A Parallel Fuzzy C Means Algorithm for Brain Tumor Segmentation on Multiple MRI Images

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Abstract. The Fuzzy C Means (FCM) algorithm has been extensively used in medical image segmentation. But for large data sets the convergence of the FCM algorithm is time consuming and also requires considerable amount of memory. In some real time applications, like Content Based Medical Image Retrieval (CBIR) systems, there is a need to segment a large volume of brain MRI images offline. In this paper, we present an efficient method to cluster data points of all the images at once. The gray level histogram is used in the FCM algorithm to minimize the time for segmentation and the space required. A parallel approach is then applied to further reduce the computation time. The proposed method is found to be almost twice as fast as conventional FCM.

1 Introduction

In the field of medical diagnosis a variety of imaging techniques is presently available, such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI). MRI provides good contrast between the different soft tissues of the body, which makes it especially useful in imaging the brain. Image Segmentation is a process of partitioning an image into non-overlapped, consistent regions which are homogeneous with respect to some properties such as intensity, color and texture [1]. It is a vital step in analysis of medical images for computer aided diagnosis. The main objective of image segmentation in brain MRI images is to isolate a brain tumor from other regions of the brain.

In certain real time applications that support computer aided diagnosis like the CBIR systems, there is a need to process and analyze a large number of medical images. The processing of each image is time consuming owing to the large size of the image itself. Thus processing of large volumes of data must be done offline. In this paper we present a parallel histogram based fuzzy c means approach to efficiently cluster data points of all the MRI images together at once and segment the images to obtain the tumors.

2 Related Work

The computation of conventional FCM algorithm for the iterative operation is time consuming for large data sets and has a high amount of memory requirement for the

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membership matrix. Modifications to overcome the drawbacks of FCM have been proposed by researchers.

Moh'd Belal Al-Zoubi et al. [2] have proposed a fast fuzzy clustering algorithm that is based on eliminating data points with a membership value lower than a threshold value. The choice of the threshold value is based on experimentations; hence the algorithm is not very efficient. Ming-Chuan Hung and Don-Lin Yang [3] have proposed a faster FCM algorithm that uses a two phase approach. Though this approach reduces computation time, additional memory is required for k-d tree and storing additional information like statistical information of the patterns in each block. S.R. Kannan et al. [4] have proposed a center knowledge method in order to reduce the running time of proposed algorithm. But the drawback here is the memory required for the distance table that is dependent on the size of the image.

The algorithm proposed by Ye Xiu Qing et al. [5] uses the gray level histogram in the FCM algorithm to minimize the time for segmentation and the space required for the membership matrix. The algorithms proposed by Weiling Cai et al. [6] and S. Zulaikha Beevi and M. Mohamed Sathik [1], speed up the conventional FCM and significantly reduce the execution time by clustering on grey level histogram rather than on pixels. The proposed methodologies are found to be efficient and robust to noise. The histogram based approach is also adopted by He Yangming and Dai Shuguang [8] and achieves great speed up. The method proposed by Arpit Srivastava et al. [9] uses a membership suppression mechanism which creates competition among clusters to speed up the clustering process. The drawback here is that the execution time depends on the size of the dataset. S. Rahimi et al. [7] and S. Murugavalli and V. Rajamani [8] have proposed parallel FCM based approaches for image segmentation. The parallel algorithms proposed divide all the image pixels equally among the processors so that each processor handles n/p data points (n is the number of pixels and p is the number of processors involved in the computation). Thus, the processing time reduces significantly.

In this paper we adopt the histogram based approach [5], thus reducing the data points to the number of gray levels in the image instead of the number of pixels. The histogram of all images is computed and the membership matrix is initialized based on all the histograms. Thus, the FCM has to be applied only once to cluster all the images. In this paper we also modify the parallel approach [7] by assigning each cluster to different processors. Each processor computes its cluster center and updates the membership matrix after each iterative operation in the FCM algorithm.

3 Proposed Methodology

3.1 Conventional FCM

Fuzzy c-means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters. It is based on minimization of the following objective function: