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Classification of diabetic retinopathy using artificial neural network

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Abstract

Diabetic retinopathy (DR) is one of the complications caused by diabetes which shows abnormalities symptoms in retinopathy and is a major cause of loss of vision. The screening by an ophthalmologist is the only way to prevent this problem. This work, aim to develop classification of diabetic retinopathy algorithm by using Artificial Neural Network (ANN) for work together with telemedicine project in Thailand. First, using mathematic morphology and image processing techniques to extract features that are factor of DR. Then, input into ANN to grading the symptoms of DR**.** When comparing the performance of proposed software with diagnosis of ophthalmologist found that, its diagnosis have accuracy of 98.89%, sensitivity of 99.26%, specificity of 97.77% and positive predictive values at 99.26%. Thus, proposed software can helps to increase occasion of screening diabetes patients, especially in remote area where lack of ophthalmologists or specialist to read fundus images. Suitable for telemedicine system. Moreover, also can improve accuracy of ophthalmologists's diagnosis.

Keywords: Diabetic retinopathy, Artificial neural network, Image processing, Telemedicine

1. Introduction

Diabetic retinopathy is a complication caused by diabetes which shows abnormalities symptoms in retinopathy, and is the leading cause of vision loss in patients with diabetes in the middle-aged to elderly patients. In worldwide, found diabetics 371 million people and about 280 million are in risk group. Predictable that in year 2030 will increase to 500 million. [1] For Thailand, in year 2012 found patients who died with diabetes 7749 cases, or an average of 22 cases per day. Northeastern part of Thailand found diabetics ranked second, next from Bangkok [2]. Typically, an eye examination by an ophthalmologist only to realize that there are developed of diabetic retinopathy. So detection in the early stages of illness is appropriate and necessary in order to prevent loss of vision. The screening can reduced the risk of vision loss in the long term to patients by as much as 50%. [3-4] Nowadays, screening requires trained ophthalmologists to spend a lot of time for manual analysis and diagnosis. Also, risk of error in various high [5]. Development computer-aided for preliminary screening and grading severity of diabetic retinopathy will allows more patients in remote areas and lack of ophthalmologist can access to screening.

Telemedicine or remotely treatment is the way to use telecommunications and IT Technology to help in diagnosis, treatment and patient care. By always aiming to bring health services to reach remote areas and lack of specialists and health services. Many countries around the world have developed telemedicine system for use in health service. In Thailand, some areas are taking advantage of application and technologies that are widely used in daily life, such "google hangout", the service which available on Google+ that many people use to talk with friends, update status and post comment, even in different and remote locations. With this advantage, Health promotion hospital "Nong Samong" in Udomsap district, which shortage of diseases specialist. Especially, chronic diseases used this application as telemedicine for consult with specialist doctor on duty at Wang Nam Kheaw hospital by talking via google hangout in form of video and audio chat like making a video conference over the internet 3G. Thus, this concept can be set to telemedicine pilot project in Thailand. The main purpose of this paper is to present automatic software that can work with telemedicine's concept for future established in Thailand.

2. Materials and methods

2.1 Image acquisition

In this work, we use 600 color fundus images, divide into two sets, 420 images for training a machine learning program (MLP) include 105 normal fundus images and groups of DR fundus images with early stage, moderate stage and severe stage, which each group contain of 105 images and 180 images used to test purpose software consist of 45 normal fundus images and 135 DR fundus images, with 45 images for each stage. All digital color fundus images are taken from fundus camera model KOWA nonmyd α-DIII at general hospital of 2 provinces in northeast part of Thailand and

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diagnosed from ophthalmologists to compare results from purpose software. All images are collected at 500x752 pixels in 24 bit with JPEG image format (.jpg) using the lowest compression ratio as shown in Figure 1.

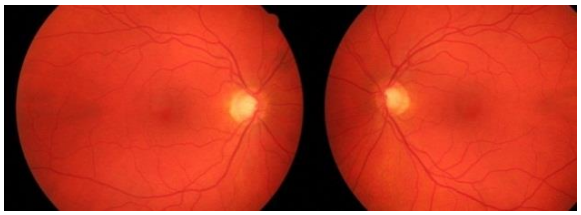

Figure 1 Typical normal and abnormal images from KOWA nonmyd α-DIII

2.2 Method

2.2.1 Pre-processing

For color fundus images used in this work consist of sub-procedure as follow:

1. Enhanced features of color fundus images before processing. Start by choosing the green channel for increase the intensity (Contrast enhancement) to obtain images with maximum clarity. Next, reduce image noise by (Median filtering) and adjust the brightness of the image distributed appropriately to increase the contrast by Histogram Equalization.

2. Locate the edge of the eye, Optic Disc, Fovea and eliminate out of images in the process of image segmentation by means of Candy Method, the result from this step are shown in Figure 2.

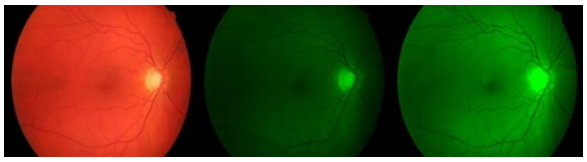

Figure 2 Shown result: (L) original image (C) green channel (R) after contrast-enhancement

2.2.2 Feature extraction

In this work, selected features 5 features of color fundus images in order to take into consideration the severity of diabetic retinopathy such as Blood Vessels, Exudates, Microaneurysms, and Texture-Identification(Entropy and Homogeneity), by using basic process principle of morphology such closing, opening, dilation and erosion.

Blood vessels detection: Areas of regenerate capillaries within the retina is one of basis pathological that used to identify abnormalities caused by DR. Because of the complications of diabetes, when body has elevated blood sugar rise for a long time. It can cause the disorder of microvascular such microvascular occlusion, causes a lack of blood and oxygen to the retina and encourages creation of new blood vessels in the retina abnormally. In this work, initial conducted with pre-processing by converting color fundus images, adaptive distribution of light in images by adaptive histogram equalization, then eliminating optical disk out of the image. Follow with image segmentation, noise reduction. Finally, eliminating the circle surrounding fundus image to keep only the blood vessels in the retina as required.

Microaneurysms (MA) detection: MA is part of the capillary fleshed out, seen as a small red spot about 15-60 microns due to vascular are weakness in the early stage of DR. Detection of MA is important in screening patients because more number of MA, more severity of DR. Our method to find out MA by using grayscale images for detect a ring around the image and create mask of optical disk. This way, we use green channel for procedure of edges detection with canny method. Then, eliminates border around image to achieve a small, encloses area at MA. The remaining space which is not associated with method will be removed by AND Logic. After that, eliminate exudates out of the image. Finally, eliminate part of areas of blood vessels and optical disk to get image of the desired, MA.

Exudates detection: Leakage of fluid and protein from abnormal blood vessels in the retina or Exudate (Ex) be expressed in the manner of a point/brighter ambit white-yellow, in contrast to the retina with varies size and shape according to the severity of DR. This procedure used grayscale processing. Fist, starts from feature enhancements process and then apply techniques of image processing, mathematic morphology analysis to eliminate blood vessels and identify areas of exudates.

Texture identification: Texture analysis is a technique widely used for measures the intensity of the pixels in a grayscale image. In this work, use two texture properties entropy and homogeneity as input data for ANN to identification stage of DR. Entropy indicated the distribution or confusion of things in grayscale image. It start to measured after applying Adaptive Histogram Equalization to green channel of fundus image. While Homogeneity is measured by applying Gray-Level Co-Occurrence Matrix to grayscale image.

2.2.3 Artificial neural network implementation

A process that continued from feature extraction each of factors to indicate the occurrence of diabetic retinopathy. Then fed the data into neural network to recognize (Training) which will lead to the ability to detect (Classification) automatically. The process of updating network weight, after input data format for training into network for each time, Output from network will be compared with expected values. Then, calculate error vector value. After that, sent error vector value back to network to modify the next weight. The characteristics of neural networks that used in this work are shown in Figure 3.

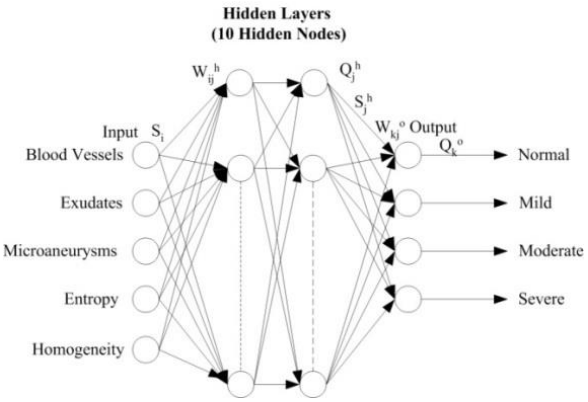

Figure 3 Show the characteristics of neural networks that are used in this work

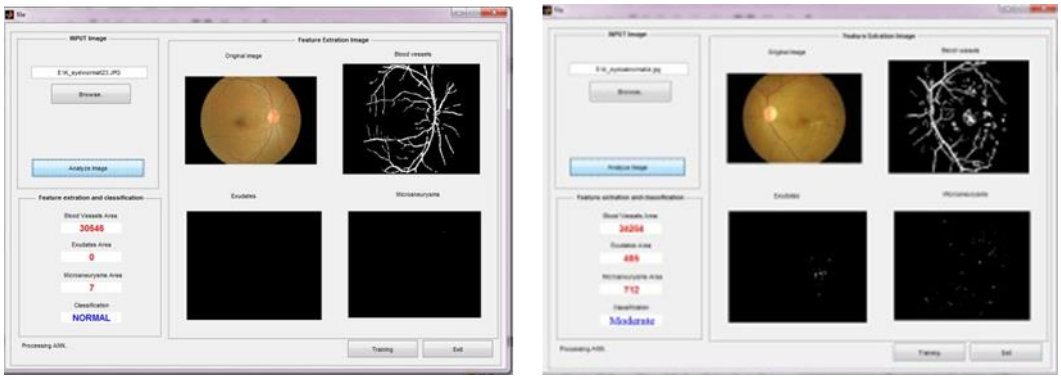

Figure 4 Shown example of result screen

Table 1 Sensitivity, specificity and positive predictive values

Class	***N of data training***	***N of data testing***	***N of correctly classified***	***Accuracy (%)***
Normal	105	45	44	97.77
Mind	105	45	45	100
Moderate	105	45	45	100
Severe	105	45	44	97.77
Total	420	180	178	98.89

Table 2 Sensitivity, specificity and positive predictive values

TP	***TN***	***FP***	***FN***	***Sensitivity***	***Specificity***	***Positive predictive values***
134	44	1	1	99.26%	97.77%	99.26%

2.3 Graphic user interface implementation

This step aim to increase the ease of use for computer aided for preliminary screening and grading severity of diabetic retinopathy to user. Focuses on the medical staff/those responsible for screening patients with diabetes in risk group of diabetic retinopathy which maybe no computer expertise to use it. Using principles of graphical user interface design and developed by GUI Matlab, which designed and developed the interface is focused on ease of use and easy to understand. User can select fundus image's file to import from data sources by click “Browse” button in left side of screen. Then, press the "Analyze Image" button located below "Brows" button to analyze the input image. After that, original fundus image is shown in the display window "Original Image". When complete each sub-procedure of feature extraction, results will shown in display window of each feature and show each value calculated in left below screen side. Result of analysis and grading severity of DR will showing at the lowest left of the screen. Figure 4 shown screen result of each type of fundus image input, both normal case and abnormal case and grading DR stage in abnormal case.

3. Results

To finding sensitivity, specificity and positive predictive value which are significant values to indicate how system developed are proper in deployment. Sensitivity refers to the probability of positive test among the subjects with the condition while Specificity refers to the probability of a negative test among the subject without condition. The equations are as follows:

$$\text{Sensitivity} = \frac{TP}{TP+FN} \quad (1)$$

$$\text{Specificity} = \frac{TN}{FP+TN} \quad (2)$$

$$\text{Positive predictive value} = \frac{TP}{TP+FP} \quad (3)$$

While TP mean true positive, FP mean fault negative, TN mean true negative, and FN mean fault negative.

After training and testing our purposed software by propose algorithm of classification diabetic retinopathy using ANN, the results of classification can show in Table 1 while Table 2 show the results of sensitivity, specificity and positive predictive values for all stages of DR classified.

After testing performance of proposed algorithm, the results show that it can provide accuracy at 98.89%, and the sensitivity of screening and grading the severity of diabetic retinopathy was 99.26%. Thus, confirming the ability of its use in screening patients actually.

4. Discussion

Diabetic retinopathy is the leading cause of blindness. Due to increasing number of diabetic retinopathy cases, ophthalmologists are experiencing serious problem to automatically extract the features from the fundus images for diagnosis and grading severity of diabetic retinopathy. This work focus on study and develop algorithm for classification of diabetic retinopathy by using ANN, with simple and friendly screen for user whom may not an ophthalmologist or whom not get a computer skill. Based on the results of the classifier, this proposed algorithm is able to achieve a fairly accurate classification for all stages include normal fundus images with an accuracy of 98.89%, sensitivity of 99.26%,

specificity of 97.77% and positive predictive values at 99.26%.

5. Conclusions

From the results of performance testing of software prototype of purposed algorithm, all testing values can confirm that presentation software can be actually works. Moreover, ophthalmologists can use this software prototype as an adjunct result tool for screening. In addition, Can be used in telemedicine project to increase chance of patients in remote areas where lack of ophthalmologists to access diabetic retinopathy screening. For better performance might be improved by increasing more training input images with fine tuning the threshold values on the images and more features extracted.

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7. References

[1] Huang ES, Basu A, O'Grady M, Capretta JC. Projecting the future diabetes population size and related costs for the U.S. Diabetes Care 2009;(32):2225-2229.
[2] Bureau of Policy and Strategy, Ministry of Public Health [Internet]. [cited 2015 August]. Available from: http://bps2.moph.go.th/.
[3] Osareh A, Mirmehdi M, Thomas B, Markham R. Automated Identification of Diabetic Retinal Exudates in Digital Colour Images. British Journal of Ophthalmology 2003;87:1220-1223.
[4] Sinthanayothin C, Boyce JF, Cook HL, Williamson TH. Automated localization of the optic disc fovea, and retinal blood vessels from digital colour fundus images. British Journal of Ophthalmology 1999;83:231-238.
[5] Ruamviboonsuk P, Wongcumchang N, Surawongsin P, Panyawatananukul E, Tiensuwan M. Screening for diabetic retinopathy in rural area using single-field, digital fundus images. Journal of Medical Association Thai 2005;88:176-180.