

## Aims

- This project aims to propose an evolutionary algorithm based automated approach to the segmentation of brain MR images into the grey matter (GM), white matter (WM) and cerebrospinal fluid (CSF).

## Introduction

- Medical image segmentation is commonly regarded as one of the most difficult tasks in medical image analyse. Despite of several decades of efforts, it remains so far an open problem.
- Magnetic resonance imaging (MRI) is a typical medical imaging technique widely used in hospital. There are three type of MRI scans T1 weighted , T2 weighted and spin density weighted MRI.
- Evolutionary algorithms are inspired by genetics and natural selection which are survival of the fittest. They keep seeking the solution generation by generation. The final generation contains the best key to problem.
- In this project, we solve the Gaussian mixture model (GMM) based brain MR image segmentation problem by using the genetic algorithm (GA) to seek an optimal set of GMM parameters that can classify brain voxels into GM, WM and CSF.

## Methodology

- Use the SPM8 package to generate a probabilistic brain atlas for each MR study, which offers the probability of every voxel belonging to each of those three classes.
- Observed image intensities are denoted by  $x_i \in R^d, i = 1, 2 \dots, n$ . All the intensities are belong to one of the k classes, in this case, modelling intensities in different type of brain tissue (GM, WM and CSF).

## Results

- This proposed algorithm was compared to the EMS, SPM, and VBM algorithm in 16 clinical T1 weighted MR studies selected from the internet brain segmentation repository (IBSR).
- Those data were acquired on a 1.5 tesla Siemens Magnetom MR System (Iselin, NJ) and a 1.5 tesla General Electric Signa MR System (Milwaukee, WI).
- Fig. 2 shows two MR slices from different studies and their segmentation results.
- Fig. 3 and 4 compares the segmentation accuracy and Dice similarity coefficients (DSC) of the segmentation of GM, WM, and CSF, respectively. It reveals that the proposed method achieved an average accuracy of 80.02%.
- Fig. 5 illustrates the proportion of best segmentation obtained by applying each algorithm. It is clear that the proposed method produced the best segmentation result in 50% of test studies.

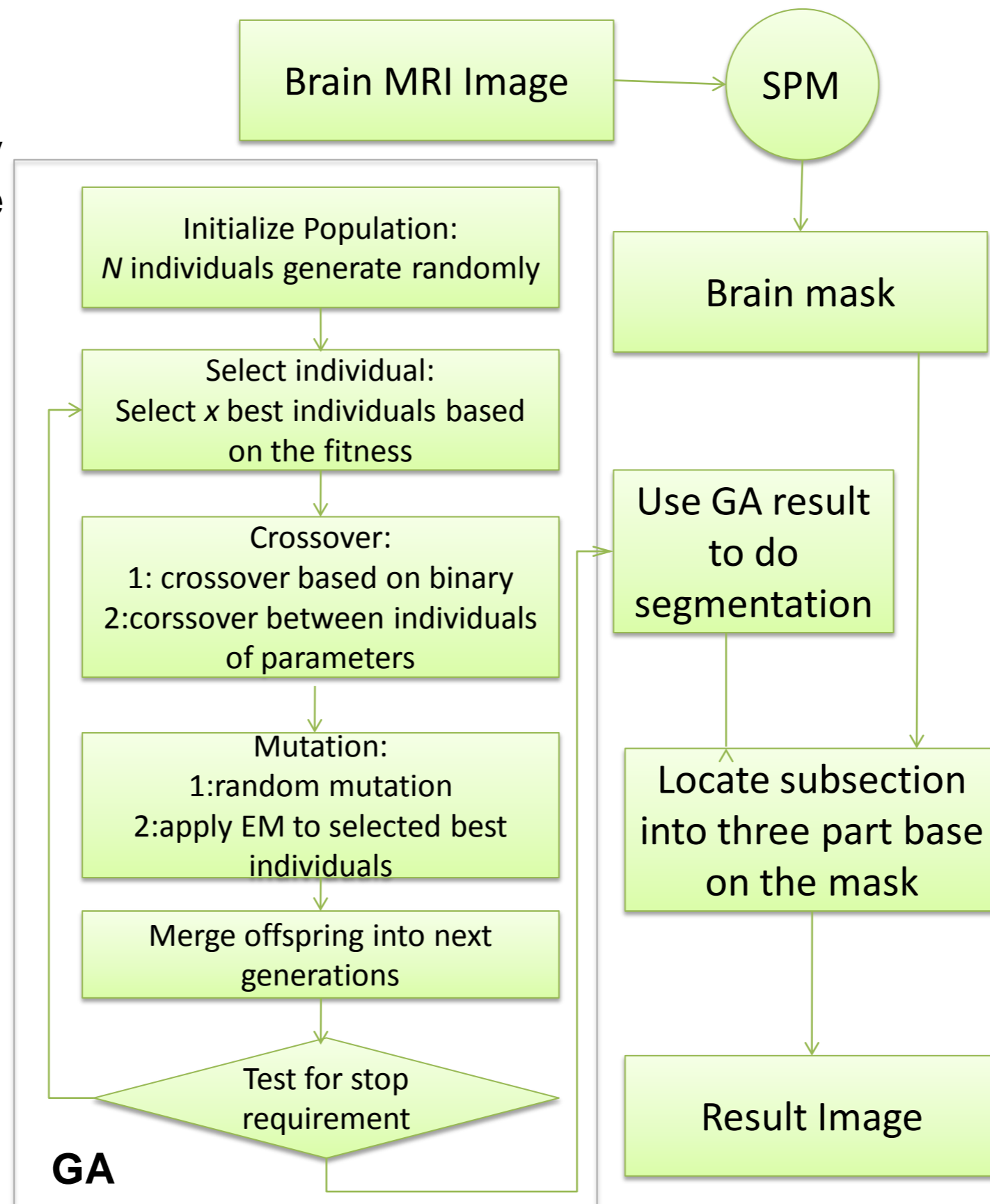


Fig. 1. Flow chart of the proposed algorithm

- In the image data, each voxel represents  $1 \times 3.1 \times 1 \text{ mm}^3$  in the real world. which means there may more than one type of tissue in a single voxel. Thus those voxel will not in the three basic pure classes. So during the process, the classes in Gaussian distribution will increase to more than three. This project will divide the image into nine classes in total.
- The problem modelling by the Gaussian distribution. In GA, each individuals contain several sets of  $N(\mu_k, \alpha_k^2)$ . in this case, there are nine sets of N. The fitness of each individuals measured by maximum likelihood.
- Initialisation:** 500 individuals randomly generated as the first generation.
- Selection:** 50% of the individuals with high fitness are selected.

## Crossover :

- (1) Traditional binary crossover
- (2)  $N(\mu_k, \alpha_k^2)$  based crossover of individuals . This crossover operator is more personalize for Gaussian distribution.

## Mutation:

- (1) Traditional random single or multiple point mutation
- (2) An optimized mutation technique - applying one step of the EM algorithm to a group of individuals selected form the current generation .

- Stop Criterion:** The GA will stop running after a 1500 generations.

- Based on the result of EA, we get nine subsection of images. the next step is class those nine session into three part based on the probabilistic brain atlas.

## Conclusions

- The proposed algorithm substantially outperforms the SPM, EMS and VBM algorithms, and can provide satisfying brain MR image segmentation results.

## Future work

- Investigate the correction of the bias field and partial volume effect, and thus improve the stability and noise resistance of this algorithm.

## Reference

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- R. Ganesan and S. Radhakrishnan, "Segmentation of Computed Tomography Brain Images Using Genetic Algorithm", International Journal of Soft Computing 4,pp 157-161,2009

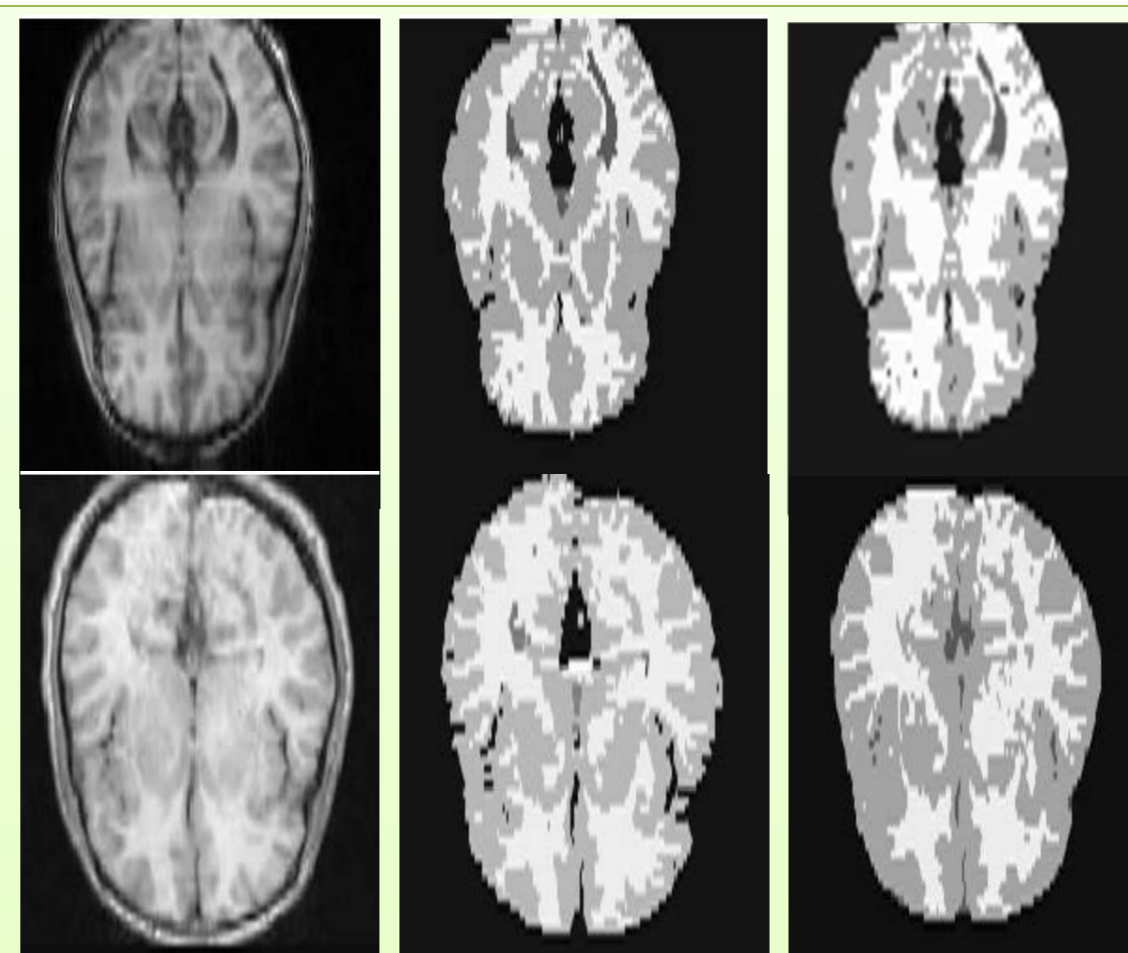


Fig. 2. Two slices of MR images (left column), segmentation results (middle column), and ground truth (right column)

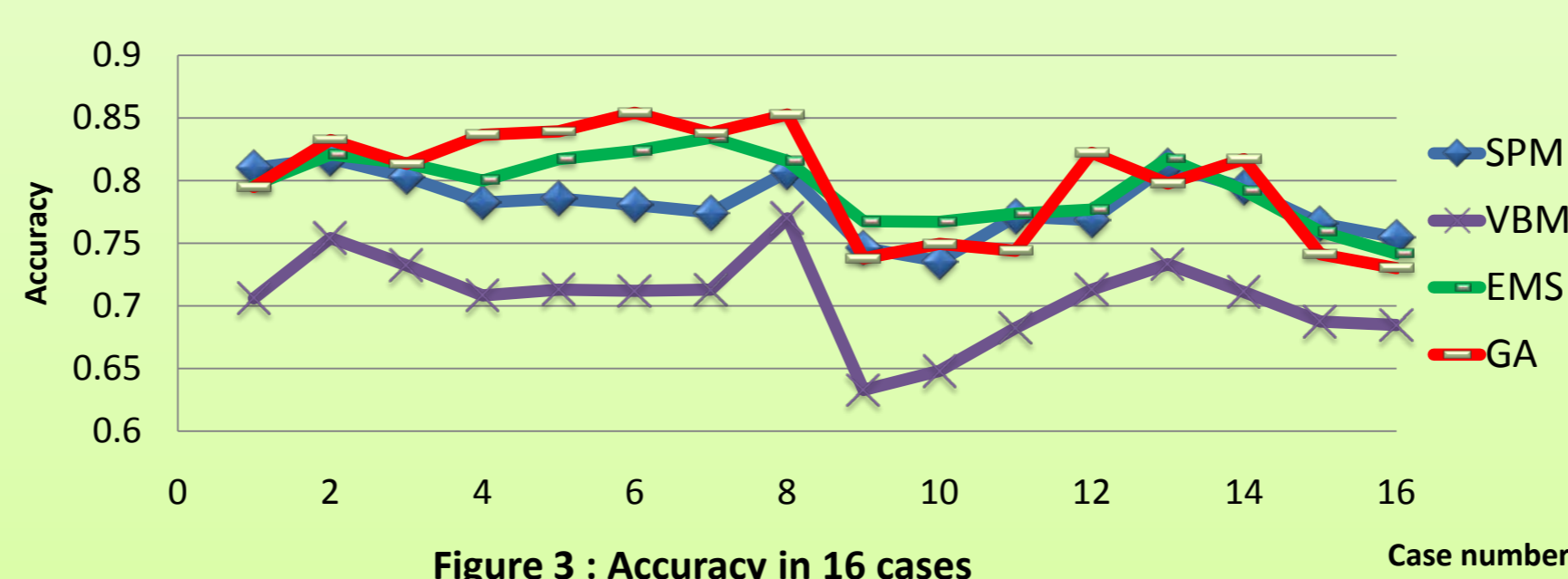


Figure 3 : Accuracy in 16 cases

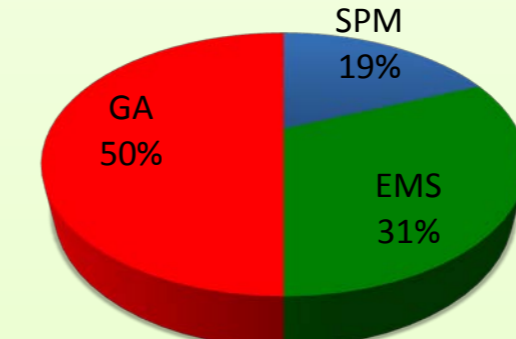


Figure 5: Compare the result from GA, SPM, EMS and VBM

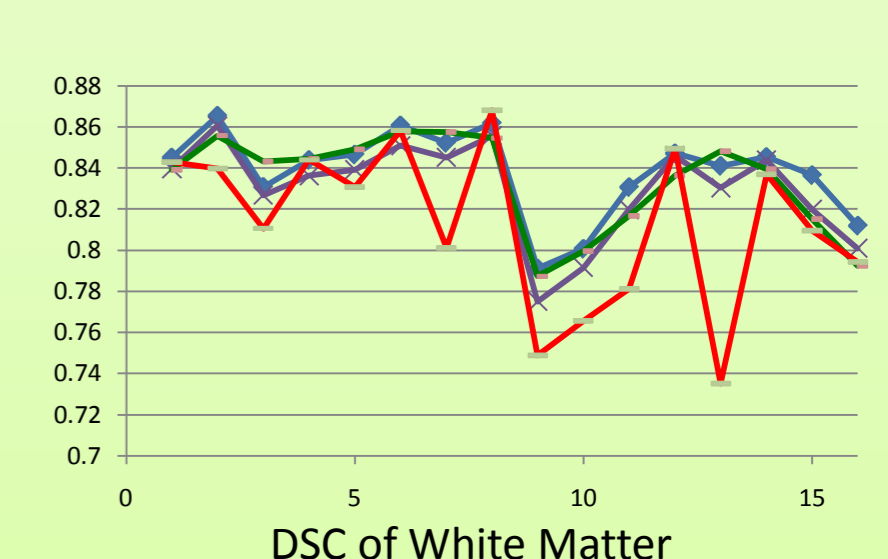
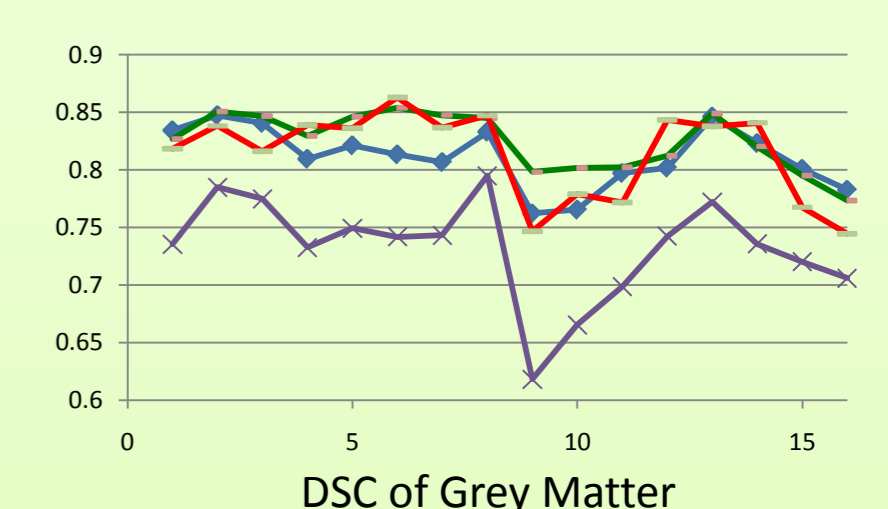
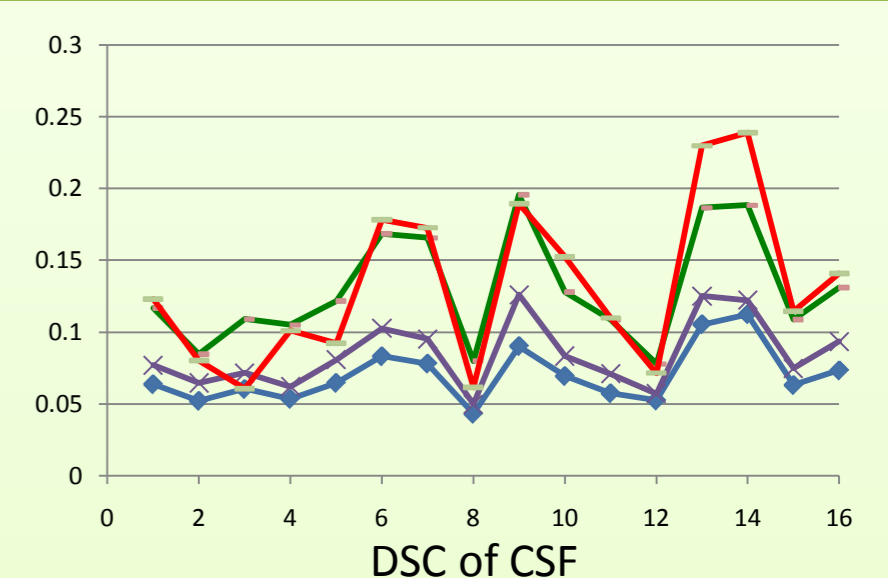


Fig. 4. DSC of the segmentation of GM, WM, and CSF