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Brain Tumor Detection using PSO-FCM Based Segmentation

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Abstract*: *Brain tumors are a serious threat to one's health and can form in any healthy human being. So, it's necessary to have accurate diagnostic technique for the same, thus came CAT scans, and the Magnetic Resonance Imaging or better known as MRI. All these techniques at their core require advanced image processing techniques to accurately analyze the images for tumor threats. In this paper we are going to be looking at a subsection of image processing called segmentation. Segmentation plays a vital role in image processing as it is through this method that we acquire the Region of Interest (ROI) or in simpler terms the probabilistic area for tumor occurrence. We are proposing the use of hybrid technique that utilizes a combination of two algorithms, first is the Particle Swarm Optimization (PSO) for the selection of an initial particle and the other is Fuzzy C- Mean Segmentation which will create the actual segmentations.

Keywords*: *Fuzzy C-Mean, Image Processing, MRI, PSO, Region of Interest, Segmentation.

I. INTRODUCTION

In the field of medical science, it is necessary to have proper and accurate diagnosis before we can start any sort of treatment, as it wouldn't make sense in giving medicine without knowing the disease. One such medical condition is Brain Tumors; without diagnosis you won't be able to pinpoint the location of the tumor without which performing an operation would be like going for a battle without any kind of ammunition. And the higher the accuracy, easier it would be for the doctors to perform surgical operations to remove tumors.

A. Tumor

A tumor is nothing but a collection of dead cells that are not ready for their death yet. What happens is sometimes due to radiations or other unclear reasons cells which usually have a short life span turn into dormant cells which are not totally dead yet, which is why they cannot be cleared out of the system but continue to exist with the other normal cells. As the number of these cells continues to grow, they start to clutter together which results in a formation of cluster of cells, thus forming a tumor [1], [2].

Basically, tumors are of two types **Benign** and **Malignant,** a benign tumor is considered as a non- cancerous tumor as it does not grow at rapid rate and is not a serious threat to one's health. On the other hand, a malignant tumor is cancerous in nature due to its high rate of expansion and requires immediate surgical operation, it's not necessary for a malignant tumor to be born in the brain itself it can spread from other parts of body to brain through the blood stream, this process is known as metastasis. There have been some cases where even the benign tumor has turned into cancers and required treatment.

B. Magnetic Resonance Imaging (MRI)

Magnetic Resonance Imaging utilizes the concept of electromagnetism and resonance to generate an image of the targeted area of the body. The patient is placed in a donut shaped machine, where a magnetic field is applied around the whole body which causes the protons in the hydrogen atoms present in our body to resonate and get to the excited state. When it comes back to its ground state it releases energy with is analyzed by the computer to form a map of the targeted region. As our body consists of various kinds of tissues and each tissue has its own characteristics, they vibrate at different frequencies. So, we can even get a very controlled and accurate image using MRI [2],[3],[4].

C. Image Processing

The image acquired from the MRI doesn't give us all the information we need for the diagnosis, in order to extract meaningful information from the image we apply image processing techniques. A basic image processing consists for following steps

- Pre-Processing
- Image Segmentation
- Morphological Operations

Main purpose of preprocessing is to get an enhanced image which is easier to analyze, for this we apply basic techniques such as contrast enhancement, edge detection techniques, filters, noise reduction and so on to get a crisp and well detailed image.

Image segmentation is applied to obtain the Region of Interest (ROI), for this we can apply various techniques, anywhere from most basic in form of thresholding to highly complex forms of Fuzzy C-Mean and hybrid techniques [5],[6],[7].

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After we get the segmented image, we apply morphological operation to pinpoint the tumor location, overlap the segmented image over original image.
This final step is for presentation purposes, which helps doctors to read the report and easier understanding.

II. PROPSED WORK

We are proposing to use a hybrid technique the uses a combination of two techniques. We use PSO to find the best particle out of the various candidate to initialize our Fuzzy C-Mean segmentation, which the uses that particle to as a reference for the initial cluster and forms the required number of clusters. After the formation of clusters each particle is compared and assigned t the cluster which it resembles the most and give us the segmented image.

A. Particle Swarm Optimization (PSO)

Particle Swarm Optimization is a loosely based on genetic algorithm developed by Dr. Eberhart and Dr. Kennedy in the year 1995, the characteristic of the algorithm is based on the flock of migratory birds. We initialize the algorithm with random **Pbest** (best neighborhood particle) and **Gbest** (best global particle) values, then for each particle we calculate a fitness value, which is then compared with these values, if the particle has a better value then we update the values of Pbest and Gbest as the values of that particle, otherwise we update the particles position and velocity according to equations (1) and (2) respectively, so as to follow the best particle [8].

$$V_{i+1} = \omega V_i + c_1 * round() * (Pbest_i - X_i) + c_2 * round() * (Gbest_i - X_i) \quad (1)$$

$$X_{i+1} = X_i + V_{i+1} \quad (2)$$

c_1& $c_2$are the learning factors while ωinitial weight.
After we go through all the particles, the one with the best fitness factor is selected as the initialization particle for the Fuzzy C- Mean Algorithm.

Step 1. For each particle
Initialize the particle
End
Step 2. For maximum number of iterations
For each particle
Calculate the fitness factor for each particle
If (Fitness Value > Pbest Value)
Update the value of Pbest to the Fitness value
End
Select the best fitness value and set it as Gbest
For each particle
Calculate the particles velocity and position using equation (1) &(2)
End
End
Step 3. Select the particle with best fitness value and use that to initialize the segmentation method.

B. Fuzzy C-Means Segmentation

Fuzzy C-Means algorithm was proposed by Bezdek, it is an improved method of segmentation based on clustering of particles which is based on minimization of objective function, with respect to fuzzy membership set U and centroids of the cluster V [9].

The objective function is represented by the equation (3)

$$J_m(U,V) = \sum_{j=1}^{N}\sum_{i=1}^{C} u_{ij}^{m} d^2(x_j, v_i) \quad (3)$$

Where x_j represents the information of the pixel, while v_i represents the number of pixels in an image, u_{ij} is the membership function that assigns the partial member value to the particles, C is the number of clusters. The details of how the Fuzzy C-means works are explained in [10].

Step 1. Initialize the C number of clusters with random centres we generated from the PSO algorithm.

Step 2. Calculate the fuzzy centre for each cluster using the equation (4)

$$V_i = \sum_{j=1}^{N}\left(u_{ij}\right)^{m} * j \Big/ \sum_{j=1}^{N}\left(u_{ij}\right)^{m} \quad (4)$$

Step 3. Calculate the membership function for each particle using the equation (5)

$$U_{ij} = \sum_{k=1}^{C}\left(d\left(x_j, v_i\right) \Big/ d\left(x_j, v_k\right)\right)^{-\left(2/m-1\right)} \quad (5)$$

Step 4. Repeat Step 2 &Step 3, until you get the minimum value for the equation (3)

Step 5. Continue repeating the above steps until we reach the condition in equation (6)

$$\| u_{ij}^{l} - u_{ij}^{l+1} \| \leq \varepsilon \quad (6)$$

Step 6. Combine the membership values and initial weights, reshape and the respective pixels to form an image. This is the resulting segmented image.

III. RESULT AND DISCUSSION

Through the use of this hybrid technique, where we are using Particle Swarm Optimization (PSO) to obtain the particles to initialize our FCM clusters we see the clusters having grey values very similar to the grey values of the image. This not only gave us faster segmentation process, but also increases the accuracy of the FCM based segmentation models. Now let's look at some of the results achieved from the proposed method shown in Fig.1 and Fig.2.

A. Case Scenario 1:

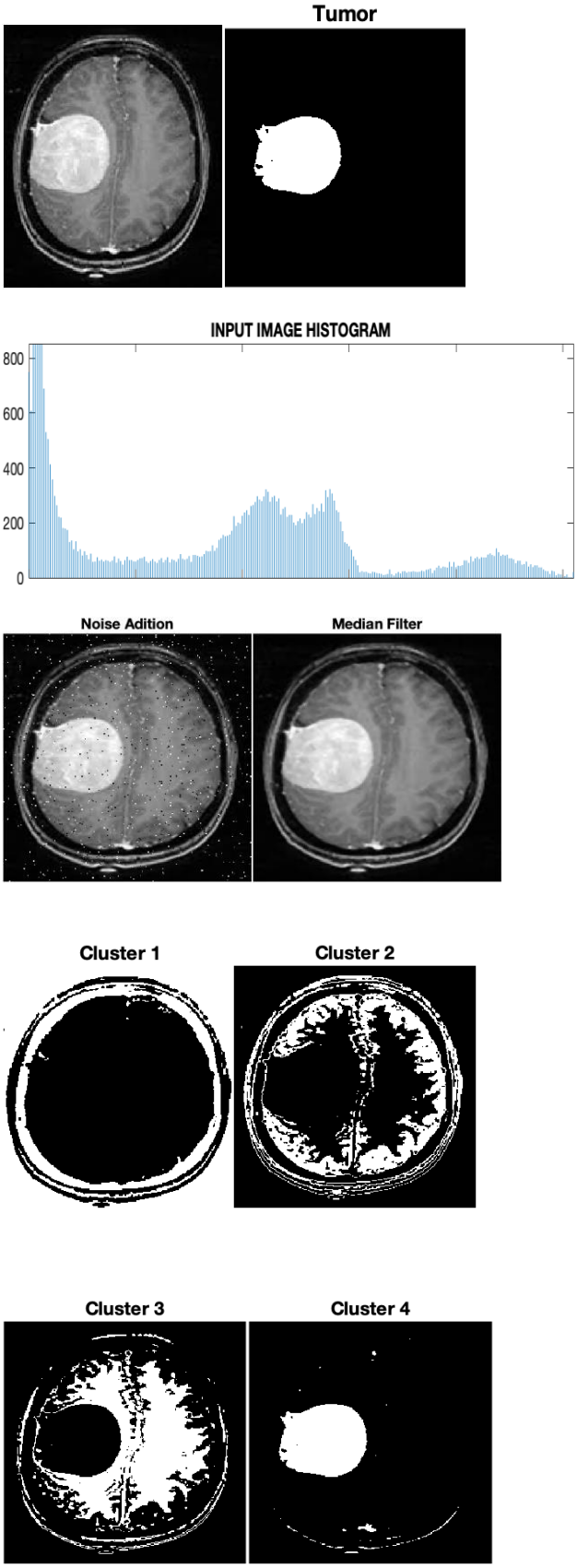

Fig. 1. Images of Scenario 1

B. Case Scenario 2:

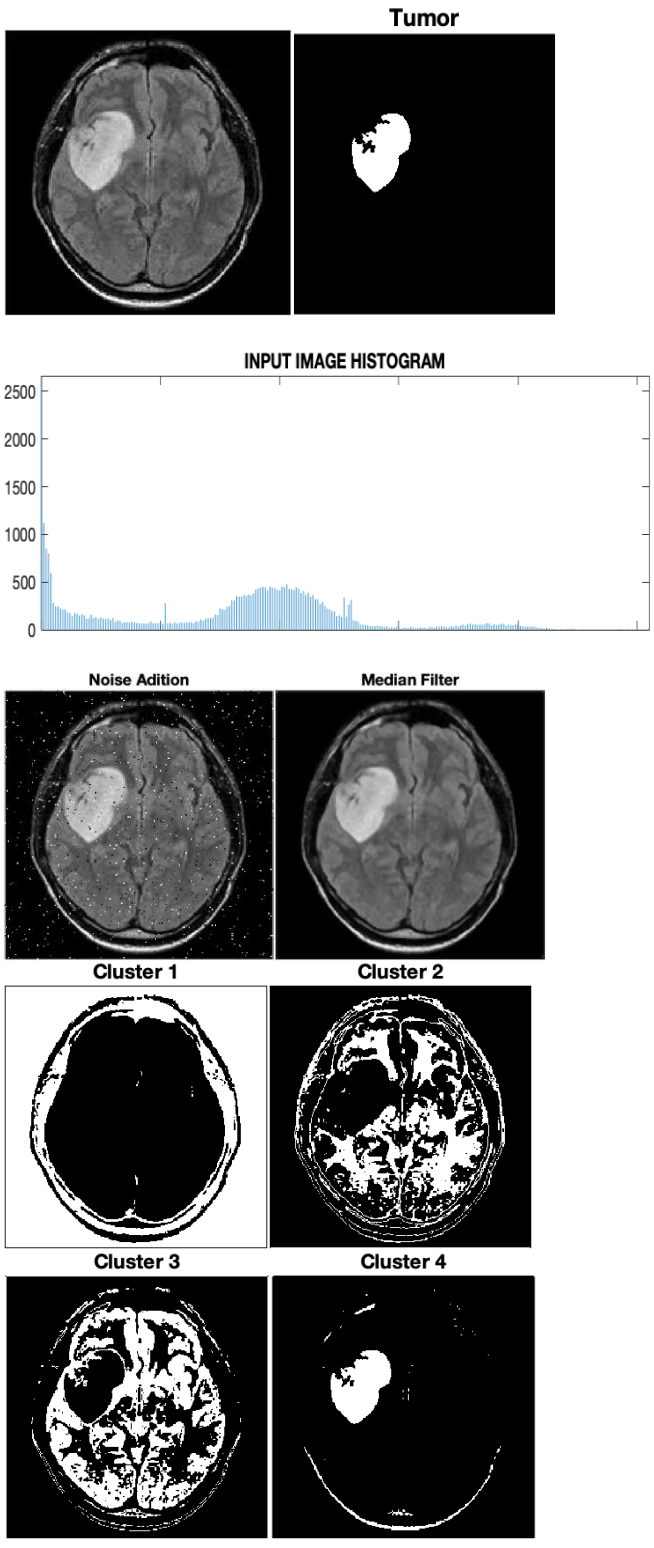

Fig. 2. Images of Scenario 2

IV. CONCLUSION

Hybrid techniques such as the one proposed have shown great improvement in the results compared to the once that were based on just a single principle.

We can improve the performance further by applying optimised PSO and advanced versions of FCM based segmentations. The results show significant improvement due to the fact that PSO was used to initialize the cluster instead of taking random values for the cluster centres which had a huge impact on the cluster formation, which is the main character for the FCM technique. There was a twofold optimization that took place in the proposed methodology, one was the selections of cluster centre using PSO and other was the minimization of objective function in FCM that helped us achieve such accurate results.

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