1. Introduction
Detection of white matter changes in brain tissue using magnetic resonance imaging has been an increasingly active and challenging research area in computational neuroscience. A genetic algorithm-based on a fuzzy c-means clustering method (GAFCM) was applied to simulated images to separate foreground spot signal information from the background, and the results were compared.

2. Problems
GAFCM is computationally expensive. This study presents a new GPU-based parallel GAFCM algorithm to improve the performance of GAFCM. The experimental results show that kernel computational performance can be increased by a factor of approximately 30 over the CPU-based GAFCM algorithm while maintaining the quality of the processed images.

3. GPU-based GAFCM Algorithm for MRI

1. Producing initial population
The chromosomes are made up of real numbers that represent GM and WM pixel intensity centers. Two clusters are used for the segmentation of the brain MRI. The population size can be set arbitrarily, but will affect the final result.

2. FCM algorithm
The FCM algorithm is used to find the cluster center. To obtain the value of member function \( u \), the distance between each data point to a center is calculated first.

\[
\begin{align*}
\mathbf{w}_i & \in \mathbb{R}^n, \\
\mathbf{w}_i & \in \mathbb{R}^n, \\
\sum_{j=1}^{n} w_{ij} = 1, \quad j = 1, \ldots, n, \\
\mathbf{w}_i & = \left( w_{i1}, w_{i2}, \ldots, w_{in} \right), \\
\end{align*}
\]

Next step is to calculate the membership of the cluster. Then computation of objective function \( J \) is performed by the GPU as a parallel reduction.

\[
J = \sum_{i=1}^{n} \sum_{j=1}^{n} u_{ij}^m d^2(x_j, A_i)
\]

3. Genetic operations
In the initial generation, 180 individuals have 180 fitness values obtained by the FCM algorithm on the GPU.

3-1. The selection method is applied to select individuals from the population pool after evaluating the fitness value of each individual.

3-2. The crossover operation determines which chromosome should be exchanged with another chromosome.

3-3. Mutation randomly changes the offspring from crossover to create new offspring that may differ from the original offspring.

4. Replacement
The replacement occurs depending on the fitness value of a child over that of a father.

5. Output
A new matrix \( u \) is produced by the Euclidean distance between the average \( u \) of the final generation and the original histogram matrix. Then, the element with the minimal value in the next matrix \( u \) and the data point in the original histogram matching the minimal value are found. The threshold is determined by the data point divided by 65535.

4. Processed Results of Brain MRI
The transverse MRIs used to evaluate the proposed algorithm were obtained using a T2-weighted turbo spin echo pulse sequence. (repetition time = 4408 ms, echo time = 100 ms, echo spacing = 10.8 ms)

(a) IMG1
(b) IMG2
(c) IMG3
(d) IMG1
(e) IMG2
(f) IMG3

5. Comparison of Computation Performance

6. Conclusion
We have presented the GPU-based GAFCM algorithm to enhance computational performance. The experimental results show that the proposed algorithm demonstrated the same results as those obtained from the GAFCM algorithm. From a comparison of the computational performance, it is obvious that the proposed algorithm can achieve better performance than traditional GAFCM executed on a CPU.