International Journal of Natural Computing Research
Volume 10 • Issue 1 • January-March 2021

An Unsupervised Hybrid Symbolic Fuzzy Clustering Approach for Efficient Sclera Segmentation

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ABSTRACT

This article performs the sclera segmentation task by proposing a new hybrid symbolic fuzzy c-means (HSFCM) clustering method. Practically, though the data point exhibits some sort of similarity, unfortunately they are not undistinguishable and exhibit some sort of dissimilarity. Thus, to capture these disparities, the proposed work uses symbolic interval valued representation method. Further, to handle uncertainty and imprecision, the paper has proposed to use symbolic fuzzy clustering methods. To assess the performance of the proposed method, extensive experimentation is conducted on SSRBC2016 dataset. The proposed clustering method is compared with existing FCM, KFCM, RSKFCM method in terms of cluster validity indices and accuracy. The obtained outcomes demonstrated that the proposed method performed better compared to the contemporary methods.

KEYWORDS

Fuzzy Clustering, Sclera, Segmentation, Symbolic Representation

1. INTRODUCTION

With the immense growth of various authentication system, surveillance system and forensic application, biometric recognition techniques are pulling many researchers to progress the efficiency of the recognition system. Basically biometric is a pattern recognition system which identifies individuals by using physical, biological and behavioral traits. To list some of the most widely used traits for identification and recognition includes: face, finger prints, iris, gait, palm vein, voice etc., (Jain et al., 2011). The aforementioned traits have its own pros and cons. Hence, to decide upon an appropriate trait will always depends upon the domain/application that the user is working on (Derakhshani et al., 2006). Recently, researchers developed a biometric system using blood vessels patterns present in Retina (Crihalmeanu et al., 2009; Sadikoglu & Uzelaltinbulat, 2016), Palm (Toh et al., 2006), Fingers (Miura et al., 2007) and Sclera (Thomas et al., 2010). Among these biometric, sclera based biometric finds variety of applications (Das et al., 2016; Zhou et al., 2013). The sclera region which is rich in vascular structure is measured to be distinctive for respective individuals and fairly very steady over time. Basically, Sclera is the white region of connective tissues and blood vessels surrounding the iris. The very important characteristics of sclera are:

DOI: 10.4018/IJNCR.2021010101

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- Blood vessel present in sclera region are not identical for individuals, not even for twins and for left and right eyes of the same individual;
- These patterns remain stable throughout person's life time;
- Sclera can be acquired in visible light.

Any sclera recognition system consists of four step: enhancement, segmentation, feature extraction and recognition. Amid the different steps, segmentation of sclera is the main challenge in sclera recognition system. The precision of the recognition system decreases dramatically due to incorrect segmentation. Even though, there are many segmentation techniques exists in the literature, sclera segmentation remains challenging due to illumination effect, noise and partial occlusion. The remaining structure of the article is as follows: section 2 comprises of associated works, section 3 elaborates on the contextual information about symbolic data analysis. Proposed method is presented in section 4. The details of the investigation and outcomes are presented in section 5. Finally, the summary and further scope are drawn in section 6.

2. RELATED WORK

Building a sclera recognition system starts with segmentation process. The very initial work of sclera segmentation was started with manual segmentation (Das et al., 2016; Das et al., 2017). Unfortunately, the method is unreliable because of human intervention. Further the method is also computationally expensive. To address this limitation, Semi-automatic method using k-means clustering has proposed by (Das et al., 2016). Later, two automatic segmentation techniques based on pixel thesholding (Bhateja et al., 2020; Bhateja et al., 2019; Crihalmeanu et al., 2009; Das et al., 2016; Das et al., 2017; Ghosh et al., 2019) and sclera shape contour (Khosravi & Safabakhsh, 2008; Lin et al., 2013; Oh & Toh, 2012; Zhou et al., 2012) was proposed. Further, Convolution deep learning methods (Alkassar et al., 2015; Crihalmeanu & Ross, 2012; Das et al., 2013) outperformed the existing conventional methods. Semantic segmentation network proposed by (Radu et al., 2015) handles multiclass segmentation approach. The proposed method uses feature maps for pixel wise classification of input images. Sclera segmentation using Fully Convolution Network (FCN) (Alkassar et al., 2015; Das et al., 2013) and Generative Adversarial Network (GAN) was proposed by (Das et al., 2013). Further, to come out with a very efficient recognition and segmentation methods of sclera trait many international competitions were held across the globe (Badrinarayanan et al., 2017; Liu et al., 2016; Rot et al., 2018; Shukla & Bhateja, 2018; Thomas et al., 2010; Zhou et al., 2013). The very recent benchmark competition which evaluates the various sclera segmentation results were proposed by (Liu et al., 2016). The maximum precision and recall rates achieved were 81.35% and 75.82%.

Many works are progressing towards using deep learning techniques. Unfortunately, these methods suffer in terms of computational complexity. Thus inspite of existing deep learning solutions, this paper has attempted to do automatic sclera segmentation techniques using simple and efficient hybrid symbolic clustering methods. The details of Hybrid Symbolic Fuzzy C-means (HSFCM) is presented in next section.

3. SYMBOLIC DATA ANALYSIS

In the traditional clustering approaches, the input samples to be clustered are represented as a vector of qualitative or quantitative measurement i.e., crisp variable. Unfortunately, these approaches fail to work on complex data like intervals, frequencies or weights. On the other hand, another important inspiring factor is the recent development in the emerging area of Symbolic Data Analysis (SDA) (Diday & Noirhomme-Fraiture, 2008). Symbolic data is the extension of the traditional data type which includes interval, frequencies, periodic, histogram etc. Among varieties of symbolic data

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