Hypertensive retinopathy identification through retinal fundus image using backpropagation neural network

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Hypertensive retinopathy identification through retinal fundus image using backpropagation neural network

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Abstract. Hypertension or high blood pressure can cause damage of blood vessels in the retina of eye called hypertensive retinopathy (HR). In the event Hypertension, it will cause swelling blood vessels and a decrese in retina performance. To detect HR in patients body, it is usually performed through physical examination of opthalmoscope which is still conducted manually by an ophthalmologist. Certainly, in such a manual manner, takes a ong time for a doctor to detetct HR on aa patient based on retina fundus iamge. To overcome ths problem, a method is needed to identify the image of retinal fundus automatically. In this research, backpropagation neural network was used as a method for retinal fundus identification. The steps performed prior to identification were pre-processing (green channel, contrast limited adapative histogram qualization (CLAHE), morphological close, background exclusion, thresholding and connected component analysis), feature extraction using zoning. The results show that the proposed method is able to identify retinal fundus with an accuracy of 95% with maximum epoch of 1500.

1. Introduction

Hypertension is a disease that spreads through out the human body in various forms. This happens because the blood pressure exceeds the normal limit and could cause damage in retina. Impaired retina due to hypertension is known as hypertensive retinopathy (HR) [1]. HR is long-term damage to the retina because high blood pressure has accumulated in the eye for several years even with patients who control their blood pressure with drugs [2].

Based on the results of the Basic Health Research in 2013, Number of people with Hypertension were declining from 31.7 percent to 25.8 percent in the span of 6 years. Existed research showed 25.8 percent of total victims are people with age of over 18 and that men have higher possibility to have hypertension in productive years. However, this do not apply to people in their 50s or above, since in this range of age, woman tend to have higher rates of possibility in experiencing this disease.

HR causes damage to blood vessels in the eye. The severity of retinal damage (retinopathy) is described on a scale of I to IV**.** In stage I, usually not found symptoms. In stage IV, it is marked with swelling of the optic nerve (papilledema) and macula (the center of the vision on the retina), which cause a decrease eye vision function. At an advanced stage, blood can enter the retina. Retinal spots are damaged by lack of blood supply and fat will accumulate in the retina. In addition to experiencing impaired vision, the patient will feel a headache.

Usually the examination of this disease is performed with physical examination and examination using funduscopy. It is also used a brightly shining ophthalmoscope device used to see the narrowing of blood vessels and excess fluid entering the blood vessels. Inspection is done manually and takes a long time. In addition, the analysis of the funduscopic is also still manual it allows for errors in consist of further action on the patient.

2. Identification of Problems

Hypertensive retinopathy (HR) occurs due to high blood pressure and causes damage to retina. In the event of Hypertension, the blood vessel will swell and decrease the performance of retina. In general, identifying hypertensive retinopathy disease through fundoscopy is still done manually by ophthalmologists. Therefore, a method is needed to help the ophthalmologist in diagnosing hypertensive retinopathy automatically so as to obtain better examination results than manual diagnosis.

3. Previous research

Quinn and Krishnan aims to segmentation of blood vessels in diabetic patients retinopathy and hypertensive retinopathy. In the preprocessing stage, use the green channel because it can show the vessels brighter than the background image. Then the equalization histogram improves the image contrast by changing the intensity of the image. To display an image that consists of edges (edges) using curvelet transform. Edge detection uses a modified Top-Hat transform with MSE Morphology. To eliminate the wrong edges that are not part of the blood vessels using morphological opening by reconstruction. Then CCA and Length Filtering to eliminate the wrong edge remnants accurately. Up to the detection of blood vessels can be done less than a minute [3].

Agurto et al through analysis of digital color fundus image obtained characteristic of hypertensive retinopathy (HR) such as AVR, silver/copper wiring, tortuosity and vessel abnormalities. These characteristics are used as inputs for classification using linear regression classifier to detect HR. The results of this research achieved an accuracy rate of 80% [2].

Nugroho et al to detect exudates on colored fundus images in diabetic retinopathy, the early stage of improving image quality by using contrast-limited adaptive histogram equalization (CLAHE) on green channels. Red channels are also used to detect and remove optical disks in imagery using median filtering and thresholding. In the segmentation stage using K-means clustering. The feature extraction stage uses GLCM and Lacunarity. For the classification using the Naive Bayes method achieved an accuracy of 92.13% [4].

Purandare and Noronha through fundus image analysis to classify diabetic retinopathy. In the preprocessing stage, use adaptive histogram equalization (AHE) to eliminate inappropriate sections of the background. Uses 2-D Gabor Wavelets for segmentation of blood vessels. The feature extraction stage uses gray level co-occurrence. SVM is used to classify normal retina or diabetic retinopathy. The accuracy achieved is 92.55% [5].

Jadhav, A., D'Cruz, J., Chavan, V., Dighe, A. and Chaudhari, J for detecting lung cancer using a CT Scan (Computer Tomography Scanner) image. In the preprocessing stage, the RGB image in the transformation becomes the grayscale and dark image, then the image enhancement process is done. A Genetic algorithm is used for image character extraction. Backpropagation Neural Network is used to classify images of lung cancer or not based on tumor size and stage of cancer [6].

Nurrahmadayeni is the identification of hypertensive retinopathy disease through retinal fundus image. Stages performed prior to identification is the process of image extraction feature extraction using two methods namely fractal dimension and invariant moments. Fractal dimension using Box

Counting algorithm. Then use the Probabilistic Neural Network method for normal retinal classification or hypertensive retinopathy. This research resulted in an excellent identification rate of 100% accuracy [7].

Sandri is the identification of retinoblastoma through retinal fundus image. Stages performed are image processing, image quality improvement and image characteristic extraction using gray level co-occurrence (GLCM). Backpropagation neural network method is used for normal retinal classification or retinoblastoma. This research resulted in an identification rate of 90% accuracy [8].

4. Research methods

The identification of hypertensive retinopathy in this research consists of several steps that begin with retinal fundus images are consist of normal image and hypertensive retinopathy image that is obtained through Structure Analysis of the Retina (STARE). This data will be used as training data and test data, followed by green channel process on the retinal fundus image to show the blood vessels and retinal structures more clearly. CLAHE is used to obtain better contrast results so that the blood vessels and retinal structures can be seen more clearly and reducing noise. Morphological close eliminates optical disk and background. Background exclusion is the process of subtraction between the result of CLAHE and morphological close. Furthermore, segmentation by using the thresholding process converts image to binary image. when thresholding process, there are still the objects size less than 70

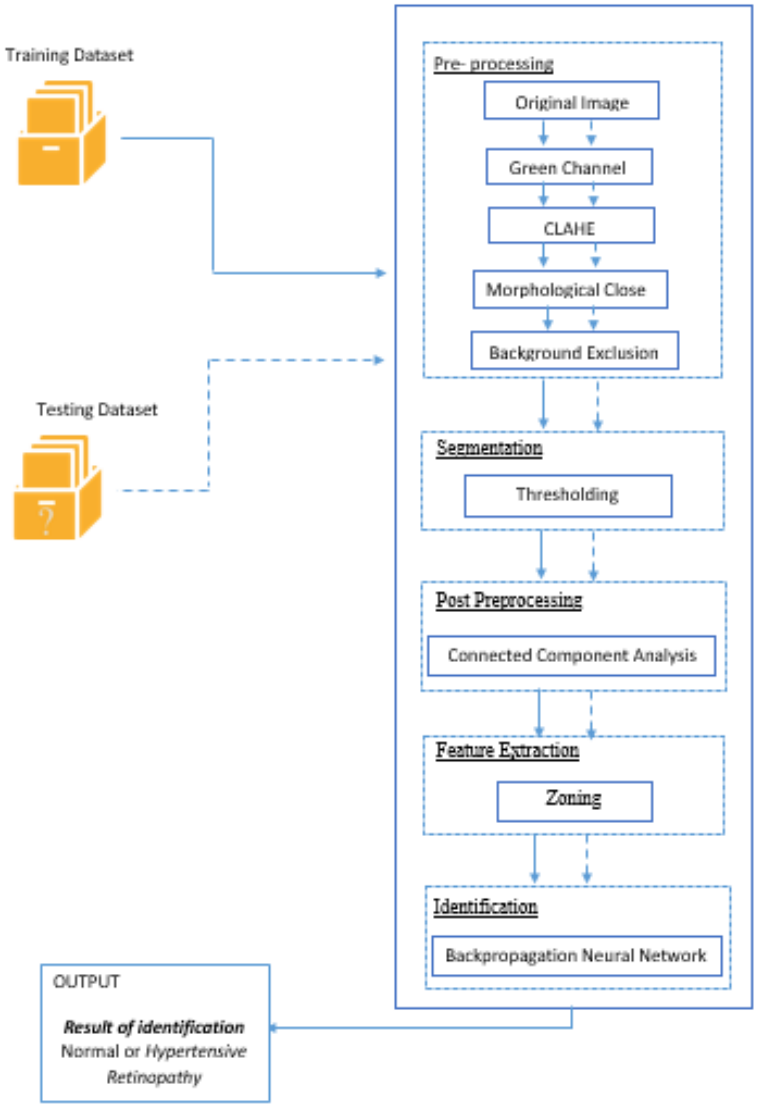

Figure 1. General Architecture

piksel, using connected component analysis eliminates them. The feature extraction using zoning and backpropagation neural network was used as a method for retinal fundus identification

Each step will be described in detail in the following sections. The methodology of this research can be seen in the general architecture of Figure 1.

4.1. Prepocessing

4.1.1. Green Channel . The early stages use the green channel because it has the best light reflections that can produce significant image information about blood vessels and retinal structures more clearly than red channels and blue channels. Green channel is a composition of red (red), green (Green) and blue (Blue). Can be calculated by the following equation:

$$I(x, y) = 0.R + 1.G + 0.B = G$$

4.1.2. CLAHE. The next stage of image contrast enhancement is using the Contrast Limited Adaptive Histogram Equalization (CLAHE) technique. CLAHE is an improved version of the previous method of Adaptive Histogram Equalization (AHE). CLAHE is used to obtain better contrast results so that the blood vessels and retinal structures can be seen more clearly, reducing noise problems and assigning a histogram boundary value

4.1.3. Morphological Close. The next stage extracts (splits) the background and optical disk by using morphological close because the object does not include the characteristics to be extracted. Morphological close used is dilation and erosion. Dilation process (image object thickening) then continued erosion process (separation of image object). Dilation process can be calculated by the following equation:

$$D(A, B) = A \oplus B = \{ x : B_x \cap A \neq \emptyset \}$$

The erosion process can be calculated by the following equation:

$$E(A, B) = A \ominus B = \{ x : B_x \cap X \}$$

4.1.4. Background Exclusion. The next stage of separation of blood vessels and retinal structures from the background is called background exclusion. The stages apply subtract operations between CLAHE image results and morphological close images to obtain blood vessels and retinal structures separate from the background.

4.2. Segmentation

4.2.1. Thresholding. The next stage is thresholding to obtain a binary image that is worth 0 and 1 (Black and White). Can be calculated the equation:

$$g(x, y) \begin{cases} 1 \; if \; f(x, y) > T \\ 0 \; if \; f(x, y) \leq T \end{cases}$$

4.3. Post Prepocessing

4.3.1. Connected Component Analysis. The next stage is to remove objects that are not blood vessels that is by using a connected component analysis. Objects that are eliminated are objects that have a size of fewer than 70 pixels and are considered not blood vessels. Connected component analysis is a technique that can be used to classify regions or objects in digital images. This technique utilizes connectivity pixel theory in the image. The pixels in the region are called connected (there is connectivity or connectivity) when obeying the pixel rules. This pixel rule exploits the properties of the pixel sizes, the existing pixels linked by neighboring relationships. There is two connectivity that can be used that is 4-connectivity (4-connected neighbors), and 8-connectivity (8-connected neighbors). 4

connectivity (4-connected neighbors) can be seen in Table 1. 8-connectivity (8-*connected neighbors*) can be seen in Table 2.

Table 1. 4 connectivity (4-*connected neighbors*)

	P (x-1, y)	
P (x-1, y)	P (x, y)	P (x, y+1)
	P (x, y+1)	

Table 2. 8 connectivity (8-*connected neighbors*)

P (x-1, y-1)	P (x, y-1)	P (x+1, y-1)
P (x-1, y)	P (x, y)	P (x+1, y)
P (x+1, y+1)	P (x, y+1)	P (x+1, y+1)

4.4. Feature Extraction

4.4.1. Zoning. Zoning is a method that borders the region into a MxN size. Image is divided into multiple zones, where each zone will generate a feature value by counting the highest white pixel count. At this stage, the image size of 700 x 605 pixels will be divided into 10 columns and 10 rows to get 100 zones representing 100 features. In each zone, the pixel size used for this zoning method is 520 pixels in size. the process of zoning method in feature extraction process on retinal fundus image include:

- Calculate the number of white pixels of each zone from zone Z1-Z100
- Specify the zone that has the highest white pixel count
- Calculate the feature value of each zone of Z1-Z100 with the Equation

$$Feature\ Value\ Zn = \frac{Z_n}{Z_{highest}}$$

range $1 \leq n \leq 100$

Zoning calculations include:

- The number of white pixels each zone among others Z1 = 90, Z15 = 140, Z40 = 200, Z80 = 180
- The zone that has the highest white pixel count is Z40 = 200
- Value Feature of each zone include:

Z1 = 90/200 = 0.45
Z15 = 140/200 = 0.7
Z40 = 200/200 = 1
Z80 = 180/200 = 0.9

Rounding on the feature value of each zone with the provision if:

$$Z_n < 0.5,\ Z_n = 0$$
$$Z_n \geq 0.5,\ Z_n = 1$$

This rounding is done so that the resulting feature value will be in the form of binary value that will be used as an input value is the process of classification in the next stage. So from the zone calculation is obtained the feature value of *Z*1 = 0, *Z*15 = 1, *Z* 40 = 1, *Z*80 = 1.

From the calculation of zoning, the feature extraction stage will generate 100 features that will be used as the input value in the classification process in accordance with figure 2.

0	0	1	1	0	0	1	1	0	0	0	1	0	1	1	0	0	1
Z1	Z2	Z3	Z4	Z5							Z40		Z80				Z100

Figure 2. Feature Extraction Value using Zoning

4.5. Classification

4.5.1. Backrpopagation Neural Network. After getting the feature value on feature extraction process using Zoning, the next step is image classification process using Backpropagation Neural Network method. The stages are as follows: design phase backpropagation Neural Network architecture, backpropagation training stage and backpropagation testing phase. Can be calculated by the following equation [9]:

1. initialization

$$\left(-\frac{2,4}{F_i}, +\frac{2,4}{F_i}\right)$$

2. Activation (Feed Forward)

$$y_j(p) = sigmoid\left[\sum_{i=1}^{n} x_i\,(p).w_{ij}\,(p)\right]$$
$$y_k(p) = sigmoid\left[\sum_{i=1}^{m} x_{jk}\,(p).w_{jk}\,(p)\right]$$

3. Training Weights

$$\delta_k(p) = y_k\,(p) - y_{dk}\,(p)$$
$$\Delta w_{jk}(p) = \alpha.y_j\,(p).\delta_k\,(p) - \mu.\Delta w_{jk}\,(p-1)$$
$$w_{jk}\,(p+1) = w_{jk}\,(p) - \Delta w_{jk}\,(p)$$
$$\delta_j(p) = \left[\sum_{k=1}^{m} \delta_k\,(p).w_{jk}\,(p)\right].y_j\,(p).\left(1 - y_j\,(p)\right)$$
$$\Delta w_{ij}(p) = \alpha.x_i\,(p).\delta_j\,(p) - \mu.\Delta w_{ij}(p-1)$$
$$w_{ij}(p+1) = w_{ij}\,(p) - \Delta w_{ij}(p)$$

4. initialization

5. Conclusions and Recommendations

The conclusions that can be taken based on testing the identification system of hypertensive retinopathy disease through retinal fundus image using Backpropagation Neural Network are as follows:

- Identification of retinal fundus image can be done by using backpropagation neural network as classification method according to the specified target with accuracy value reaching 95%..
- The selection of backpropagation neural network parameter values have an effect on the result accuracy. In parameter testing at backpropagation neural network parameter, the test provides an accuracy of 95% at the maximum value of epoch 1500.

References

[1] Faheem M R and Muizzuddin 2015 Diagnosing Hypertensive Retinopathy through Retinal Images *Biomed. Res. Therapy* **2**(10): 385-388.

[2] Agurto C, Joshi V, Nemeth S, Soliz P, Barriga S 2014 Detection of Hypertensive Retinopathy Using Vessel Measurements and Textural Features *2014 36th Annu. Int. Conf. IEEE Eng Med. Biol.* pp. 5406–5409.

[3] Quinn EA and Krishnan KG 2013 Retinal Blood Vessel Segmentation using Curvelet Transform and Morphological Reconstruction *Int. Conf. Emerging Trends Comput. Commun. Nanotechnol. (ICECCN)* pp. 570-575.

[4] Nugroho HA, Oktoeberza KW, Adji TB and Najamuddin F 2015 Detection Of Exudates On Color Fundus Images Using Texture-Based Feature Extraction. *Int. J. Technol.* **2**: 121-129.

[5] Purandare M and Noronha K 2016. Hybrid System for Automatic Classification of Diabetic Retinopathy using Fundus Images. *Online Int. Conf. Green Eng. Technol. (IC-GET)* pp. 1-5.

[6] D'Cruz MJ, Jadhav MA, Dighe MA, Chavan MV and Chaudhari JL 2016 Detection of Lung Cancer Using Backpropagation Neural Networks and Genetic Algorithm. *Int. J. Adv. Res. Comput. Commun. Eng.* 5(4): 963-967.

[7] Syahputra M F, Nurrahmadayeni, Aulia I, Rahmat R F 2017 Hypertensive retinopathy identification from retinal fundus image using probabilistic neural network *International Conference on Advanced Informatics, Concepts, Theory, and Application*

[8] Sandri W E 2017 *Identifikasi Retinoblastoma Menggunakan Backpropagation Neural Network*. Skripsi. Universitas Sumatera Utara.

[9] Negnevitsky M 2005 *Artificial Intelligence: A Guide to Intelligent System. 2nd Edition. Pearson Education Limited: Upper Saddle River.*

[10] Dataset Structured Analysis of the Retina http://www.ces.clemson.edu/~ahoover/stare/.