Automatic Detection of Proliferative Diabetic Retinopathy with Hybrid Feature Extraction Based on Scale Space Analysis and Tracking

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***Abstract*-Feature extraction is a process to obtain the characteristics or features of an object where the value of the features will be used for analysis in the next process. In retinal image, extraction of blood vessels' characteristics can be used for detection of proliferative diabetic retinopathy (PDR). Retinal blood vessels' features can be obtained directly with segmented image and with additional spatial method. For PDR detection, we need the suitable method that can produce maximum feature representation. This paper proposed hybrid feature extraction using a scale space analysis method and tracking with Bayesian probability. The result of the retinal images classification from STARE database using soft threshold m-Mediods classifier shows the best accuracy of 98.1%.**

***Index Terms* - Feature extraction, soft threshold m-Mediods, proliferative diabetic retinopathy, retinal blood vessel segmentation, scale space analysis, tracking.**

INTRODUCTION

Feature extraction is a process to get the characteristics of an object where the value of the features will be used for the analysis in the next process. In retinal image, extraction of blood vessels' characteristics can be used for detection of proliferative diabetic retinopathy (PDR). PDR is a disease affecting the eye that change the structure of blood vessels in the retina. Through feature extraction, retinal blood vessels can be differentiated into normal and abnormal which can be used for the detection of PDR.

Retinal vessels' features can be obtained using properties of a retinal image and segmented image, but it will be difficult for width and direction features. Hence spatial method is applied to obtain width and direction features. Scale space analysis method with isotropic undecimated wavelet transform (IUWT) is used to produce retinal image segmentation [1]. Width and direction features are obtained through the spatial domain using tracking methods [2]. After feature extraction, then performed classification to detect PDR. Retinal image data has multimodal distribution that requires special treatment in the classification. Soft threshold m-Mediods can perform classification in multimodal data which suitable to use in the retinal image classification [3].

There are other studies that did PDR detection but used different methods of feature extraction, such as with 2D Continuous Wavelet Transform [3], the combined standard line operator and the modified line operator [4], as well as Gabor wavelet and active contour method [5]. This study proposed a hybrid feature extraction based on scale space analysis and tracking with soft threshold m-Mediods classifier for the automatic detection of PDR.

PROPOSED METHOD

This section explains the method which is used in this study. Flowchart of system using the proposed method is shown in Figure 1.

I. Preprocessing

Image preprocessing is performed using thresholding to separate between retinal object and background into a binary image.

II. Isotropic undecimated wavelet transform

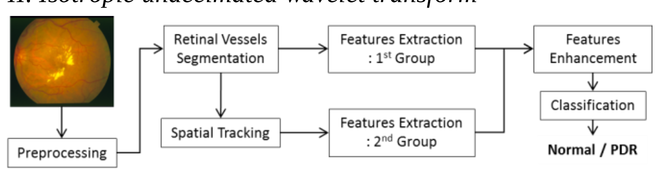

Figure 1. PDR Detection System's Flowchart.

Isotropic undecimated wavelet transform (IUWT) is a segmentation method using scale space analysis. In the two-dimensional or higher dimensions, filters, scaling function and wavelet function should be close to isotropic.

III. Spatial tracking with bayesian probability

Tracking starts with initialization to determine a pair of edge point of the blood vessel. At each iteration, tracking is performed with semi-ellipse dynamic window which is shown in Figure 2. Parameters such as vascular edge point, center point, direction and diameter of blood vessels are always stored. Iteration stopped when a blood vessel whose width is less than 1 pixel. At iteration k, a combination of two candidate points χ is selected from a set of candidate points Y_k of semi-ellipse window as the

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next edge points. Edge points selection is based on a combination of points that have the greatest Bayesian probability using Equation (1) where y_i is pixel intensity of a candidate point.

$$P(Y_k|\chi) = \prod_{i=1}^{N_k} P(y_i|\chi). \quad (1)$$

III. Feature extraction: 1st group

In the 1st group, features is obtained using properties of retinal and segmented image. The features are area, energy, mean gradient, standard deviation gradient, mean intensity, intensity variation, vessel segment, and vessel density.

IV. Feature extraction: 2nd group

To obtain vascular segment width and vascular direction variation, spatial tracking with Bayesian probability is performed on segmented image.

V. Multivariate m-Mediods classifier

Classifier method used is soft threshold m-Mediods. Before, local fisher discriminant analysis (LFDA) is applied to improve the representation of feature space. Learning vector quantization (LVQ) is used for modeling and recognition. Soft threshold m-mediods applied with more than one LVQ that can be referred as mediods. Class label is obtained using voting based on all LVQs output label. Several parameters is determined at this stage, such as the number of dimension reduction on LFDA, as well as number of hidden nodes and learning rate value on LVQ.

Experimental Results

There are two type of evaluation in this study, evaluation for vascular segmentation with IUWT and for PDR detection with multivariate m-Mediods. For each evaluation, accuracy is determined using Equation (2),

$$accuracy = \frac{TP+TN}{TP+FP+FN+TN}, \quad (2)$$

where TP, TN, FP, and FN is obtained using Table 1.

TABLE 1. CONFUSSION MATRIX FOR ACCURACY

Actual	**Predicted**	
	Yes	No
Yes	TP	FN
No	FP	TN

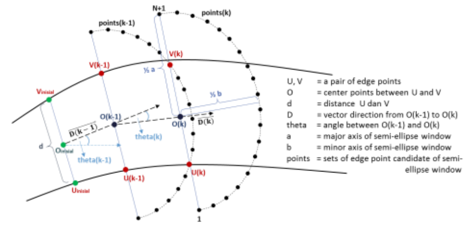

Figure 2. Semi-ellipse Window for Tracking.

I. Evaluation for vascular segmentation

Segmented image is evaluated against ground truth image. The results of the vascular segmentation evaluation with retinal image from DRIVE database generate the accuracy value of 95.04% with ground truth comparison.

II. Evaluation for PDR detection

Evaluation for PDR detection is performed with 24 train and 53 test data from STARE database to produce best accuracy. Based on our experiments, the optimum value of parameters such as number of dimension reduction on LFDA, number of hidden nodes and learning rate value on LVQ is 3, 8, and 0.1 respectively. Using the optimum value of these parameters, soft threshold m-Mediods classifier can produce the best accuracy of 98.1% for PDR detection. This result is better than study in [1] which has accuracy of 94.3% and [3] which has accuracy of 97%.

References

[1] Wilda Imama Sabilla, Chastine Fatichah, Rully Soelaiman, “Implementasi Pengklasifikasi Segmen Vaskular Retina Mata dengan Metode M-Mediods Multivariat”, *JURNAL TEKNIK POMITS* Vol. 2, No. 1, 2014.

[2] Yi Yin, Mouloud Adel, Salah Bourennane, “Retinal vessel segmentation using a probabilistic tracking method”, *Pattern Recognition*, vol. 45, pp. 1235-1244, 2012.

[3] Shehzad Khalid, Anam Tariq, M. Younus Javed M. Usman Akram, “Detection of neovascularization in retinal images using multivariate m-Mediods based classifier,” Journal Computerized Medical Imaging and Graphics, vol. 37, no. 5-6, pp. 346-357, September 2013.

[4] R.A. Welikala, J. Dehmeshki, A. Hoppe, V. Tah, S. Mann, T.H. Williamson, S.A. Barman, “Automated detection of proliferative diabetic retinopathy using a modified line operator and dual classification”, Computer Methods and Programs in Biomedicine, vol. 114, pp. 247–261, May 2014.

[5] Israr Ul Haq, Usman Akram, Yoshifumi Saijo, “Automated Detection of New vessels for Classification of Proliferative Diabetic Retinopathy”, *the 2nd International Conference on Intelligent Systems and Image Processing 2014 (ICISIP2014)*, pp. 35-38, 2014.