c means along with that k means algorithm.

On the basis of intensity of Gray level present in the brain images, a different template is selected along with the feature of images. The template based on fuzzy c means and k means equation is given by:

$$J = \sum_{i=i+1}^{M} \sum_{j=j+1}^{N} B(x_i, y_i) \times \sum_{i=1}^{K} \sum_{j=1}^{C} P_{ij}||x_i - c_j||^2 \times \sum_{j=1}^{R} \sum_{i=1}^{C} (U_{ij})^m d^2(x_j, v_i)$$

The template that is based on the window is selected by

$$T_{mn} = \sum_{i=1}^{M} \sum_{i=1}^{N} P(x_i, y_i) * \sum_{k=1}^{G} \sum_{l=1}^{S} P(x_k, y_i);\ k\epsilon M, l\epsilon N$$

TKFCM algorithm

The enhanced proposed algorithm for the detection of tumors from MRI images of the brain is fundamentally based on fuzzy c means and k means algorithm.

At first the MRI brain images are acquired, next pre-processing of the input image is done. After pre-processing image enhancement is conducted and then the selection of the template based is done.

The output window is also segmented by using the segmentation of k means algorithm. Later, the features extracted are detected by the improved C-means algorithm and then it automatically chooses image

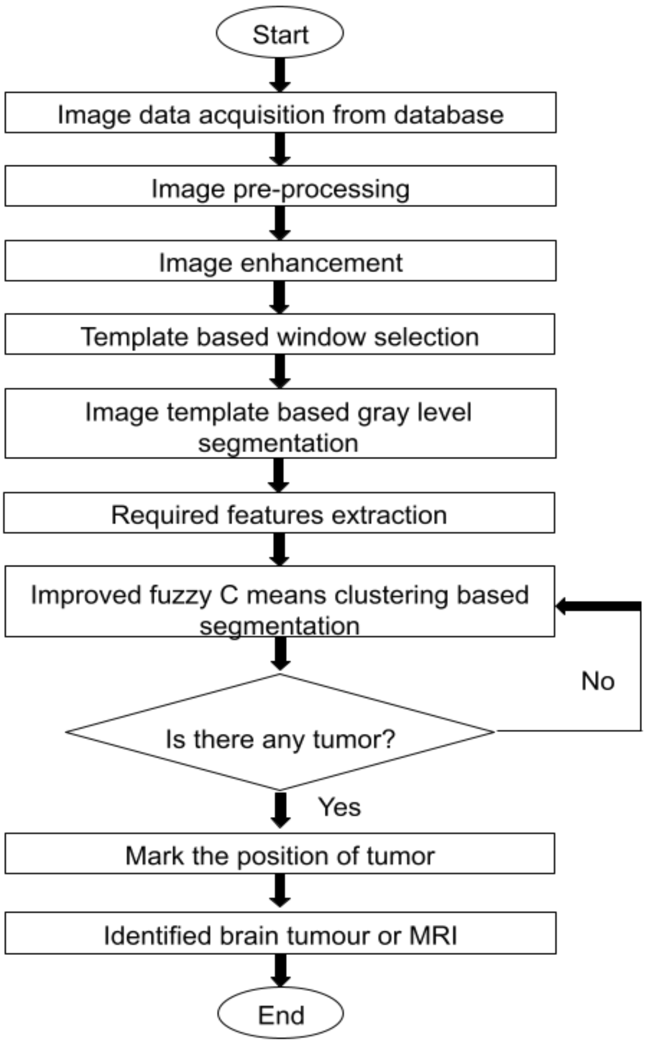
Algorithm

1. Initialize : Define number of gray level and determine square matrix, $A = \Sigma\Sigma P(x_k, y_1)$ and image matrix, , $P = \Sigma\Sigma P(x_i, y_j)$
2. Then, define template $T_{mn} = P\Theta A$
3. Determine coarse image $B(x_i, y_j)$from template T_{mn}
4. Reshape template based on k means segmented image,

$$P_1 = \Sigma_{i=1}^{k} \Sigma_{j=1}^{C} P_{ij}||x_i - c_j||^2 \times \Sigma_{i=i+1}^{M} \Sigma_{j=J+1}^{N} B(x_i, y_j)$$

5. Repeat step 2 to 4 until, $T_{mn} \leq \Sigma_{k=1}^{G} \Sigma_{1=1}^{S} [T_{mn}(k) - T_{mn}(l)$
6. Post process the P_1
7. Determine cluster centroid, C and degree of fuzziness, m
8. Initialize membership function $U_{ij}{}^{(0)}$ of FCM
9. Calculate cluster center $V_i{}^{(1)} \Leftrightarrow U_{ij}{}^{(1)}$ $(i = 1,2,3, \dots . C)$ and $(1 = 1,2,3, \dots)$
10. Determine image features, $F(x_j, v_j{}^{(1)}) \leftrightarrow v_j{}^{1}$
11. Update U_{ij} with $d(x_j, v_j{}^{(l)})$ until $|| U_{ij}{}^{(l)} - U_{ij}{}^{(l-1)} || \leq \epsilon, \epsilon = 0\ to\ 1$

4. FLOW CHART OF THE PROPOSED ALGORITHM



4. OUTPUT

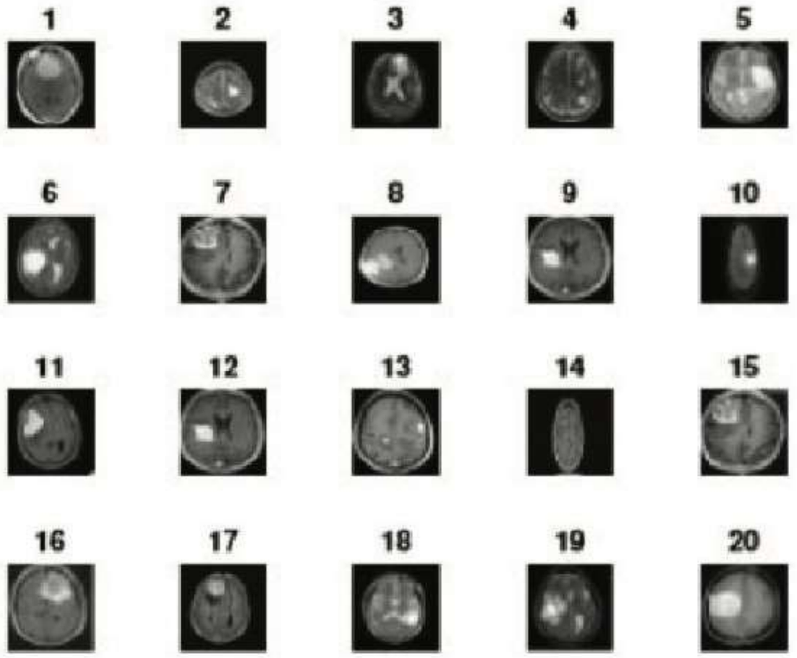


Fig 4.1. Database images 1

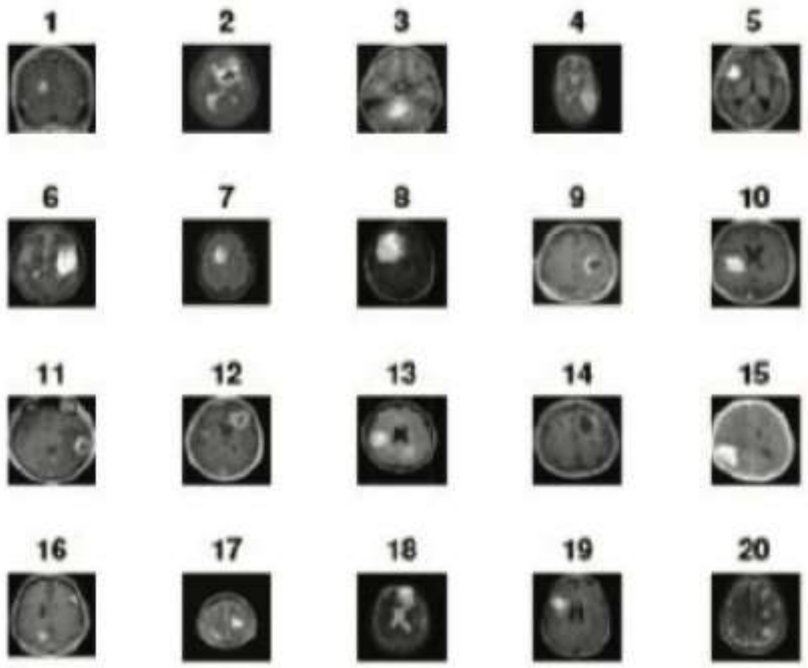


Fig 4.2. Database images 2

Different database images are collected in order to detect the tumor present in the cells

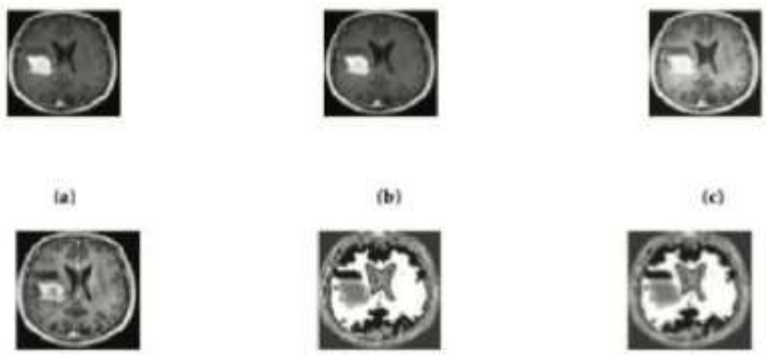


Fig 4.3. Enhanced input images

Once the features of the images are extracted, tumors are detected using different features

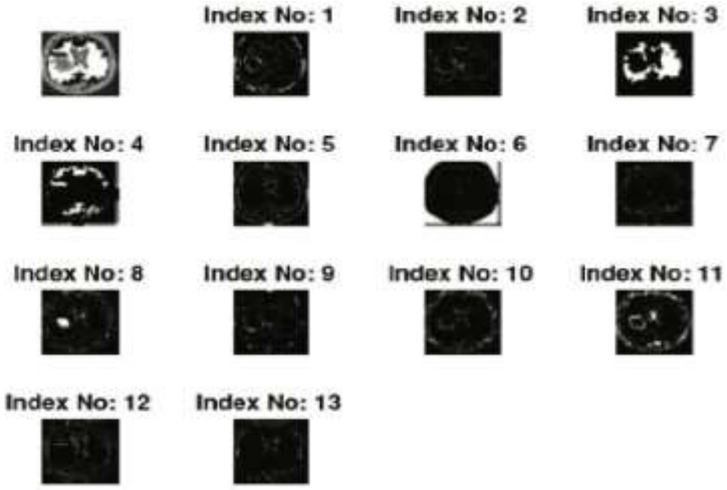


Fig 4.4. Images that are clustered

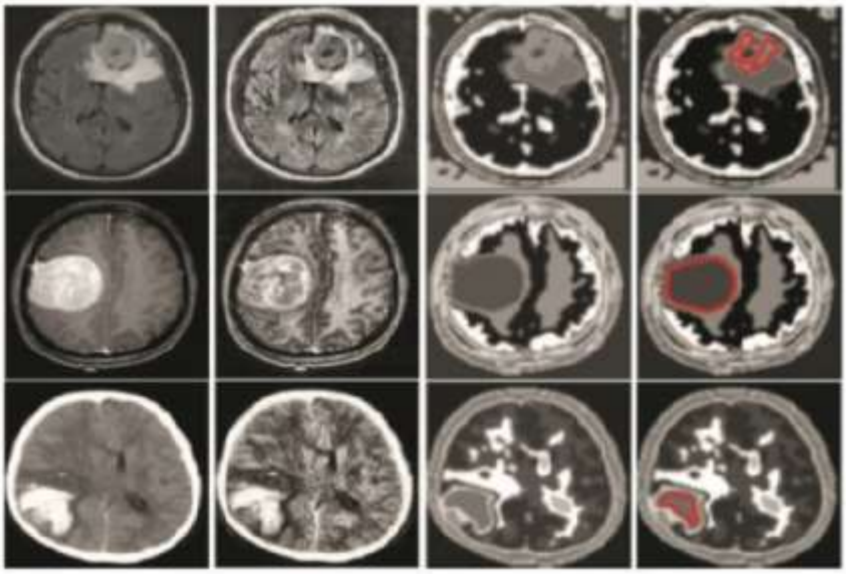


Fig 4.5. Tumor detected cells 1

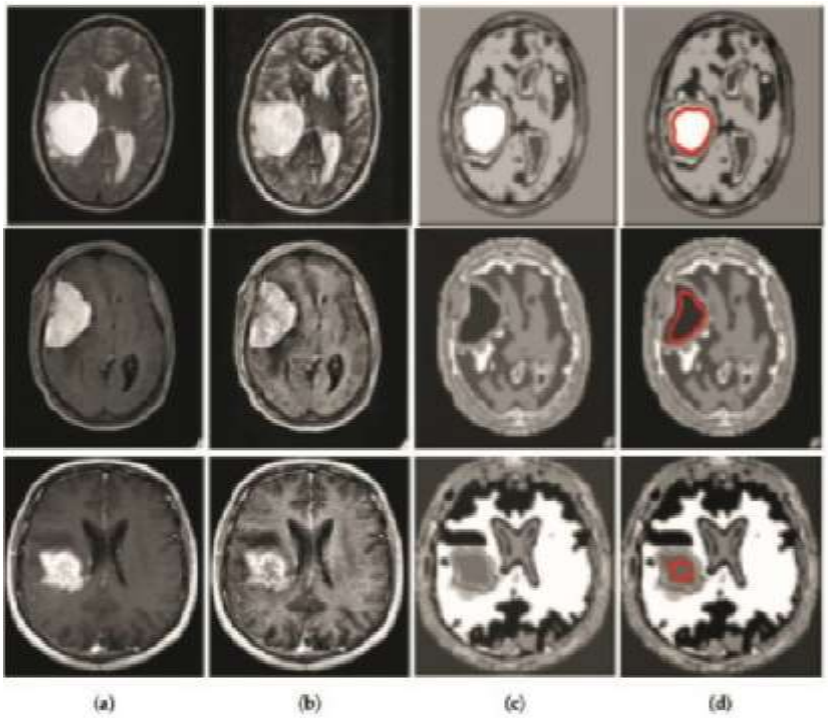


Fig 4.6. Tumor detected cells 2

5. RESULT ANALYSIS

Performance analysis of these images obtained by using the TKFCM algorithm is:

Table 4.1 Analysis of Images

Algorithms	TP	FP	TN	FN
Thresholding	22	5	9	4
Region Growing	27	2	10	1
TK-means	20	3	12	5
FCM	24	1	10	5
Second Order + ANN	21	2	16	1
Texture Combined + ANN	21	1	17	1
Proposed TKFCM	38	0	1	1

Sensitivity, specificity and accuracy are given by :

Table 4.2 Extracted Features

Algorithms	Sensitivity(α)	Specificity(β)	Accuracy (η)
Thresholding	76.9	64.25	72.5
Region Growing	92.8	81.3	90
TK-means	82.7	90.9	85
FCM	80	80	80
Second Order + ANN	95.5	88.5	92.5
Texture Combined + ANN	95.45	94.44	95
Proposed TKFCM	97.43	100	97.5

Computational time is given by:

Table 4.3 Analysis of Computational time

Algorithms	Computational time (t)
Thresholding	3 min
Region Growing	10 min
ANN	7-15 min
FCM	130-140 s
TK-means	4 min
Proposed TKFCM	40-50 s

6. CONCLUSION

In this paper based on the above results. It can be concluded that the performance of the system was improved by employing the TKFCM algorithm when compared to several other conventional schemes.

By the work of detecting the tumor present in the brain the sensitivity was 27.07% , 1.98% , 4.75% , 17%, 89% when compared to other conventional schemes.

Accuracy of the system was improved to 25.64% , 5.12%, 7.69%, and 17.94% over many thresholds.
So the maximum time required to identify the presence of a tumor through MRI images is extremely minute when compared to other conventional algorithms.

In my future work, analysis of features will include more features that will be primarily used to detect the accuracy, but in turn might increase the required computational time.

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