

# Hybrid Clustering Technique for Enhanced MRI Brain Image Segmentation

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*EN.585.703.81.FA24 Applied Medical Image Processing  
Course Project Proposal*

## **Project Title:** “Hybrid Clustering Technique for Enhanced MRI Brain Image Segmentation”

### **Introduction**

Medical imaging segmentation is a fundamental form of image processing that identifies different tissue types by exploiting differing signal intensities to create a clear separation between regions of interest. In clinical practice, imaging segmentation of MR imaging of the brain is essential for delineating normal/healthy brain tissue from tumors, identifying neurodegenerative changes like hippocampal atrophy in Alzheimer's disease, assessing the degree of stroke burden in the setting of acute stroke and consideration for mechanical thrombectomy, and presurgical planning for neurosurgeons. Various segmentation methods have been used in MR imaging, including manual segmentation by a radiologist, which is time-consuming and subjective, thresholding, which does not work well with regions of low contrast, clustering algorithms (k-means, fuzzy C-means), atlas-based segmentation, and deep learning or AI-based segmentation [1–4]. Our project aims to utilize clustering algorithms to optimize the segmentation of MR imaging of the brain.

### **Related Work**

The fuzzy C-means (FCM) clustering algorithm is an unsupervised machine-learning-based algorithm commonly used in imaging segmentation [4]. Its limitations include sensitivity to noise and its initial parameters. There have been recent hybrid approaches claiming to improve FCM and increase its robustness to noisy images and adaptability [5–8].

### **Objective**

Our project will first consist of implementing the algorithm described in reference [5] - a hybrid image segmentation method based on fuzzy C-mean and modified bat algorithm. We will, then validate its performances in different datasets. Finally, we will compare them with performances obtained with more traditional or recently established segmentation algorithms. If time permits, we will implement *de novo* algorithms described in [6], [7] or [8] and compare their performances with the algorithm in [5].

### **Methodology**

- **Implement and Evaluate the Modified Fuzzy Bat Algorithm (MFBA):** Reproduce the MFBA-based Fuzzy C-means (MFBAFCM) algorithm discussed in the paper [5]. This step involves integrating the MFBA optimization into the FCM clustering for MRI brain image segmentation.
- **Noise Robustness Testing:** Assess the robustness of the MFBAFCM algorithm on MRI brain images with varying noise levels and non-uniform intensity. This would showcase its effectiveness in handling common MRI images.
- **Algorithm Comparison:** Compare the performance of MFBAFCM with our course-provided **k-means** implementation and other clustering-based segmentation methods, such as standard Fuzzy C-means (FCM) and recent algorithms from the literature.

- **Segmentation Accuracy Metrics:** Use different clustering validity and segmentation accuracy metrics such as Dice Similarity Coefficient (DCS) or other clustering metrics to evaluate the segmentation performance. To help with this task, we can utilize annotation pipelines such as FreeSurfer (<https://surfer.nmr.mgh.harvard.edu/>) or FSL (<https://fsl.fmrib.ox.ac.uk/fsl/docs/>), or similar tools. We will then compare the segmentation performances of these tools with our implementation of MFBAFCM.
- **Visualization:** Generate visual plots of segmentation results using MRI images to demonstrate the improvements brought by the proposed method.

## Datasets

- **OpenNeuro Dataset:** 86 T1-weighted images of 78 adult brains with segmentations of 12 brains into gray and white matter compartments validated by two expert neuroradiologists. (<https://openneuro.org/datasets/ds005216/versions/1.1.0>)
- **IXI Dataset:** 600 MRI images in NIFTI formats collected at three different hospitals in London pending approval by the Imperial College of Science, Technology and Medicine (<https://brain-development.org/ixi-dataset/>)

## Expected Outcomes

The modified segmentation algorithm, MFBAFCM, should have superior performances compared to standard FCM, and other brain segmentation approaches, including intensity-based approaches. If time permits, we will include hybrid approaches such as contour-based, or metaheuristic machine learning. Due to the lack of infrastructure for model training and tuning, as part of this project, we will not consider deep learning algorithms.

## Milestones - Timeline

- Dataset(s) identification and acquisition (*Beginning-October*)
- MFBAFCM implementation (*Mid-October*)
- Noisy Image Generation (*End-October*)
- Experimental Setup (*End-October*)
- Experimental Results (*End-October*)
- Visualization Plot Creation (*Beginning-November*)
- Report Writing (*Beginning-November*)
- Presentation Deck Creation (*Mid-November*)

## **References**

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