GLAUCOMA DIAGONSIS FCM_TK ALGORITHM BASED ON FUNDS CAMERA

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Abstract: Glaucoma is considered one of the most important human eye diseases that causes loss of vision. The main objective of this paper is extracting the features from fundus image to evaluate and minimize the risk of Glaucoma. This evaluation based on the Cup-to-Disc Ratio (CDR) of a color retinal fundus image. Actually, CDR is the actual value for the evolution of the risk of Glaucoma. Features used to evaluate the Glaucoma risk are extracted by detection and segmentation process. In this paper a method is proposed for Glaucoma image classification. The proposed method is as follows: the features extracted by discrete wavelet transform (DWT) and then followed by Teager-Kiaser Energy (TKE) operator to improve the detection quality, then classification is done based on fuzzy clustering method. The results showed that the proposed methods succeeded to diagnose the Glaucoma disease with high accuracy compared with the other state of the art techniques.

Keywords: — Teager-Kaiser operator energy, Glaucoma, Gabor filter; SVM; K-means, discrete wavelet transform, Clusters.

1. Introduction

Image processing is considered one of the most important methods in medical images analysis. Computing analysis and image processing are the most practical and quickly methods which have used features and detection techniques until now. Moreover, Image processing has improved the detection and classifications methods based on some techniques such as the support vector machine, neural network and also discrete wavelet transform. Research has presented the detection of dangerous diseases such as "Glaucoma". Glaucoma is considered one of the most dangerous eye diseases. It is the primary cause of blindness. One of the causes of this disease is the rising of eye pressure and the vision will lose when sustaining this rising pressure for a long time [1].

The most recent research has introduced some of the ideas for detection of the Glaucoma disease to help the doctors in the diagnosis. Some of the researchers have focused on the types of the filter before detection such as in [2]. In [2], authors have presented Gabor transformation as a method for extraction some of the features to help in Glaucoma diagnosis. They have extracted a number of features included mean, variance, skewness, kurtosis, energy, Shannon, R ényi, and Kapoor entropies. The performance of this method has achieved by highest values, an average accuracy of 93.1%, and sensitivity of 89.7% and specificity of 96.2% using 23 features with Support Vector Machine (SVM) classifier.

In [3], authors have applied method which focused on optic disk and cup segmentation technique. This method was based on the online database and also, they have updated the system continuously with more clinical ground-truth images.

Moreover, authors in [4] have achieved a novel computational for automatic detection for retinal image analysis and displayed the features of glaucoma and also achieved accurately especially in prediction result. Further, they have proved multi-class categorization training accuracy of 100% in classifying 45 images. Furthermore, there was a lot of reviews have described the degree of eye diseases and the types of dangerous diseases such as in [5].

The authors have applied survey with the percentage of spreading of the eye diseases and they have displayed the types of these diseases.

In some researches, authors have focused on the classification of glaucoma based on the neural networking and they have tried to improve the method to be more accurate such as in [6]. Actually, in [6] authors have tried a new technique for detection based on the artificial neural network. The simulation on MATLAB has approved good accuracy in the detection of glaucoma based on Cup to Disc ratio of retinal fundus images. Further, authors in [7] have achieved a new method for diagnosing glaucoma but only just on suspected glaucoma. The method has proved 93.5% as the accuracy of detection of suspected glaucoma. Fuzzy logic has considered one of the most technique is very useful in detection and classifications

In [8], authors have applied fuzzy logic method a new expert system for diagnosing glaucoma. They have applied Randomized Hough Transform to extract some of features parameters and also have achieved a classification of these features based on "Fuzzy logic" technique. The accuracy of this method has compared to other methods has achieved more than 94% especially in prediction.   In [9], authors have applied new segmentation technique to extract features of glaucoma called Ocular cup. They achieved   high exactness in segmentation process. Furthermore, Teager-Kaiser energy operator has played important role in prediction and feature extraction techniques especially in biomedical system. Some authors as in [10], authors approved that Teager-Kaiser energy operator can be used in detection processing.

In [10], authors have approved the features extraction from ECG signal based on fuzzy cluster based on applying of Teager-Kaiser energy operator. In [11], authors have achieved new method to improve detection based on robust system that which consisted of pre- processing of the signal with Teager-Kaiser operator also, they have approved good accuracy.

In this paper the proposed algorithm is focused on how to extract the features of glaucoma using wavelet transform followed by Teager-Kaiser energy operator. On the other hand, thresholding is used before segmentation. Classification of features based on fuzzy cluster method. The research work of this paper is organized as follows: Sec 2 explains Teager-Kaiser operator energy, the proposed methodology presented in sec3, Results and discussions are presented in sec4

2. Teager-Kaiser energy operator (TKEO)

Teager-Kaiser (TK) operator was proposed by Teager to track the energy in speech signals.Teager-Kaiser (TK) operator is a nonlinear quadratic operator on Newton's law of motion used to measure the real physical energy of a system. The total energy was combined, both potential and kinetic. By using The TK energy operator. The energy needed to generate can be estimated, TKEO is used to analyze single component signals from an energy point of view [10], TKEO can be defined in discrete and continuous domain.
The main advantage of this operator is the ability to compute the energy functions of quite complicated function, these functions can be defined as products of the simplest function
The discrete TK energy operator, Ψ is defined in time domain as:

$$\psi(x_n) = x_n^2 - x_{n+1}x_{n-1} \tag{1}$$

For an oscillatory signal
$$x_n = A\cos(\omega_n + \phi) \tag{2}$$

The o/p of TK energy operator given by (li et al.2007)

$$\psi(x_n) = A^2 \sin^2(\omega_n) \qquad\qquad (3)$$

The equation above is expressed the energy of an oscillatory signal it deepened on amplitude and frequency values. The nonlinear operator has several features such as: the ability to track instantaneously, varying special patterns, efficiency and simplicity. There are several applications have been derived for one-dimensional and two-dimensional signal processing [11].

3. Methodology

The proposed system consists of three main stages: the pre-processing stage, features extraction stage, and the classification process. Fig (1) shows the block diagram of the system each block will be discussed briefly in the following sections**.**
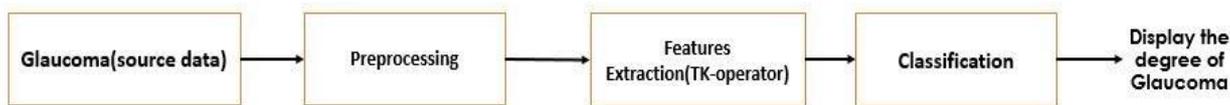

Figure 1: The main block diagram of proposed system

3.1 Glaucoma database input stage

The main objective of the proposed system is how to diagnosis the glaucoma, updated the glaucoma using the system continuously with more clinical ground-truth images. The proposed method focuses on optic disk [12]

3.2 Preprocessing stage

In this stage, Gabor filter will be applied for denoising the images based on equation (4). The filter has played an important role in this case because the fundus camera in some of the images had some of more brightness and lights so, Gabor filter have tried to enhance the image to be more clearly than before.

$$g_e(x) = \frac{1}{\sqrt{2\pi\sigma}} e^{\frac{-x^2}{2\sigma^2}} \cos(2\pi w_0 x) \qquad\qquad (4)$$

The pre-processing stage has included the segmentation process and actually, the segmentation process has achieved by the thresholding method
Otsu thresholding method have approved as the best method for image segmentation [13].

3.3 Feature extraction stage

This process has divided into two stages: First stage is how to extract features based on discrete wavelet transform. Second stage is how to improve this stage of feature extraction using Teager-Kaiser operator energy (TK).
Actually, discrete wavelet transform has played an important role in the extraction process. DWT is applied on the pre-processed image   based on equation (5) [14].

$$\text{DWT }(m,k) = \frac{1}{a}\sum_{n=0}^{N=1} s(n) g\left(\frac{k-b}{a}\right) \qquad\qquad (5)$$

Where s(n) is the binary segmented image, (a,b) are the scaling parameters, m is the decomposition level, $g(\cdot)$ is the mother wavelet function and N is the number of features.

The operator Teager-Kaiser has been used in classification using fuzzy cluster method and also in prediction technique [10, 15].

3.4 Classification stage

In this stage, the degree of glaucoma is classified based on fuzzy clustering method [14]. The fuzzy cluster method is applied and approved. The equation of fuzzy cluster is as shown in equation (7) [16-21].

The main operation of classification is applied based on the following steps:
First step is to determine the clusters after partitioning the data into fuzzy groups where the vector of data x_i=1, 2,…n, then, the second step is determining the center of each cluster c_i=1,2,….c, and then, determining the membership function from the following equation (6) :

$$\mu_{ij} = \frac{1}{\sum_{k=1}^{c} (d_{ij}/d_{kj})^{2/m-1}} \qquad (6)$$

After that, we have to determine the objective function from:

$$\sum_{i=1}^{c} J_i = \sum_{i=1}^{c} . \sum_{i=1}^{c} \mu_{ij}^{m} d_{ij}^{2}$$

Where i=[1,2,..,c] is the number of clusters selected from data points n,j is the number of objects $m \in [1,\infty]$, μ_{ij} is the member function for object j and cluster i, and $d_{ij}=\|c_i - x_j\|$ is the Euclidean distance between c_i and x_j.

Finally, Compute the new c-fuzzy cluster using the following equation (7) [18]:

$$c_i = \frac{\sum_{j=1}^{c} \mu_{ij}^{m} x_j}{\sum_{j=1}^{c} \mu_{ij}^{m}} \qquad (7)$$

3.5 The main algorithm:

The block diagram, given in Figure (1), is programmed using Python. In the following, the general algorithm of the system is described by the flow chat as in Figure (3). Figure 2 is the pseudo code for the proposed algorithm.

Start
Apply PIL (Python Library)to import our database test or images of fundus camera.

Apply Gray scale level for colored images. Create

Thumbnails (from PIL).

Convert to grayscale level.

Applying Gabor filter (a Gaussian kernel) and we have used Matplotlib . Extract the

segmentation in separate image.

Applying DWT functions and apply TK- our structure code

Applying FCM (Fuzzy logic functions based on C-means) End

Figure 2: pseudo code for the proposed algorithm

The cup-to- Disc ratio (CDR) is measured to estimate the progression of glaucoma, the optic disc may have an amount of cupping or flat. Glaucoma is affected on CDR where it produced pathological cupping of the optic disc [22, 23] ,when glaucoma increased ,the cup maximized till it full the disc area .the normal value of cup- to disc ratio is 0.3 if it is increased ,The patient will suffer from the glaucoma .
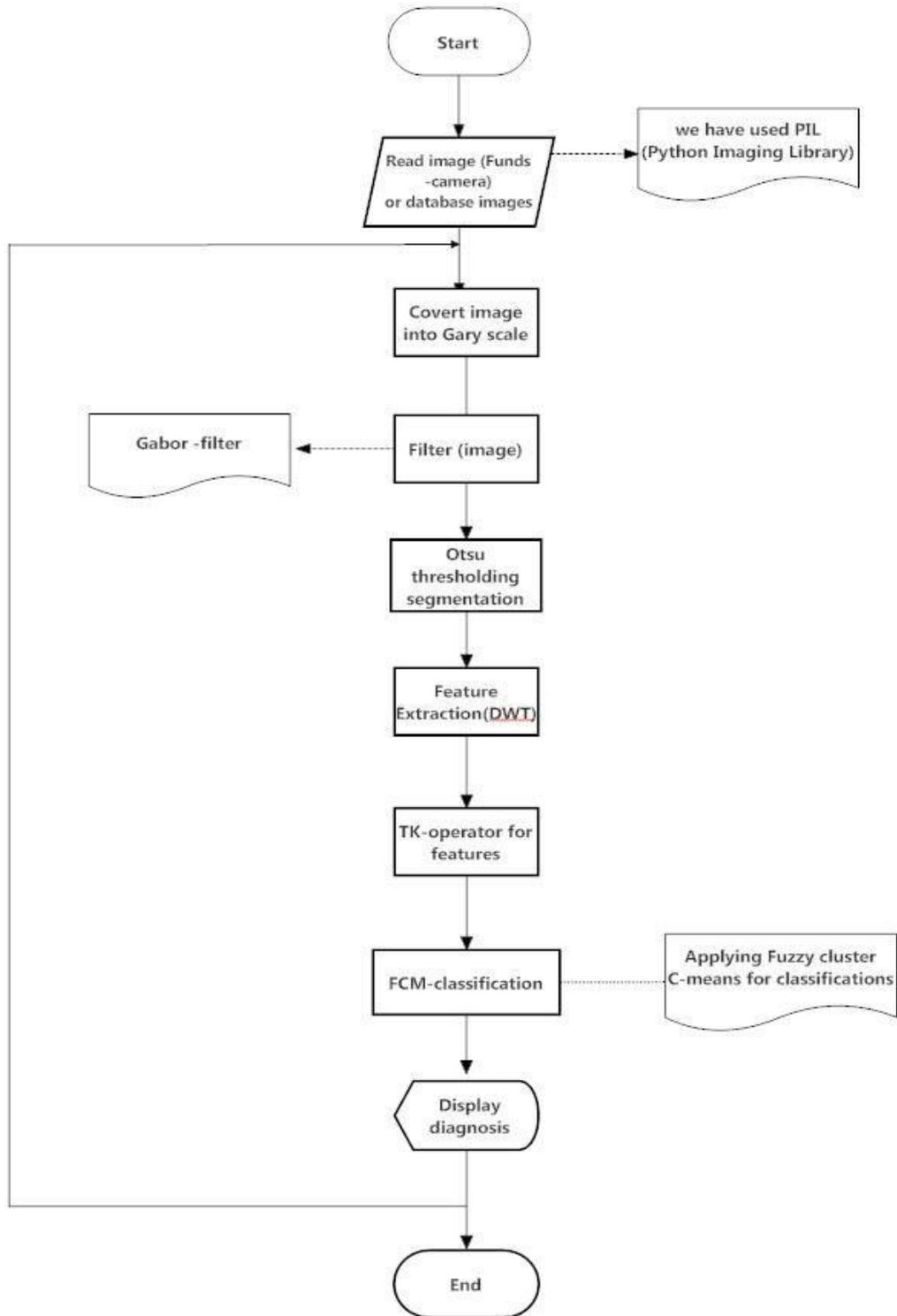
Figure 3: The Flow chart of system

4. Results and Discussion

The proposed methodology is based on two categories the first was based on -online database, and the other was based on fundus camera images. From pervious sections, Gabor filter method was applied to filter images glaucoma especially from fundus camera. The segmentation processes were applied based on thresholding technique and in this approach a set of calculations is done. The figures from figure (4) to figure (6) shows the process of segmentation before the feature extraction method. Figure (3) indicates the image before gray level, in figure (6) after calculations the optic disc is displayed and the diameter of optic disc can be determined. Increasing of diameter of optic disc is indicated that the patient suffers from glaucoma actually, in the feature extraction method DWT with TK- operator was applied to improve the extraction technique as the pervious researches in the other applications. Furthermore, we have compared our work after classification with the others work and the result showed that the proposed technique achieved more than 95% classification accuracy using   TK- operator with fuzzy cluster operation method.
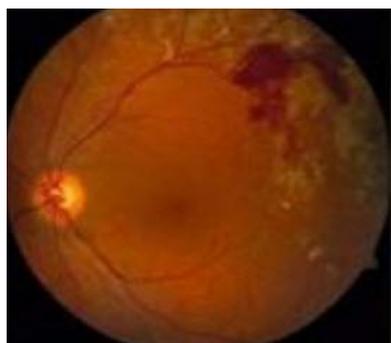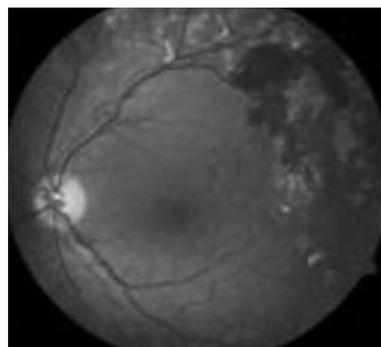

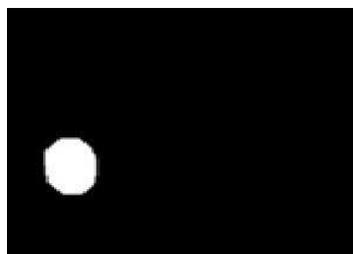Figure 4: Image before gray level

Figure 5: Image in gray scale

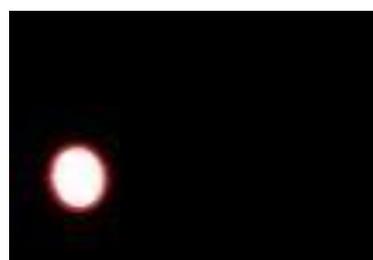Figure 6: Image after Threshoding and
and display Morphological operation

Figure 7: Image after calculation
the optic disk diameter

	Proposed method	Glaucoma detection using cup to disc ratio [6]	image processing algorithms for early glaucoma diagnosis.[8]
accuracy	95%	93.5%	94%
CDR	0.29	0.34	-

In this paper diagnosis of glaucoma is based on the CDR is done, the system was tested on dataset of 120 images and the accuracy is high when compared to others, i.e. Proposed methods succeeded to detect the Glaucoma disease with high accuracy.

The accuracy can be defined as the percentage of correctly classified instances (TP + TN)/(TP + TN + FP + FN). where TP, FN, FP and TN represent the number of true positives, false negatives, false positives and true negatives, respectively

Confusion Matrix

		Predicted	
		ROI	Background
Ground Truth	ROI	TP	FN
	Background	FP	TN

Accuracy = (TP + TN)/(TP + FN + FP + TN)
Over segmentation = FP / (TP + FP + FN)
Under segmentation = FN / (TP + FP + FN)

		Predicted	
		Optical Disc	Background
Manual Segmentation	Optical Disc	2019	1102
	Background	3507	80988

Accuracy = (2019+80988)/ (2019+1102+3507+80988) = 83007/87616 = 0.94739
Over segmentation = 3507 / (2019 + 1102 + 3507) = 0.529
Under segmentation = 1102 / (2019 + 1102 + 3507) = 0.16626

5. Conclusion and future work

In the proposed system, algorithm is implemented to improve the diagnosis process of glaucoma by extracting the features using DWT which followed by Teager-Kaiser operator energy and that was helped in classification technique and the system is achieved a good accuracy when fuzzy cluster method is applied. The proposed system can be used with doctor, it can minimize the human error and diagnosis the glaucoma. In future we can enhancement the accuracy, and apply the system to diabetic person

6. Data Availability

Our work in this paper have based on two sources of data as described before one of them is an online clinical database such as in [12] and the other is fundus camera images.

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