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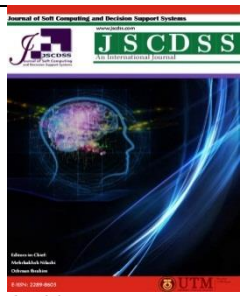

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Intelligent Approaches towards Fuzzy Segmentation and Fuzzy Edge Detection

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Abstract

Fuzzy method is one of the most popular methods for image segmentation. In this paper, fuzzy segmentation and fuzzy edge detection methods are presented to segment and detect the edges of the images. The experimental results of our proposed method show that this algorithm performs well and it segments and detects the edges of the image precisely.

Keywords: Fuzzy edge detection, Fuzzy segmentation, Image segmentation; Fuzzy logic

1. Introduction

Segmentation (Edalati-rad and Mosleh, 2019) is a standard method which requires when some part of the image has to be recognized and thus, it builds a group of partitioned pixels in regions (Drozdzal et al., 2018). In other words, the aim of Image Segmentation (IS) (Wang et al., 2019; Soualmi et al., 2018; Winston and Hemanth, 2018; Wang et al., 2019) is to separate the image into different areas and then, it extracts the favourable objectives. One of the most troublesome subjects in image processing and pattern recognition fields is IS. So far, there have been proposed several segmentation (Ahmadi and Akbarizadeh, 2016; Ahmadi and Nilashi, 2018) methods that are includes clustering (Huang et al., 2019), graph cut (Chen and Pan, 2018), edge detection (Ahmadi and Akbarizadeh, 2015; Ahmadi and Akbarizadeh, 2019), and level set (Zhi and Shen, 2018). The boundaries demarcate the regions; however, these boundaries are not usually clarified. Fuzzy methods (Mahmood et al., 2018) have been producing well-known approaches for segmenting the crisp images as they can model distinguish genre of noisy images effectively (Naidu et al., 2018). A set of pixels which are partitioned into a particular joined region is called a crisp IS (Sarkar et al., 2016). Fuzzy C-means Clustering (FCM) method has been performed extensively to IS among the Clustering Segmentation (CS) approaches (Çetin et al., 2019).

The rest of this paper is organized as follows. In Section 2, we review multiple literature reviews. Our proposed method and experimental results are described in Section 3 and 4, respectively. Finally, this work is concluded in Section 5.

Table 1

List of acronyms.

Acronyms	Description
FCM	Fuzzy C-Means Clustering
FCM-S	Fuzzy C-Means Clustering-Special Constraints
LCFCM-S	Local Correntropy and FCM-S
IS	Image Segmentation
CS	Clustering Segmentation
FIS	Fuzzy Image Segmentation
MsGKFCM	Multi-Scale Gaussian Kernel FCM
MsVFC	Multi-Scale Vector Field Convolution
ROI	Region of the Interest
US	Ultrasound
SRAD	Speckle Reducing Anisotropic Diffusion
FRC	Fuzzy Region Competition
GMM	Gaussian Mixture Model
ML	Machine Learning

2. Related Work

In the past, numerous methods have been surveyed in the literature by the scholars for IS. Fuzzy logic has been an effective technique for complex systems implementation (Nilashi et al., 2019a; Nilashi et al., 2019b; Nilashi et al., 2019c; Nilashi et al., 2019d; Nilashi et al., 2019e; Mardani et al., 2019; Yadegaridehkordi et al., 2018). Fuzzy segmentation is one of the well-known approaches that it has been gained multifarious popularity during the years (Ahmadi and Akbarizadeh, 2017; Hooda et al., 2019; Subashini et al., 2016; Ahmadi and Akbarizadeh, 2018; Ahmadi et al., 2019). Chouhan et al. (2018) presented a novel study based on Fuzzy C-means Clustering (FCM) – Special constraints (FCM-S) for image segmentation. But it is not very useful due to its computational complexity issues, shortage of sufficient power to outliers, and noise. To solve

this obstacle, the authors proposed a hybrid method based on Local Correntropy and FCM-S (LCFCM-S). Furthermore, in the study provided by Gómez et al. (2015), hierarchical clustering is utilized for Fuzzy Image Segmentation (FIS). They used this method based on the current relations between the two problems (fuzzy boundary set and hierarchical IS) to create fuzzy boundaries. Moreover, Panigrahi et al. (2019) performed a clustering approach that is based on the following methods. First, they used Speckle Reducing Anisotropic Diffusion (SRAD) approach for filtering the images. Then, Multi-scale Gaussian Kernel FCM (MsGKFCM) method is applied to segment the Region of the Interest (ROI) of the breast lesions Ultrasound (US) automatically. Moreover, combined techniques are applied utilizing MsGKFCM and Multi-scale Vector Field Convolution (MsVFC) to achieve a precise lesion boundary in the image of US breast. Viswanathan (2015) proposed a method for detecting leukemia. The author first used contrast enhancement approach to distinguish the nuclei and then morphological contour segmentation method was applied and last but not least, FCM model was carried out to recognize leukemia. Additionally, a hybrid Fuzzy Region Competition (FRC) and Gaussian Mixture Model (GMM) methods were performed in the research presented by Yin et al. (2018) for segmenting the large-scale remote sensing images.

3. Proposed Method

In this research, we propose a fuzzy IS and fuzzy edge detection methods. Our aim is based on crisp IS that can be classified into sets of edges which divide adjacent regions of this segmentation.

3.1. Fuzzy Image Segmentation (FIS)

In fact, FIS in the image is defined as set of fuzzy regions $R_1,\ldots,R_i$ that each of them has separate membership function $\mu_{R1},\ldots,\mu_{Ri}$ which shows the possession of the every degrees to every pixel of the image in the region. It is crucial to make emphasis that individuals carry out fuzzy segmentation naturally, because it is clear from the tested and segmented people's images. Individual segmentation does not match an image segmentation which is crisp, in other words, the visualization features for all lines of the segmentation should demonstrate matchless intensity.

The fuzzy segmentation concept is defined through the concept of fuzzified edge segmentation as follows. A graph G = (V, E) which provide the neighbourhood between the image pixels and it is considered to be fully connected. An edge that joins the two p and p' is defined as $e = \{p; p'\} \in E$ and we require to assess the degree $d_e \geq 0$ dissimilarity between the two p and p'. The lower the degree d_e, the more similar p and $p'$are. $D = \{d_e | e \in E\}$ is defined for the total number of differences. Eq. (1) shows the summary of image net with information related to image I.

$$N(I) = \{G; D\} \quad (1)$$

Consider a network image $N(I) = \{G = (V, E); D\}$ and fuzzy set $\tilde{B} = \{(e, \mu_B(e)), e \in E\}$ that creates a FIS with $\alpha \in [0,1]$ and $B(\alpha) = \{e \in E: \mu_B(e) \geq \alpha\}$ which is crisp set and it builds an IS. Regarding the edge for fuzzy set $\tilde{B}$ membership function, it shows the division degree between the two p and p'pixels in the segmenting procedure.

3.2. Fuzzy edge detection

Image Segmentation (IS) is shown by the achieved contour regions. In this method, there are two groups of pixels that are black and white, where black pixels demonstrate the centre of the similar regions. This way of representation is more frequent in edge detection problem.

The initial stage is to categorize the pixels (into black and white) with S which is defined for IS. Moreover, S (p) is defined for the pixel p that locates in the belonged region and V is defined for the whole black and white pixels. N(I) and S are defined as the network image and segmentation, respectively and they are shown as follows.

$$N(I) = \{G = (V, E); D\} \quad (2)$$
$$S = \{R_1, \ldots, R_k\} \quad (3)$$

The black and white classes are defined as following:

$$Black = \{p \in V \text{ and } S(p) = S(p') \forall e = (p,p') \in E\} \quad (4)$$
$$White = \{p \in V \text{ and } e = (p,p') \in E \text{ with } S(p) \neq S(p')\} \quad (5)$$

4. Experimental Results

All the approaches carried out in this research are implemented on the same PC. The specifications are: IntelCore i5 2.3GHz, 4GB RAM, Windows 7 and MATLAB R2013b.

According to Table 2, it demonstrates the elapsed time for fuzzy segmentation and fuzzy edge detection approaches. Fig. 1 shows the image that is segmented based on fuzzy approach. Fig. 1 (a) depicts colour mode of the image, Fig. 1 (b) shows the grey mode presentation, Fig. 1 (c) shows the low resolution of the image, Fig. 1 (d) demonstrates the medium resolution of the image, and (e) shows the segmented resolution with high resolution. Fig. 2 illustrates the fuzzy edge detection approach. Fig. 2 (a) and Fig. 2 (b) are for colour and grey modes of the image, respectively, Fig. 2 (c) shows the edges clearly, and Fig. 2 (d) depicts the edges slightly unclear.

Table 2
Elapsed time for fuzzy segmentation and fuzzy edge detection methods.

Method	Elapsed Time (s)
Fuzzy segmentation	1.149668
Fuzzy edge detection	16.619927

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(a) (b) (c) (d) (e)

Fig. 1. Segmented Image based on Fuzzy method. (a) Color scale of an image, (b) Gray scale of an image, (c) Segmented image with low resolution, (d) Segmented image with medium resolution, and (e) Segmented image with high resolution.

(a) (b) (c) (d)

Fig. 2. Fuzzy edge detection method. (a) Color scale of an image, (b) Gray scale of an image, (c) Clear detected edges, and (d) Detected edges a bit unclear.

5. Conclusion

In this study, fuzzy segmentation and edge detection methods are used. We have tested our proposed method on both coloured and grey scale images to obtain more accurate results. Our experimental results show that our model is an appropriate method but it needs to be more concise and faster. For the future study, the combination of machine learning techniques would be considered in order to have more accurate and fast segmentation approach. In addition, the use of other clustering techniques such as self-organizing map (Ahani et al., 2019a; Ahani et al., 2019b) and expectation maximization algorithms (Nilashi et al., 2015; Nilashi et al., 2016) are also suggested for image segmentation.

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