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Research Article

MRI brain tumor detection by different approaches, A Study and Performance analysis

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Abstract: In this paper, we introduce a completely programmed brain tumor segmentation technique by using different models. However, this strategy for location opposes the exact assurance of stage and size of tumor. This strategy permits the division of tumor tissue with exactness and reproducibility similar to manual division. Likewise, it additionally diminishes the ideal opportunity for investigation. Towards the finish of procedure, the tumor is distinguished from the MRI picture and image correct shape and position additionally decided. The phase of the tumor is shown in light of the measure of zone figured based on medical applications and also it will be used to doctors while diagnosis. The results are carried using MATLAB software or may use the latest powerful technology using Python.

Keywords: Magnetic resonance imaging, brain tumor, parametric deformation model, K-means, FCM and Convolutional Neural Networks

1. Introduction

MRI And its Working

MRI is a medical imaging device commonly used to examine the soft tissues of the human body. Machine the key components are the magnet, Radio waves, Gradient and A computer

Our bodies are made up of 60% water and water is magnetic. Each of the billions of water molecules inside us consists of an oxygen atom bonded to two hydrogen atoms. We know it as H2O.small parts of the hydrogen atoms act ae tiny magnets and are very sensitive to magnetic fields.[1] MRI stands for *Magnetic Resonance Imaging* and an MRI scanner is one of the main diagnostic tools that doctors use to examine inside our bodies. The first step in taking an MRI scan is to use a big magnet to produce a unified magnetic field around the patient. The gradient adjusts the magnetic field into smaller sections of different magnetic strengths to isolate specific body parts. For example, the brain.

Normally the water molecules inside us are arranged randomly. But hen e lies inside the magnetic field most of our water molecules move at the same rhythm or frequency as the magnetic field. The ones that don't move along the magnetic field are called lo energy water molecules. To create an image of a body part, for example the brain, the machine focuses on the low energy water molecules. Radio waves move at the same rhythm or frequency as the magnetic fields in an MRI machine.by sending radio waves that match or resonate with the magnetic field the low energy water molecules absorb the energy they need to move alongside the magnetic field. When the machine stops emitting radio waves the water molecules that had just moved along the magnetic field release the energy they had absorbed and go back to their position. This movement is detected by the MRI machine ant the signal is sent to a powerful computer which uses imaging software to translate the information into an image of the body. By taking images of the body in each section of the magnetic field the machine produces a final three-dimensional image of the origan which doctors can analyze to make a diagnosis.[2]

Brain Tumors and it's types

The different kinds of tumors that occur in the brain, we break it down to the tumors that are within the substance of the brain, versus those that are outside the brain, pushing on the brain. the diagnosis, the type of tumor, has a different implication based in it's growth potential. Based on the natural history of the tumor might change either with treatment or without treatment, and the care for an individual person is very much dictated by the diagnosis. Again, the diagnosis is established usually with an operation. Although there some tumors that are very characteristic on MRI imaging, and the diagnosis is almost assured on the imaging itself, such that an operation might not be necessary when it's first picked up.

The intrinsic lesions in the brain, and those are tumors that grow from the substance of the brain. They frow from a cell that's normally in the brain. Those are tumors that have the most implications. Those are usually the tumors that need the quickest care. They come in slow-growing or faster-growing versions. They're also called *low grade* or *high grade*. There are different classifications schemes that mean the same thing. There's, they're called *astrocytoma* and *a plastic astrocytoma or glioblastoma*, *multi forming*. They also go by *numbers 2,3 and 4*.

It can be difficult to tell on a MRI scan exactly which diagnosis somebody might have. It can be somewhat anxiety provoking to search out to much information about diagnosis, until you've sat down with either a surgeon or healthcare provider, to have them explain some of the new answers of the MRI scan, the likelihood of different diagnoses. Ultimately the procedure is to get tissue, to establish that diagnosis, and then the path that someone's going to be on.[3]

Segmentation and its types

The procedure of isolating or gathering a picture into various parts is picture division. These assembled parts relate to something that people can without much of a stretch separate and view as individual articles. Since PCs have no method for insightfully perceiving items, thus a wide range of strategies have been produced to portion diverse sorts of pictures. The division process in taking into account different elements found in the picture. This may be shading data that is utilized to make histograms, or data about the pixels that demonstrate edges or limits or surface data. Most popular techniques still used by the researchers are Edge Detection, Threshold-based, Histogram-based; Region based methods and watershed Transformation.

K-Means Clustering Algorithm

K-means clustering is the algorithm used to group the objects based on the attributes into a k number of classes where k is the positive integer. The clustering is made by reducing the Euclidean distance between the data points and the corresponding cluster centre/centroid [4].

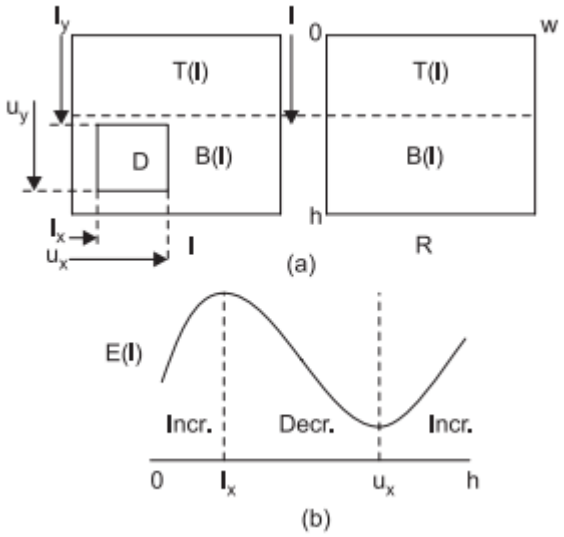


Figure 2: (a) Finding anomaly D from test image I using reference image R and (b) Energy function plot

One of most popular and the widely used the clustering algorithm is to separate the input data points in Euclidian region is the K-means clustering [5]. It is the non-hierarchical method which follows simple and easy method to classify the given dataset points through the certain number of clusters that are known as a priori. The K-means algorithm is constructed using an iterative scheme where elements of data are interchanged between the clusters in order to satisfy the criteria reducing the constant change within the Study and Performance Analysis of Different MRI Brain Tumour Segmentation Methodologies for Medical... 971 each cluster and maximizing the variation between the clusters [6].When no elements are interchanged between the clusters, process is stopped [7]. That we can refer from below Figure 3.

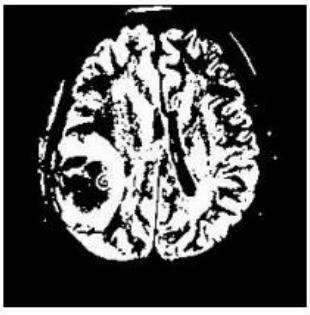


Figure 3: K-means clustering output

The 5 steps of the k-means algorithm are described below:

1. Initially figure the force appropriation of the intensities.
2. Initialize the centroids with k irregular intensities.
3. Rehash the accompanying strides until the group of the picture does not change any longer.
4. Cluster the points based on the distance of their intensities from the centroid intensities.
   c(i) = arg min ||X(i) - j||^2

5. Compute the new centroid for each of the clusters.

$m_i = \{ \sum_{i=0}^{m} I\{c(i) = j\}x(i) \} / \{\sum^{m}{}_{i=1} 1\{c(i)=j\}\}$

Fuzzy-C Means Clustering Algorithm

It is fuzzy clustering method where each point has a degree of belonging of clustering as in fuzzy logic, rather than belongs to just one cluster. In this, centroid of a bunch is the mean of all focuses, weighted by then level of fitting in with the cluster. It is also called soft k-means clustering method. The Fuzzy C-Means (FCM) clustering algorithm was first introduced by Dunn and later was extended by [8]. The result can be referred in below Figure 4.

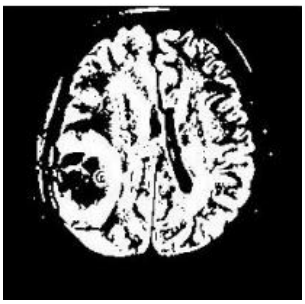


Figure 4: Fuzzy-C means clustering output

The calculation is an iterative bunching strategy that creates an ideal c segment by minimizing the weighted inside of gathering whole of squared mistake objective function. $Y_m = \sum^{N}{}_{i=I} \sum^{C} j_{=1} u^{m}{}_{ij} \| X_i - C_j \|^2$

Where, X = {X_1, X_2, X_3, ..., X_n} belongs to RP is the data set, n is the number of data item, c is the number of clusters, p is a weighting exponent.

Steps in fuzz y c-means algorithm: Let X = {X_1, X_2, X_3, ..., X_n} be the set of data points and C = {C1, C2, C3, ..., Cn} be the set of centers.

1. Randomly select 'c' cluster centers.
2. Calculate the fuzzy membership 'μ_{ij}' using:

$$\mu_{ij} = \frac{1}{\left[\frac{||xi-Cj||}{||xi-Ck||}\right]^{\frac{2}{m-1}}}$$

3. Compute the fuzzy centers 'Cj ' using:

$$c_j = \frac{\sum_{i=1}^{N} u_{ji}^{m} . x_i}{\sum_{i=1}^{N} u_{ij}^{m}}$$

4. Repeat step 2 and step 3 until the minimum 'J' value is achieved or

$\|U^{(K+0)} - U^{(K)}\| < \beta$

Where,

'k' is the iteration step

'β' is the termination criterion between [0, 1]

'$U = (\mu_{ij})_{n*c}$' is the fuzzy membership matrix

'J' is the objective function.

Parametric deformation Model

Snakes or active contour models' goal is to apply division procedure to a picture by doing twisting of the underlying shape towards the limit of the object of hobby. These are vitality minimizing splines that are guided by outer requirements and inside imperatives, and are affected by picture compels that force them towards highlights like lines and edges. They are intended to be intelligent, in that the client must be given a few hints as to where the limits may be, and the snakes are utilized to minimize vitality thus follow the form or limit. Below Figure shown below the output for the algorithm after execution.

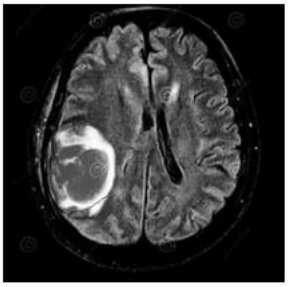


Figure5: Parametric deformation algorithm output

This model works on the assumption that edges are found not only by looking at the local gradient, but also at the long-range distribution of the gradient [9]. This is done by using the curvature constraints aswell as the continuity constraints. Snakes have an interior vitality capacity which decides their versatility and inflexibility, and an external energy function based on image information and user interaction[17,18].

$$E^*_{snake} = \int_0^1 E_{snake}(V(S))\,ds = \int_1^0 (E_{internal}(V(S)) + E_{image}(V(S)) + E_{com}(V(S))\,ds$$

Where,

E^*_{snake} - the energy function of the snake

$E_{internal}$ - The internal energy of the spline (snake) due to bending

E_{energy} - the forces of image acting on spline

E_{con} - the external constraint forces introduced by use

The capacity of snakes to give a straight portrayal of the article shape amid the season of merging without including additional handling is the principle point of interest of this model [10]. Be that as it may, what logically restricts the utilization of snakes is the need of the strategy to have solid picture slopes to have the capacity to drive the form.

Tumor detection model

With the help of latest advanced techniques like Machine Learning we can build a system that simply detected the tumor. Machine Learning is branch of Artificial Intelligence [11, 12] that makes computers to learn from the given data to predict the output of new data.

A model can be built in 5 steps

- ➢ First, we collect raw data [13]
- ➢ Then we preprocess the data based on our requirement
- ➢ Then we use required algorithm to build our model
- ➢ We divide our data in to train and test data sets

Train the model with the train data

- ➢ Evaluate our model with the test data

Convolutional neural networks

CNN the neuron in a layer will only be connected to a small region of the layer before it. CNN, is a type of feed-forward artificial neural network in which the connectivity pattern between its neurons is inspired by the organization of the visual cortex. CNN compares the image piece by piece. The pieces that it looks for are called

features. By finding rough feature matches, in roughly the same position in two images, CNN gets a lot better at seeing similarity than whole-image matching schemes.

Generally, CNN consist of three layers are convolution, ReLU and Pooling.

Convolution: Line up the feature or filter and the image patch (by default image patch size is taken of 9 pixels). Multiply each image pixel by the corresponding feature pixel. Add them up. Divide by number of pixels in the feature.

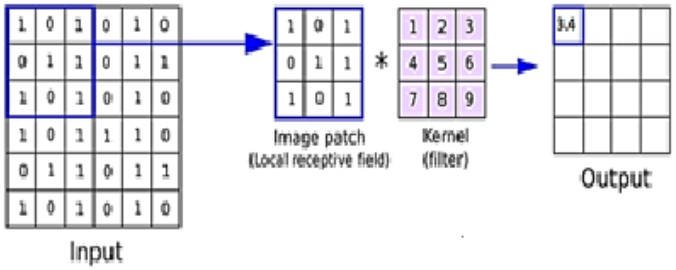
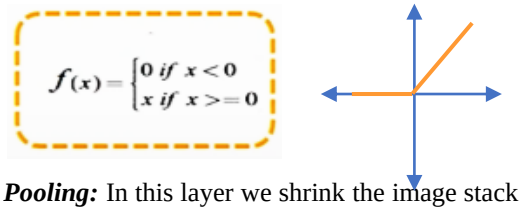


Figure6: representation of pixels convolution

$$\text{Convolution} = \frac{\sum (\text{image patch pixels X filter pixels})}{\text{no. of pixels or size of filter}}$$

ReLU layer: *Rectified Linear Unit (ReLU)* transform function is also known as activation function. In this layer we remove every negative values from the filtered images and replaces it with zero's. This is done to avoid the values from summing up to zero.



Pooling: In this layer we shrink the image stack into a smaller size. Pick a window size (usually 2 or 3). Pick a stride (usually 2). Walk your window across your filtered images. From each window, take the maximum value.[14]

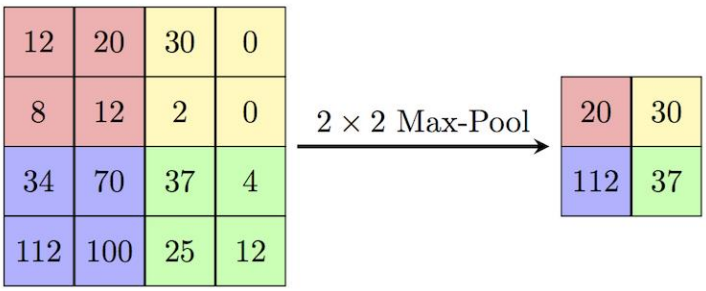


Figure7: representation of pixel pooling

Fully connected: This is the final where the actual classification happens. Here we take our filtered and shrinked images and put them into a single list or a vector.

Stack up the multiple layers of convolutional, ReLU and pooling layers until the min size of pixels (2x2) of particular feature and the resultant packs of pixels are given to Fully connected Layer. Therefore, collected data is trained.[15]

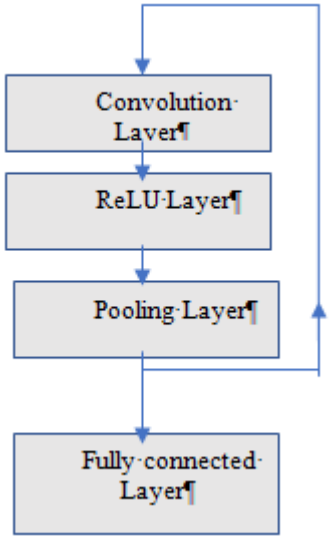


Figure8: layers model flow for train the data

Testing and result:

Let's consider a new data (MRI image) and given to the trained CNN model and the results are displayed as shown in below figures.

If the predicted value of image is less than or equal to 0.5 then the MRI represents no tumor otherwise brain tumor is recognized (when pixels values are normalized between 0 and 1). [16]

Figure9: original and resultant plotted images of MRI

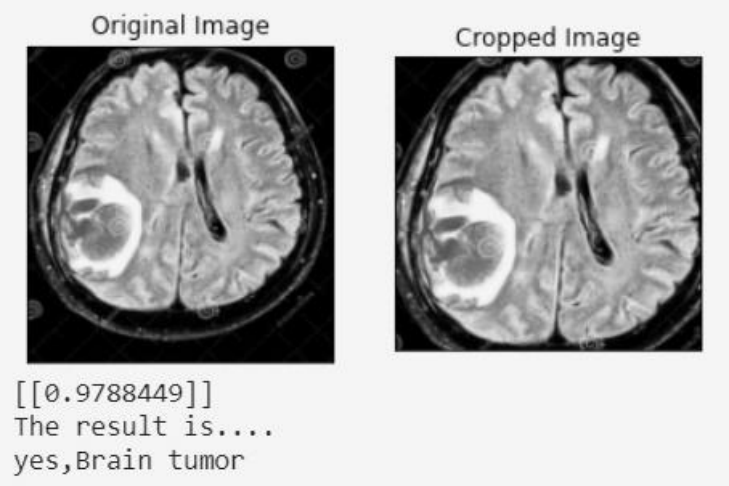


Figure10: original and resultant plotted images of MRI which has Brain tumor

2. Results And Discussion:

Here, the results of the work are mentioned in the figures [Figure No. 3,4,5,9 and 10] of the different proposed algorithms such as K-means clustering algorithm, Fuzzy-C means clustering algorithm, parametric deformation model algorithm and newly CNN with their prospects are checked.

And CNN provides good results of the tumour compared to K-means clustering, Fuzzy C-means clustering and parametric deformation model algorithms. Therefore, the algorithms are compared pictorially as shown in above figures including the representations of tumour regions which are affected in medical Imaging.

3. Conclusion

In the medical diagnosis field, broadly assorted qualities of imaging strategies are available, such as CT and MRI scan. MRI scanned image is the well addressed image model used for diagnostic image properties for the brain tumour. K-mean algorithm can determine a brain tumour quicker than Fuzzy C-means, but Fuzzy C-means can determine tumour cells exactly. Parametric deformation model algorithm in which function is also based on user interaction makes the work reliable and provides good results.

Hence concluded, CNN model is more reliable than the Parameter Deformation model, K-Means and FCM. and provides good results.

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