**A Hybrid Technique for Medical Image Segmentation**

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1. Introduction

Image segmentation is an important processing step in image understanding and computer-aided diagnosis and therapy. The objective of image segmentation is to partition an image into homogeneous regions with respect to some attributes such as intensity and texture [1]. Techniques such as thresholding, clustering, edge detection and region extractio make up the foundation of classical image segmentation processes.

Since thresholding locates the identical regions for fuzzy clustering and improve the corresponding performance, we will examin a consolidation of both thresholding and fuzzy clustering techniques. Thresholding method is a method to convert a gray scale image into a binary one so that objects of interest are separated from the background [3]. The histogram thresholding, which is based on the shape properties of histogram, is the most convenient and widely used technique.The image histogram has different peaks and valleys, with each peak corresponding to one distinct region and each valley as one threshold value to separate two different regions [4, 5]. In terms of computational complexity, the segmentation algorithms based on thresholding are then generally more efficient than other segmentation methods, and one of the most representative methods for image segmentation is Otsu’s clustering-based thresholding [6].

In addition, in image clustering and segmentation, a method that has been widely and successfully applied is fuzzy clustering [7]. One of the basic methods is the fuzzy c-means (FCM) clustering [8, 9], which is a soft segmentation method that has been widely used to improve the compactness of regions with better cluster validity and simple implementation. If we assume that each feature is of equal importance, then FCM can adopt on the Euclidean distance between pixels as the dissimilarity measure. This assumption may seriously affect clustering performance because features are not equally important in most real-world applications. Thus, many techniques have been proposed to improve the performance of FCM, such as rival checked FCM and suppressed FCM (SFCM), which incorporates the hard c-means (HCM) and FCM in the interest of boosting the convergence speed and the clustering performance [10, 11].

Based on the advantages of thresholding and fuzzy clustering algorithms for image segmentation, hybrid techniques combining various FCM-based methods with thresholding have been proposed by some authors. Tobias and Seara proposed histogram thresholding using fuzzy theory [12] in which the image histogram is thresholded based on a criterion of similarity between gray levels and a measure of fuzziness is used for assessing this similarity. Because of the used assumption, in which objects and background must occupy non-overlapping regions, the proposed method is limited to images that satisfy such a requirement. Ben et al. came up with an idea to combine automatic thresholding with FCM [13]. The results of this technique are quite satisfactory that significant peaks and valleys could now be recognized appropriately. To overcome the FCM’s sensitiveness to the initialization condition of cluster centroids and selection of the number of clusters, another hybrid approach, which uses the histogram thresholding, was introduced by Tan and Isa [14]. However, some of the flat parts of the histogram curves had been recognized as the dominant peaks and that is a drawback of this algorithm. To overcome the drawbacks of the above methods, we propose a hybrid technique using Otsu thresholding and enhanced SFCM (EnSFCM). Furthermore, we use vector median filtering to reduce impulsive noise that is widely presented in magnetic resonance (MR) images.

2. Proposed Image Segmentation Framework

The proposed image segmentation approach consists of vector median filtering, which is used to reduce impulsive noise in medical images, Otsu thresholding, which is then employed for rough segmentation of brain MR images, and EnSFCM, which is applied to have well-segmented images. More details about the proposed approach are described in Figure 1 and the following sections.

2.1. Vector Median Filter

In medical images, impulsive noise, which is randomly distributed over the image, is independent and uncorrelated to the image pixels. In magnetic resonance (MR) images, the low resolution of sensors is the cause of impulsive noise in the partial volume [11, 15], which can result in low segmentation performance. Thus this paper uses a vector median filter (VMF) to remove that impulsive noise. VMF can be used because it preserves the image without getting blurred and no shifting of boundary [16]. Its approach is the searching the most robust vector in the processing window. This process is as follows.

Assume that I is an image to be processed, and W is the processing window centered on the pixel under processing of size N×N, N=3, 5, 7,.... and so forth. We consider that each input vector xi is associated with the distance measure,

for *i =* 1,2,...,*N,* (1)

where *γ* represents the selected norm. The distance between two samples can be defined by

, (2)

where *m* is the distance of the vectors and *xik* is the *k*th element of *xi*. Thus distance *Li* serves as an ordering criterion of which implies the same ordering of the input vectors. The VMF output of the set is defined as the sample that satisfies the following condition:

, for *j* = 1,2,…,*N*. (3)

2.2. Otsu Thresholding

Otsu’s algorithm is one of the most referenced thresholding methods in image segmentation. It automatically selects threshold values from the histogram of the image by using the variance property of the image. The variance property is used because the greater difference between variance values represents the greater difference between the background and the object [4, 6]. Initially, two regions are separated by the intensity threshold, and then minimizing the within-class variance or maximizing the between-class variance determines the optimal threshold.

Assume that are the probabilities of the gray-level image histogram of an image, where *L* is the range of intensity levels. We can calculate the probabilities of background () and the probabilities of object () of the image with a threshold *t* as follows:

, (4)

,

The mean associated with the background and the object can be further calculated using the following equations:

, (5)

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