**Automatic Diabetic Detection System based on Retina Using an artificial intelligent system**

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**Abstract.** The Diabetes measurement level usually uses the blood sugar test method, where patients have to fast for eight hours before the test. Glucose tests generally only require a small sample of blood using a sterile needle from the glucometer. The sufferer may feel pain due to a pin prick. However, not all diabetics can do glucose tests regarding having a great fear of syringes, especially in older patients. Therefore, in this work, the diabetic detection system with the retina is an alternative for early checking of patients without having to take a sample of the blood patient. The Contrast Limited Adaptive Histogram Equalization (CLAHE) is used to extract the signal, in which the extracted the retina image is later used as input to the artificial neural network (ANN) based identifier. The retina image parameters are compared and classified to identify the human retina that are intended to be performed. The results of the computer simulation show that this technique produces good accuracy 100% and 96.6%, for training and testing phases, respectively.

1. **Introduction**

Diabetes is one of several non-communicable diseases (PTM) which is the leading cause of death in Indonesia[1]. Diabetes checks usually use the blood sugar test method, where patients must fast eight hours before the test. Glucose tests generally only require a small sample of blood using a sterile needle from the glucometer. The sufferer may feel pain due to a pin prick. However, not all diabetics can do glucose tests regarding having a great fear of syringes, especially in older patients. This diabetic detection system with the retina is an alternative for the early checking of patients without having to take a sample of the sick blood to be taken[2].

An automatic diabetic detection based on a retina recognition system has been developed to detect the diabetes of the patients. The morphology method od retina processing has been developed to detect the diabetes level based on countras[3]. By using Gray Level Co-occurrence Matrix as a feature extraction method and Support Vector Machines as a method for recognition of brain signal activity[4]. The accuracy of the training and the accuracy of the proposed system testing are 95.93% and 91.07%, respectively [4]. Other experiments that recognize the diabetes recognition system by applied Neural Network to identify the level of diabetes which have accuracy of 96%(5).

Based on the previous study, in this work, An automatic identification of diabetes based on the retina is developed. The system uses CLAHE for feature extraction techniques. Binary classification is based on a Neural network algorithm as applied as a recognition system of the brain activity patterns. The significance of this work is observed the better intelligent identification system suitable for the brain recognition system. The effectiveness of the proposed system based on binary classification of Neural Network ANN is evaluated experimentally.

2. **Proposed System**

This paper considers diabetic detection based on the Retina identification system. The other technique is an artificial neural network (Ann) which is a very popular pattern machine for the fruit classification system. The multilayer perceptron (MLP) network with a backpropagation learning algorithm is the most well-known of ANN [1]. A block diagram of the conventional Retina identification system is shown in Figure 1. There are two important phases on the diabetic identification system, namely training and testing phases respectively. In the training phase, the system is trained to classify the retina data of the eyes, which are taken by the camera and processed in the Personal Computer (PC). The retina image is digitized and some of them are carried out to create a template for the retina pattern of the normal and diabetic condition and stored in the memory. In the testing phases, the system is tested with the new data, the data which are not applied to train the system.
Figure 1. Block diagram of conventional speaker identification

The overall model of the proposed system for the ANN-based retina identification system as depicted in Figure 1. The training phase consists of three important steps, capturing the data, feature extraction, and identification system. Capturing the data is a process of taking the data using a special camera called Fundus. The data is capturing and convert to the matrix form to use as an input to the identification system. The digitized retina image signal, that has the process of image processing and data selection, passed through the processing stages from which Contrast Limited Adaptive Histogram Equalization (CLAHE) features are extracted and passed through the ANN learning algorithm for both training and testing. Image processing and data selection process called feature extraction is used to perform a feature vector of the retina image that will be used as input to the system. In this work, the feature extraction method which applied are consist of image processing and data selection. In image processing, data applied to the three important steps, namely Pre-processing, optic disk elimination, and segmentation, respectively. There is three important parts classification system, namely image preprocessing, feature extraction, and pattern matching [7].

Image preprocessing is the process of converting a continuous image signal to a discrete form. It consists of uploading images into the PC, convert the color image into the gray image, and determine the edge of the image (segmentation of the image). Feature Extraction is to extract a sequence of feature vector of the image signal that will be used as input to the system. Many techniques are used to extract the image such as wavelet transform [8], Principle Component Analysis (PCA) [9], Discrete Wavelet Transform (DWT) [10] and Fast Fourier Transform (FFT) [11]. In this research, a Fast Fourier Transform (FFT) is used to extract the fruit image.

Pattern matching is to measure the similarity between unknown feature vector and feature vector that is saved on the memory of the system. The model of the fruit image is constructed from the extracted feature of the fruit image signal. The pattern matching algorithm compares the incoming fruit image to the reference model and scores their difference called as distance. The distance is used to determine the unknown pattern. There are two types of models: stochastic models and template models. In stochastic models, the pattern matching is a probabilistic result, such as HMM, Ann, and SVM. For template models, pattern matching is deterministic such as dynamic time warping (DTW) with K-nearest neighbors (KNN).

2.1 Convert the image into the grayscale
A grayscale image as shown in Figure 2, is an image that has one channel value at each pixel, the grayscale image consists of three kinds of colors namely red, green, and blue. All images will turn gray and white black, an example for 8-bit grayscale is the number of possible values \(2^8 = 256\), the color and the maximum value is \(2^8 - 1 = 255\), the following possible colors of 0-255 are the values for each red, green, and blue.
2.2 Fungsi Imadjust
The adjust function is a function used to transform the intensity of an image that has a grayscale. This function provides the gamma parameter option which defines the shape of the function between coordinates (a, c) and (b, d). if the gamma value is more than 1, then a concave rises, if less than 1, a concave falls, as shown in Figure 3.

![Figure 3. adjust function](image)

2.3 CLAHE
A histogram is a diagram that displays the number of pixel sizes and the number of frequency sizes with gray levels in an image. The histogram has 2 axes namely the X-axis and the Y-axis. The Y-axis is the pixel size value while the X-axis is the frequency value. CLAHE is used to enhance and modify contrast in an image, as shown in Figure 4.

![Figure 4. Contrast Limited Adaptive Histogram Equalization (CLAHE)](image)
2.4 Median Filter
A median filter is a filter used to refine images and reduce noise. The median filter is a median that has nonlinear properties, the median filter is sought by sorting the number of pixels with a predetermined mask area, as shown in Figure 5.

![Median Filter](image)

Figure 5. Median Filter

2.5 Eliminasi Optical Disk
Optical Disk is the part of the retina, which is the optical center of the conscious place as the meeting point of the nerve of the eye. Optical disk elimination is a step in analyzing retinal images for disease diagnosis, as shown in Figure 6. This optical disk erase must ensure the right position of the circle, optical disk has an important role to be erased because it has a high contrast value, otherwise this circle will be detected along with the exudate.

![Optic Disk Location](image)

Figure 6. Optic Disk Location

2.6 Segmentation
Segmentation is one of the important processes in image processing. The results of this segmentation will be used for further high-level processes such as the classification process and object identification process. Segmentation itself serves to simplify and / or change the presentation of an image to something easier to analyze, as shown in Figure 7.
2.7 Artificial Neural Network (ANN) Approach

Artificial Neural Network (ANN) is a system that resembles the workings of the brain and can also be trained like the brain in humans. After training or commonly called neural network training, ANN can provide output in the form of identification results [12]. By looking at the amount of input-output in ANN, ANN can find quite accurate results. ANN has also been used in the engineering control field for its identification system and also for its control system [13].

In Figure 8 above, ANN has three main layers, namely the input layer, hidden layer, and the output layer. The input layer functions to enter object data input and carry it for further processing in the hidden layer. In the hidden layer, data will be processed again using artificial neurons. The output layer functions to receive data from the hidden layer and output it as output data in this case in the form of identification of fish species.

3. Experimental Result and Discussion

3.1. Experiment setup

Figure 9 shows the proposed system description, the system basically consists of two main components, namely camera (Fundus) capturing for the retina, laptop for processing the retina image processing and identification system. A Fundus camera is commonly used for capturing the retina image, the computer system is used as an image processing system and recognition of the person’s retina image. The capturing image is processed in the image-based recognition system which will recognize the retina where the person has a diabetic or normal condition. A personal computer (PC) of 2.1 MHz Intel Core i3 processor equipped with an image card is used for speaker recognition system implementation. In this system, all of the image data processing and diabetics recognition algorithms are implemented in the PC using MATLAB and its toolboxes [15].
The overall process of the proposed system for diabetic detection based on retina recognition system is shown in Figure 9. A digital image processing is passed through a preprocessing procedure. The preprocessing step is used to spectrally flatten the signal and making less susceptible to finite precision effects at a later stage. The preprocessing image is then used as input to the feature extraction steps. Feature extraction is the process of converting the raw image into the feature vector which will be used as input for the classification system. There are two important phases in the proposed system, namely training phases, and testing phases. In the training phase, the system is trained to develop a retina based model of the diabetic and normal retina, respectively, a template for the model pattern stored in the memory. In the testing phase, the input data will match with the model to recognize the retina.

In this work, the data used are provided by the STARE (Structured Analysis And of The Retina Dataset) & HRF (High-Resolution Fundus) database. The data consists of two different conditions; Diabetic and normal condition [16]. To evaluate the effectiveness of the proposed diabetes and normal retina recognition system, the diabetics data is applied. The database consists of two different images, which are diabetics and normal image retina, which are illustrated in Figure 10 and Figure 11, respectively.

The retina and normal image convert the green part of the image to the grayscale, as shown in Figure 12 and Figure 13, for diabetics and normal retina, respectively. The CLAHE method is then applied to improve the contrast of the image, as shown in Figure 14 and Figure 15, respectively. The median filter is applied to reduce the noise, as shown in Figure 16 and Figure 17, for diabetics and normal retina, respectively. The segmentation is applied to the filtered image to detect the exudate which indicates the retina involves the diabetic disease, as shown in Figure 18 and Figure 19 for both diabetic and Normal Retina, the results of the exudate is then applied as 8 by 8 matrices using GLCM function. To obtain the CLAHE coefficients, the 8 by 8 coefficients are used. These methods improving the contrast of the image segments in which resulting in the matrix 8 by 8 matrix from the extracting method.

**Figure 9.** identification system of the *Retinopathy Diabetic*
Figure 10. Retina with Diabetic

Figure 11. Normal Retina

Figure 12. Gray diabetic retina

Figure 13. Gray normal retina

Figure 14. CLAHE method for retina image

Figure 15. CLAHE method for normal image
3.2. Training and classification

To evaluate the effectiveness of the proposed system, the 21 data of each of the diabetic and normal retina which a total of 42 data respectively are performed to train the system. As discussed above the training phase is applied in order of getting the model each of the cases, diabetes, and normal retina respectively. The 30 other data for normal and diabetes retina are evaluated. Each of the images of the retina is modeled based on the CLAHE technique into eight by eight CLAHE parameters. The training data involve 21 retina data each of the normal and diabetes condition. Therefore, the training data involve 248 parameters for all two kinds of normal and diabetes retina. The other brain signal activity, 248 parameters are applied as testing data.

The ANN-based classification is applied to perform identification of processes using the binary classification method. The ANN-based multilayer perceptron (MLP) network with the backpropagation learning algorithm has been used in this paper and it contained a hidden layer. The numbers of neurons in the input, hidden and output layers are 11, 11, 11 respectively. The ANN gives 100% accuracy for training phased. This means the ANN has perfectly classified all of the two kinds of retina normal and diabetes, respectively. Furthermore, the results of analysis with another retina data testing stage produce 96.67% classification rate which is similar to the result obtained with ANN.

The testing classification rate results have shown that the performance of the ANN-based pattern matching technique has better performance in terms of training and testing accuracy.

4. Conclusion

An ANN-based diabetic recognition system has been proposed and discussed in this paper. This technique is developed based on image processing and intelligent system, the method based on ANN. The accuracy of the ANN-based retina image recognition was found good result. It was also clear, from our computer simulation results, that the proposed method requires much less training time than the existing one. These results identify whether normal or
diabetic based on the retina image is considered. In the future, it is needed to clarify the performance and complexity with increasing number of human retina images to prove its usefulness in the real system.

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