Egyptian Informatics Journal (2015) **16**, 71–81

Cairo University

Egyptian Informatics Journal

www.elsevier.com/locate/eij
www.sciencedirect.com

ORIGINAL ARTICLE

Brain tumor segmentation based on a hybrid clustering technique

Eman Abdel-Maksoud [a,*], Mohammed Elmogy [b], Rashid Al-Awadi [c]

[a] *Information Systems Dept., Faculty of Computers and Information, Mansoura University, Egypt*
[b] *Information Technology Dept., Faculty of Computers and Information, Mansoura University, Egypt*
[c] *Communication Dept., Faculty of Engineering, Mansoura University, Egypt*

Received 30 April 2014; revised 15 January 2015; accepted 18 January 2015
Available online 10 February 2015

KEYWORDS

Medical image segmentation;
Brain tumor segmentation;
K-means clustering;
Fuzzy C-means;
Expectation Maximization

Abstract Image segmentation refers to the process of partitioning an image into mutually exclusive regions. It can be considered as the most essential and crucial process for facilitating the delineation, characterization, and visualization of regions of interest in any medical image. Despite intensive research, segmentation remains a challenging problem due to the diverse image content, cluttered objects, occlusion, image noise, non-uniform object texture, and other factors. There are many algorithms and techniques available for image segmentation but still there needs to develop an efficient, fast technique of medical image segmentation.

This paper presents an efficient image segmentation approach using K-means clustering technique integrated with Fuzzy C-means algorithm. It is followed by thresholding and level set segmentation stages to provide an accurate brain tumor detection. The proposed technique can get benefits of the K-means clustering for image segmentation in the aspects of minimal computation time. In addition, it can get advantages of the Fuzzy C-means in the aspects of accuracy. The performance

* Corresponding author at: 44th Hamza Ibn Abdulmotaleb ST., Ahmed Maher ST., Mansoura City, Dakahlia Gov., A.R.E., Egypt. Tel.: +20 10 281 42 420.
E-mail addresses: eng.eaaar@yahoo.com, eng.eman.te@gmail.com (E. Abdel-Maksoud), melmogy@mans.edu.eg (M. Elmogy), actt_egypt@yahoo.com (R. Al-Awadi).
Peer review under responsibility of Faculty of Computers and Information, Cairo University.

ELSEVIER | **Production and hosting by Elsevier**

http://dx.doi.org/10.1016/j.eij.2015.01.003

of the proposed image segmentation approach was evaluated by comparing it with some state of the art segmentation algorithms in case of accuracy, processing time, and performance. The accuracy was evaluated by comparing the results with the ground truth of each processed image. The experimental results clarify the effectiveness of our proposed approach to deal with a higher number of segmentation problems via improving the segmentation quality and accuracy in minimal execution time.

1. Introduction

Image segmentation refers to the process of partitioning a digital image into multiple regions. The goal of segmentation is to change the representation of an image to be more meaningful and easier to analyze. It is used in order to locate objects and boundaries in images. The result of image segmentation occurs as a set of regions that collectively covers the entire image [1]. Therefore, medical image segmentation plays a significant role in clinical diagnosis. It can be considered as a difficult problem because medical images commonly have poor contrasts, different types of noise, and missing or diffusive boundaries [2]. The anatomy of the brain can be scanned by Magnetic Resonance Imaging (MRI) scan or computed tomography (CT) scan. The MRI scan is more comfortable than CT scan for diagnosis. It is not affect the human body because it does not use any radiation. It is based on the magnetic field and radio waves [3]. On the other hand, brain tumor is one of the leading causes of death among people. It is evidence that the chance of survival can be increased if the tumor is detected correctly at its early stage. In most cases, the physician gives the treatment for the strokes rather than the treatment for the tumor. Therefore, detection of the tumor is essential for the treatment. The lifetime of the person who affected by the brain tumor will increase if it is detected early [4]. Thus, there is a need for an efficient medical image segmentation method with some preferred properties such as minimum user interaction, fast computation, accurate, and robust segmentation results [5].

On the other hand, image segmentation algorithms are based on one of the two fundamental properties of image intensity values: discontinuity and similarity [6]. In the formal category, the segmentation approach is based on partitioning the processed image based on changes in intensity, such as edges and corners. The second one is based on partitioning an image into regions that are similar due to a set of predefined criteria. Therefore, there are many segmentation techniques which can be broadly used, such as histogram based methods, edge-based methods, artificial neural network based segmentation methods, physical model based approaches, region-based methods (region splitting, growing, and merging), and clustering methods (Fuzzy C-means clustering, K-means clustering, Mean Shift, and Expectation Maximization) [7–9].

There are many challenging issues to image segmentation like development of a unified approach that can be applied to all types of images and applications. Even, the selection of an appropriate technique for a particular kind of image is a difficult problem. Thus, there is no universal accepted method for image segmentation. So, it remains a challenging problem in image processing and computer vision fields [10].

One view of image segmentation is a clustering problem that concerns how to determine which pixels in an image belong together most appropriately. There is an extensive literature on the methods that perform image segmentation based on clustering techniques. These methods usually show clustering in one of the two different ways, either by partitioning or by grouping pixels. In partitioning, the whole image is divided into regions that are "good" according to some criteria. Whereas in the grouping, the pixels are collected together based on some assumptions that determine how to group preferably [11]. There are many clustering algorithms that can be used in image segmentation process, such as hard clustering or K-means clusters, and Fuzzy clustering. Therefore, clustering is a challenging field. It can be used as a stand-alone tool to gain insight into the distribution of data in different clusters for further analysis. Cluster analysis serves as a pre-processing step for other algorithms, such as classification that would then operate on detected clusters [12].

We used image segmentation techniques based on clustering to detect the brain tumor and calculating the tumor area. We developed a novel image segmentation approach, called K-means integrated with Fuzzy C-means (KIFCM), for abnormal MRI images. We integrated K-means clustering algorithm with the Fuzzy C-means algorithm to overcome the limitations and get benefits of them. After clustering stage, the extraction of the tumor is done automatically without user interaction by using thresholding and level set methods to contour the tumor area. The last stage of our proposed technique is calculating the tumor area in the processed image. K-means algorithm can detect a brain tumor faster than Fuzzy C-means. However, Fuzzy C-means predicted tumor cells that are not predicted by K-means algorithm. The proposed technique gives an accurate result as compared to the K-means algorithm. Even though, original Fuzzy C-means algorithm yields good results for segmenting noise free images, it fails to segment noisy images. Therefore, we get benefits from integrating these two algorithms to reduce the number of iterations, which affects execution time and gives an accurate result in tumor detection.

This paper is organized as follows. In Section 2, the current scientific research in medical image segmentation is introduced. Section 3 presents the materials and methods used in this work. It describes the image datasets used in this work. It also shows the proposed medical image segmentation system based on clustering. Section 4 depicts the experimental results obtained from the evaluation of the proposed methods using three types of data sets and discusses the central questions derived from them. Finally, conclusion and future work are drawn in Section 5.