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AN EFFICIENT APPROACH FOR MR BRAIN IMAGE MULTILEVEL SEGMENTATION AND PERFORMANCE ANALYSIS

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Abstract:

Complex organs can be analysed by using the Magnetic Resonance Image (MRI). This kind of imaging helps the doctors for diagnosis and treatment of neurological diseases. Brain is the complex organ of the human body. It controls the all the organs in our body. Accurate segmentation and analysis of brain tissues such as Gray Matter and White Matter help the doctors for the diagnosing of some complex diseases and neuro surgery. In this paper an efficient method for the segmentation of Gray Matter, White Matter and Cerebrospinal Fluid, Skull regions from MRI brain image using Spatial Fuzzy C-Means was proposed. However, accuracy of this algorithm is not efficient for abnormal brain. To improve the accuracy of segmentation Firefly Optimization algorithm was implemented. Proposed method was implemented using MATLAB 8.6.0.267246 (R2015a) and various parameters were analysed.

Keywords: *Magnetic Resonance Imaging (MRI); segmentation; Spatial Fuzzy C-Means (SFCM); Firefly Optimization (FO); Gray matter (GM); White Matter (WM); Cerebrospinal fluid (CSF).*

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1. Introduction

Human brain is the most complex part of human body which is made up of many complex neurons. This organ controls all necessary functions of the body. Many dangerous diseases are discovered that affect the functioning of brain. Diagnosing diseases in such a complex organ is a challenging task. MR brain image analysis techniques are widely used to detect the abnormalities in the human brain [1]. Magnetic Resonance Imaging (MRI) is one of the commonly used brain imaging techniques. The main advantage of using MRI instead of other Imaging technique is that MRI does not emit any harmful radiation to the human body [2]. One of the problems with MRI is low contrast image. Diagnosing with these low contrast images is a difficult task for doctors. By increasing the contrast of an image, detailed information of the diseases can be analysed. Thus contrast enhancement of an image is important stage in every MRI image analysis work.

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There are many methods proposed for MRI contrast enhancement [2-4]. In this study contrast of the image was enhanced using Adaptive Histogram equalization and image segmentation was carried out using Spatial Fuzzy C- Means (SFCM).

2. Related Works

Sayali D. Gahukar *et al.,* [5] presented Fuzzy C-Means with Ant colony optimization for MRI brain image segmentation.

Priyanka *et al*., [6] proposed methods of edge detection. Among them they found that sobel method of edge detection is more suitable.

Anjum Sheikh *et al.*, [7] presented an approach for segmentation of brain tumour using Ant Colony Optimization. They discussed the energy efficiency of the algorithm with respect to transmission, execution time and energy cost.

Vishnumurthy *et al., [8]* they proposed morphological techniques for the segmentation of MRI brain images and compared the result with Maximum expectation technique and Fuzzy C-Means with reference to performance measures and processing time.

N. Senthilkumaran *et al.,* [9] provided a study on different segmentation approaches such as Edge based approach, Genetic algorithm and Neural network based approach, Split and merge technique and hybrid technique.

a.Meena et al., [10] proposed a method based on Spatial Fuzzy C-Means for the segmentation of Positron Emission Tomography (PET) based images.

Sudip Kumar Adhikari et al., [11] presented an approach based on Conditional Spatial Fuzzy C-Means for MRI brain images.

3. Methodology

MR Image Data Set

MR brain image data set was collected from the brain web database.All the images taken for the experiment are axial orientation images.

Contrast Enhancement

MR images are low contrast images. The minute details in the image must be visible for the diagnosing purpose. In this work, we proposed Adaptive Histogram Equalization (AHE) method for MRI brain image contrast enhancement.

Optimization

In this paper Firefly Optimization algorithm was used to improve the segmentation accuracy.
Firefly Optimization Algorithm Pseudo code:
The basic steps of the firefly algorithm can be summarized as the pseudo code shown below.
Objective function $f(\mathbf{x})$, $\mathbf{x} = (x1, ..., xd)^T$

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Generate initial population of fireflies **x***i* (*i* = 1, 2, ..., *n*)
Light intensity Ii at **x***i is determined by f* (**x***i*)
Define light absorption coefficient γ
while (*t* <*Max Generation)*
for *i* = 1 : *n all n fireflies*
for *j* = 1 : *i all n fireflies*
if *(Ij > Ii), Move firefly i towards j in d-dimension;* **end if**
Attractiveness varies with distance r via $\exp[-\gamma r]$
Evaluate new solutions and update light intensity
end for *j*
end for *i*
Rank the fireflies and find the current best

Segmentation

Spatial Fuzzy C-Means was used for the segmentation of the MR brain image. Here, randomly, the number of cluster is selected as 4 and the performance iteration is varied. The initialization of fuzziness factor is 2. For each iteration, distance between each pixel and the cluster centroid is calculated. If distance is less than the threshold value, objective function is determined. Otherwise update the membership and cluster centroid values. Finally, segmentation is done according to the calculated threshold value.

4. Experimental Results

Our proposed work was implemented in the MATLAB environment. Our method was compared with other clustering techniques such as K-Means clustering and Fuzzy C- Means clustering. Comparison results shows that execution time of K-Means is lesser when compared with FCM and SFCM. In other words, K-Means is faster than the other two methods. Various image quality determining parameters were also analysed. The parameters include PSNR, SSIM, Dice coefficient, Mean Square Error. This work yields an accuracy of about 86.5% in average by comparing the segmented results such as the GM, WM, CSF and Skull with the ground truth image which was collected from the brain web database.

Table 1: Performance Analysis

Method	**Execution time**	**Accuracy**
K- Means	16 sec	79.8%
FCM	28 sec	84.5%
SFCM	45 sec	86.5%

5. Conclusion

In this paper, an approach based on SFCM was implemented on the MATLAB environment for multilevel segmentation of the MR brain image. Table: 1 shows the performance analysis done during the work. This study revealed that the execution time of K-Means is good but accuracy is high in SFCM when compared to the other two methods.

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