Iris segmentation using Hough Transform method and Fuzzy C-Means method

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Abstract. Complementary and Alternative Medicine (CAM) therapy is quite popular for chronic diseases such as diabetes, arthritis, and others. CAM has become very popular in the last period. One area of CAM is iridology, which is an alternative diagnosis that links iris patterns, color, tissue weakness, damage and other characteristics, which can obtain evidence about the patient's systemic health. In identification based on the eye image, it requires an iris separation process. This separation process in image processing is done by segmentation. So that segmentation plays an important role in the identification of diseases based on images. In this research segmentation is done by combining the Hough Transform method and the clustering-based segmentation method, the Fuzzy C-Means method. The segmentation is done on the iris object which is sourced from UBIRIS V2 database. System evaluation is done by measuring accuracy, sensitivity, specificity and execution time. Test results on the tested iris image indicate the proposed method is able to segment the iris image properly.

1. Introduction

Di In the modern era, the development and advancement of information technology have a great influence on life. In medical research, the use of image processing techniques is currently growing very rapidly. When processing images, it often happens that not all information in an image is used. Sometimes even just a small part of the image is important information to use. In the process of gathering information needed image segmentation is used.

Image segmentation is one of the difficult problems in the field of image processing. Image segmentation is the process of labeling each pixel in an image so that pixels with the same label share certain visual characteristics[1]. Where image segmentation is a task that triggers thinking in medical image investigations because images contain complex boundaries and are often influenced by noise. FCM is the technique most often used in medical image applications [2][3].

In the medical world, many people have used images as a diagnostic tool even in Complementary and Alternative Medicine (CAM). One of the images used in CAM analysis is iris. Iris is like a body map - changes in certain organs are reflected in certain parts of the iris. The right iris shows the condition of the right side of the body, while the left iris reflects the condition of the left side of the body [4][5][6].

The exact relationship between the iris and body parts can be seen from the iris table. Iris map, dividing the iris surface into a number of segments, each segment is discussed with internal organs or systems [7]. The diagnosis of the iris is also known as iridology.

The main purpose of the iris segmentation process is to extract the iris texture from the surrounding structures and eliminate pupils and reflections from the iris texture. Over the years, several iris segment methods have been proposed with the aim of increasing recognition accuracy. In facilitating the segmentation process in the iris image with different sizes and iris positions. Jeong et al.[8] limits the iris window targeted by the Adaboost algorithm before applying the segmentation algorithm. In the Proena and Alexandre algorithm, iris and pixel sclera are classified based on local color features. On top of this, sclera pixels are used as a surrounding landmark for iris pixels [9].

In another approach, Tan et al. [10] classify the iris image into skin and iris: first, the brightest pixel is the skin and the darkest pixel is approved as iris. Unspecified pixels are then determined as skin and iris regions by calculating point-to-region distances and measuring the validity of connection connections between unassigned pixels and candidate regions.

Reviewing the geometrical shape of the iris in the form of a circle, this study segmented the iris using the Circular Hough Transform (CHT) method and the Fuzzy C-Means (FCM) algorithm. And also in this study only focuses on the part of Iris that can be seen, in other words, which part of the Iris is not hidden under the eyelid.

2. Method

Image segmentation is an important and challenging process of image processing [11][12]. Image segmentation techniques are used to partition images into meaningful parts that have similar features and properties. The main purpose of segmentation is to simplify and / or change the representation of images into something that is more meaningful and easier to analyze. Image segmentation is usually used to find objects and boundaries (lines, curves, etc.) in images [13].

In this study, iris segmentation was performed using a combination of CHT and FCM methods. Where the steps are taken as follows:

- The CHT method is used to search for the center point of iris and pupillary localization.
- While the FCM method is used to segment the iris with the outer border of the iris.

2.1. Circular Hough Transform

General Hough transform can be used to detect geometric shapes that can be written in parametric shapes such as lines, circles, parabolas, and hyperbolas [14][15]. Circular Hough Transform can be used to detect circles of known radii in an image. Circles are more easily represented in parameter space, compared to lines, because circle parameters can be directly transferred to the parameter space[16]. The circle equation can be written as an equation (1)

$$r^2 = (x-a)^2 + (y-b)^2 \quad (1)$$

Where r is the radius of the circle, a and b are the center coordinates. In parametric form, the points on the equation of a circle can be written as follows [17]:

$$x = a + rcos(\theta) \quad (2)$$
$$x = b + rsin(\theta) \quad (3)$$

When the angle θ sweeps across the full 360 degree range, the points (x, y) trace around the circle. Transformation is calculated by drawing circles from the radius given at each point on the edge drawing. For each point where the circumference of a circle drawn passes, the coordinates increase by 1.

2.2. Fuzzy C-Means

The FCM algorithm was first introduced by Dunn in 1973 and was developed by Jim Bezdek in 1981. FCM is a grouping algorithm that uses fuzzy concepts [18]. From a number of existing fuzzy clustering algorithms, FCM is the most popular algorithm because this algorithm is easy to use and accurate [1].

FCM assigns pixels for each category by using the fuzzy membership function, for example $X = \{x_1, x_2, \cdots, x_N\}$ represents an image with N pixels that are partitioned into c clusters, with x_i represents data. The FCM algorithm is an iterative optimization that minimizes the cost function defined in the equation (4) [19]

$$J = \sum_{j=1}^{N} \sum_{i=1}^{c} u_{ij}^{m} \left\|x_j - v_i\right\|^2 \tag{4}$$

With u_{ij} represents pixel membership x_j in the *i* cluster, v_i is the center of the i-cluster, $\|\cdot\|$ is the norm metric, and m is a constant, in this case, m = 2 is used [19].

When a pixel has a distance close to its cluster centroid, it will have a high membership value, while if a pixel has a distance that is far from a centroid it will have a low membership value. The fuzzy membership function can represent the probability that a pixel belongs to a particular cluster. In the FCM algorithm, the probability depends only on the distance between the pixels and each centroid. The membership function and cluster center are updated using the following formulas in equations (5) and (6):

$$u_{ij} = \frac{1}{\sum_{k=1}^{c}\left(\frac{\left\|x_j - v_i\right\|}{\left\|x_j - v_k\right\|}\right)^{2/(n-1)}} \tag{5}$$

and

$$v_i = \frac{\sum_{j=1}^{N} u_{ij}^{m} x_j}{\sum_{j=1}^{N} u_{ij}^{m}} \tag{6}$$

where $u_{ij} \in [0,1]$

Steps of the FCM Algorithm [20] :

1. Given data X=$\{x_1, \cdots, x_n\}$, $x_i \in R$, specified $c \in \{2,3,\cdots,n-1\}$, $m \in (1,\infty)$and initialization of the matrix $U^{(0)} \in M_{fc}$. M_{fc} is a fuzzy c-partition.
2. At the l[th] iteration, l = 0, 1, ..., calculated the vector c mean (centroid)

$$v_i^{(l)} = \frac{\sum_{k=1}^{n}\left(u_{ik}^{(l)}\right)^m x_k}{\sum_{k=1}^{n}\left(u_{ik}^{(l)}\right)^m}, \quad 1 \le i \le c \tag{7}$$

3. Updating $U^{(l)} = \left[u_{ik}^{(l)}\right]$to $U^{(l+1)} = \left[u_{ik}^{(l+1)}\right]$ using

$$u_{ik}^{(l+1)} = \frac{1}{\sum_{j=1}^{c}\left(\frac{\left\|x_k - v_i^{(l)}\right\|}{\left\|x_k - v_j^{(l)}\right\|}\right)^{\frac{2}{m-1}}}, \quad 1 \le i \le c,\ 1 \le k \le n \tag{8}$$

4. Iteration (steps 2 and 3) stops when $\left\|U^{(l+1)} - U^{(l)}\right\| < \varepsilon$ if it is not so then $l = l + 1$ and repeats from step 2.

2.3. *Performance Evaluation*

The performance of segmentation algorithms is generally measured in segmentation errors, which gives more segmentation capabilities than a test set. It is important to have an accurate assessment of testing errors, because it provides guidance on the selection of a reliable method and a method assessment[21].

Based on the confusion matrix, segmentation performance measurements can be calculated using sensitivity, specificity, and accuracy [22][23].

2.3.1 Accuracy, or the ratio of the correctly classified elements over all available elements can be calculated as follows:

$$Akurasi = \frac{TP+TN}{(TP+TN+FP+FN)} * 100\% \tag{9}$$

2.3.2 Sensitivity, Sensitivity measures the proportion of true 'positives' that are properly segmented. Sensitivity is also called true positive rate (TP rate), or recall. 100% sensitivity means that the segmentation method recognizes all positive pixels observed. Calculation of sensitivity as follows:

$$Sensitivity = \frac{TP}{(TP+FN)} \tag{10}$$

2.3.3 Specificity, Specificity measures the true 'negative' proportion that is properly segmented. 100% specificity means that the segmentation method recognizes all negative pixels observed. Calculation of specificity as follows:

$$Specificity = \frac{TN}{(FP+TN)} \tag{11}$$

3. Result and Discussion

Tests in this study were carried out with Intel Intel Core i7-8550U 1.80GHz (8CPUs) hardware processor specifications, with memory 8GB RAM and VGA 4GB. The data used were 30 images taken randomly from the UBIRIS v3 database.

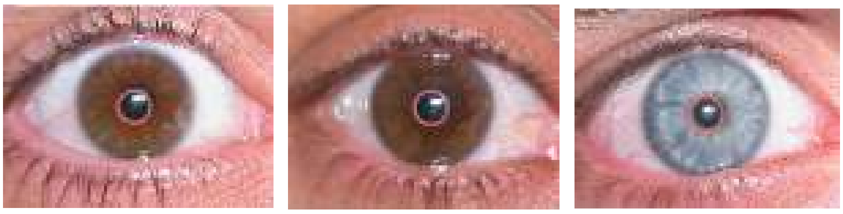

Figure 1. Results of pupillary localization by the CHT method

Figure 1 shows the results of determining the iris center point and pupillary localization using the CHT method. The test results show that the average running time for the thirty images is 1.1971 seconds. The results of measurements of sensitivity, specificity and accuracy are shown in Figure 2. So that the average value of sensitivity obtained is 99.5610; the average specificity value was 57.7103 and the average accuracy value was 90.5884%.

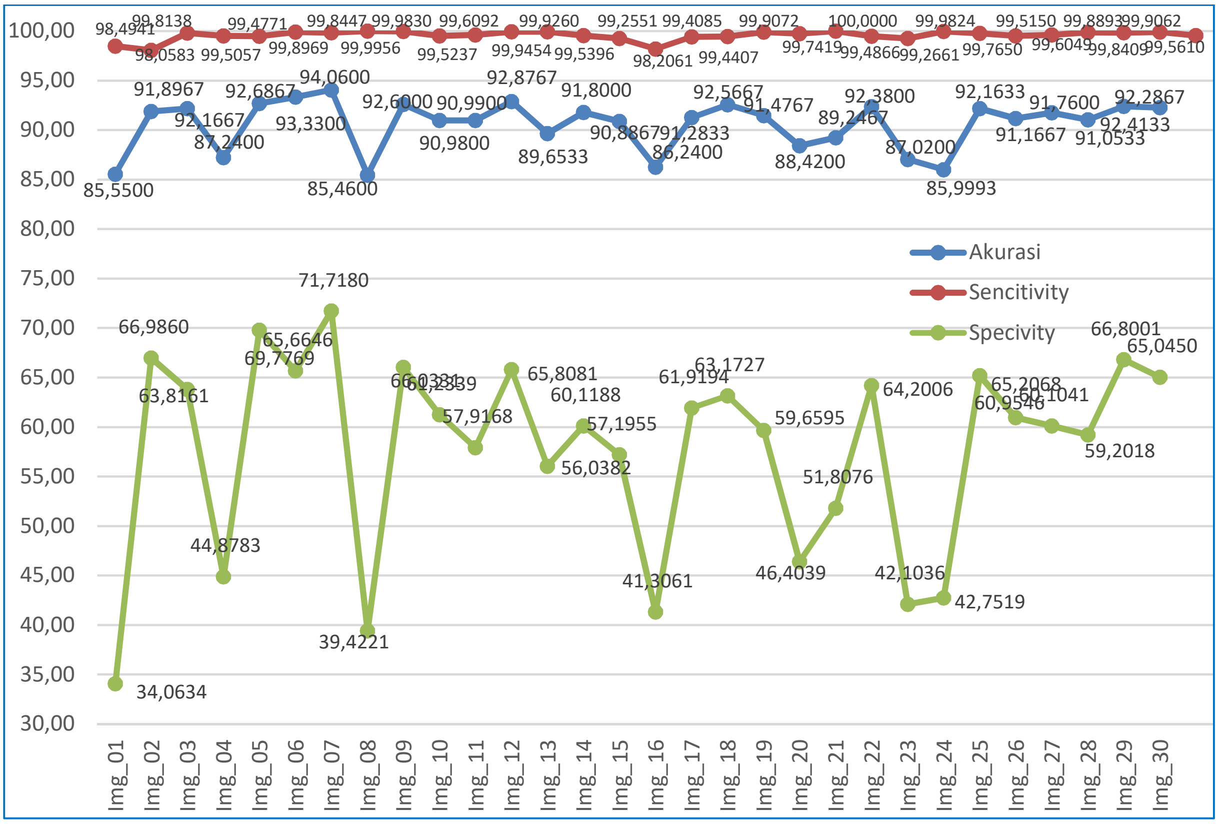

Figure 2. Value of accuracy, sensitivity and specificity of test results

Based on the test results, a combination of CHT and FCM techniques is good for segmenting iris images. Judging from the average specificity there needs to be an increase in the performance of CHT and FCM because CHT and FCM are still not good enough to detect wrong pixels.

4. Conclusion

Based on experiments, a combination of CHT and FCM techniques can be used for iris image segments. So far the combination of CHT and FCM has shown good results for the segmentation of iris images that do not have a lot of noise (for example iris areas that are not covered by the eyelids, the position of the pupillary flashlight on the iris). With an average sensitivity value obtained is 99.5610; the average specificity value was 57.7103 and the average accuracy value was 90.5884%.

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