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The Application of HAAR Wavelet and Backpropagation for Diabetic Retinopathy Classification Based on Eye Retina Image

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A B S T R A C T

Diabetic Retinopathy is a disease that attacks eyes retina and can cause blindness. The severity of Diabetic Retinopathy consists of four; they are; normal, Diabetic Retinopathy Non-proliferative, Diabetic Retinopathy Proliferative, and Macular edema. In this research, author proposes a new strategy for Diabetic Retinopathy can be grouped by combining HAAR wavelet method and backpropagation. The number of data used were 612 images. The images size 2304x1536, 2240x1536 and 1440x960. The feature extraction of digital image used was HAAR wavelet at red image, green, and blue at level 1 and level 4 at subband LL and grouping with backpropagation with learning rate 0,1; 0,01 dan 0,001; the division percentage of training data and test data were 70:30, 80:20, 90:10 and 95:5, the value of MSE used was 10-6, epoch maximum 100.000 iteration. The results of this research is the highest test accuracy obtained is 56,25% with image size 2440x1448, HAAR level 4th and the percentage of comparative training data and test data 95:5, Learning rate 0,1;0,01 and 0,001. Thereby, HAAR wavelet algorithm cannot identify the feature of diabetic retinopathy and the decomposition process will eliminate much information from diabetic retinopathy.

Keywords: Backpropagation, Diabetic Retinopathy, Eye Retina Image, HAAR Wavelet, RGB

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1. Introduction

The position of Indonesia as a country with diabetes explained by Prof. Dr. Sidartawan Soegondo in 2005 that Indonesia is at number four as the country with many cases of diabetes. He conveyed that fact based on data of WHO (World Health Organization) about diabetes cases in 2000 which are India with number of cases 31,7 million, China with number of cases 20,8 million, United States of America with number of cases 17,7 million, and Indonesia with number of cases 9,4 million people. According to WHO, the number of diabetics in all over the world is 143 million. This number will increase doubled in 2030 and 77% will occur in developing country like Indonesia (Pangaribuan, 2016).

One of the consequences of diabetes mellitus disease complication is diabetic retinopathy which is the disease that attacks eye retina and can cause blindness (Sabrina and Buditjahjanto, 2017). Diabetics retinopathy starts from weak or the distruction of capillary obtained at eyes retina, then blood leaks and then thickening occurs, bleeding, and large thickening. That causes vision becomes blur until finally blindness occurs (Gitasari, Hidayat and Aulia, 2015). The features of diabetic retinopathy are neovascluration, soft exudates, hard exudates, mikroneurisma and hemorrhages (Kauppi *et al.*, 2007).

Ophthalmologists conduct grouping towards those eye-to-eye retina features taken by using fundus camera (Sitompul, 2011). That way is less effective because it takes a long time in what makes an occurance in conducting that observation. This causes the ophthalmologists to be slow and difficult to administer to patients (Putra and Suarjana, 2010). Therefore, this research, author of a new strategy for Diabetic Retinopathy can be grouped by combining HAAR wavelet method and backpropagation. To overcome that problem, image processing is necessary to conduct the grouping of diabetic retinopathy signs. The signs are done by conducting extraction features with wavelet HAAR for the energy difference from the image signs. Next, the energy obtained will be grouped by using the artificial neural network Backpropagation Neural Network (BPNN).

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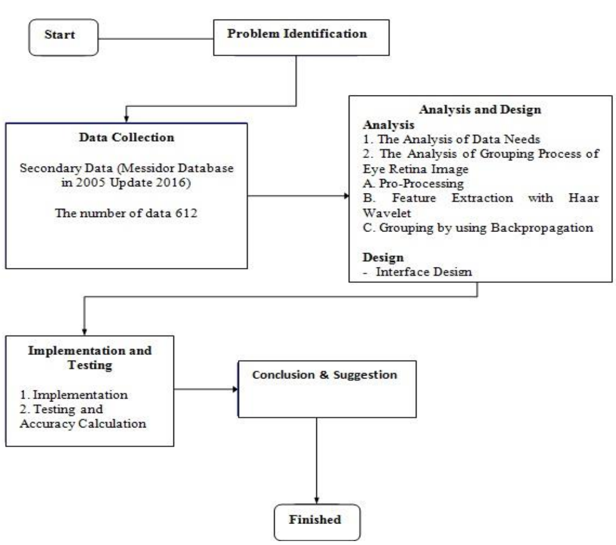
The previous research about HAAR wavelet or backpropagation is identifying the signature by using HAAR wavelet method until 4th level and conducting grouping with backpropagation artificial neural network generating optimum results by using two hidden layer and each used 20 and 10 nodes that have accuracy in the amount of 95,56% and 100% (Kumalasanti, Ernawati and Dwiandiyanta, 2015). Another research about face identification by using HAAR wavelet and euclidean distance by using 5 basis of data that own accuracy for each is 63,33%, 82,67%, 92,67% 95,33% and 96% (Puri, 2010). Then comparative research HAAR wavelet and doubechies and classification of using backpropagation produces the highest accuracy of HAAR wavelet in the amount of 93,33% and doubechies wavelet 92,22% (Kumalasanti, Ernawati and Dwiandiyanta, 2016). Fingerprint identification research with wavelet transformation and classification by using backpropagation artificial neural network produces the best accuracy in the amount of 96,36% (Wijaya and Kanata, 2004). Java letter patterns identification research by using backpropagation artificial neural network produces accuracy in the amount of 99,563% (Nurmila, Sugiharto and Sarwoko, 2005). The research that compares between Backpropagation and learning vector quantization about diabetes mellitus classification produces higher accuracy level of backpropagation compared to learning vector quantization (Nurkhozin, Irawan and Mukhlash, 2011).

The previous research about diabetic retinopathy that had been conducted is Optic Segmentation towards diabetics of diabetic retinopathy by using GSF Snake (Ulinuha, Purnama and Hariadi, 2010). In that research, exudate detection was conducted, spotting blood at the eyes caused by diabetic retinopathy disease. Beside that, this research is specialized on disc optic or eye nerve center. Eye nerve center is the center point of eye retina and the position where all eye nerves meet.

2. Methodology

The stages or the steps in this research can be seen at Figure 1 as follows:



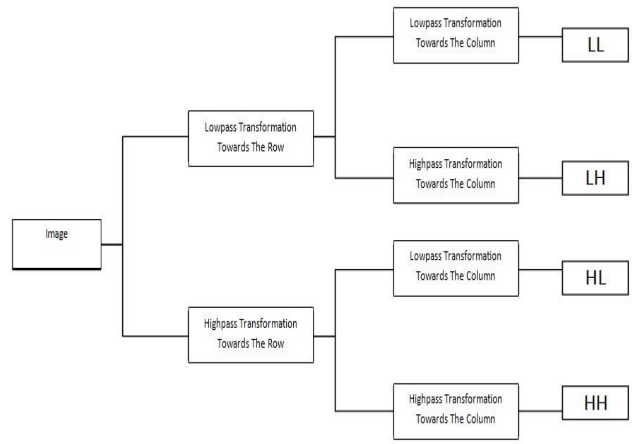


Figure 1 Research Method

Pre-Processing

Pre-Processing conducted was eliminating background manually by using photoshop application.

HAAR Wavelet

HAAR wavelet algorithm is as follows (Wijaya and Kanata, 2004):

Figure 2 HAAR Wavelet Algorithm

The stages of HAAR wavelet algorithm in accordance with Figure 2 are as follows:

1. An image that will be used either in the form of grayscale, colorful, or binary
2. Transformation process is conducted towards the image

$$M = \begin{matrix} T11 & T21 & Tn1 \\ T12 & T22 & Tn2 \\ T1n & T2n & Tnn \end{matrix} \quad M' = \begin{matrix} T11 & T12 & T1n \\ T21 & T22 & T2n \\ Tn1 & Tn2 & Tnn \end{matrix} \qquad (1)$$

3. The image result of the transformation is conducted filter lowpass or filter highpass process (Adi *et al.*, 2016) towards the row.

$$\text{Filter Highpass} = \begin{bmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \\ 0 & 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \end{bmatrix} \qquad (2)$$

$$\text{Filter lowpass} = \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & 0 \\ 0 & 0 & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix} \qquad (3)$$

4. The result of row filter lowpass is conducted transformation process back, then multiplied with column filter lowpass then it will get subband LL.
5. The result of row filter lowpass is conducted transformation process back, then multiplied with column filter highpass then it will get subband LH.
6. The result of row filter highpass is conducted transformation process back, then multiplied with column filter lowpass, then it will get subband HL.
7. The result of row filter highpass is conducted transformation process back, then multiplied with column filter highpass, then it will obtain subband HH.

8. After obtaining subband the result of HAAR wavelet, then next counting the value of energy with the equation as follows (Chang and Jay Kuo, 1993):

$$e = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}|x\ (i,j)| \quad (4)$$

e = energy value
i = matrix row
j = matrix column
M = the number of rows
N = the number of columns
X(i,j) = the value of matrix pixel

2.1. Backpropagation Neural Network

Backpropagation process is conducted for diabetic retinopathy grouping after the data pass normalization process. The following is backpropagation neural network algorithm (Siang, 2005):
Step 1 initialization. Conducting weight initialization and biased (conducted setting with random numbers take randomly. And conduct iteration maximal initialization, learning rate, and error tolerance.
Step 2 doing it during the condition to stop before it is fulfilled. For stop condition, it can be done with iteration maximum or with error tolerance given. If the condition has reached maximum iteration then the process stops or if the error tolerance condition has lacked or has been the same then the process stops.
Step 3 Input unit (X1, X2…. Xi) obtains input signal then conduct distribution to all existed hidden layers.
Step 4 Hidden (Z1, Z2, …. Zi) conduct input signal calculation and with the weight and its biased by using the formula as follows:

$$Z\_in_j = V0j + \sum_{i=1}^{n} x_i v_{ij} \quad (1)$$

Then by using activation function that has been determined, then will be obtained the output of the existed hidden, the equation used is:
yk = f(z_inj) (2)
Step 5 Output (Y1, Y2, …. Yi) that conducts calculation of hidden signal together with biased and its weight by using the equation as follows:

$$Z\_in_k = V0k + \sum_{j=1}^{p} Z_i W_{jk} \quad (3)$$

Then by using activation function that has been determined since the beginning, then obtained output signal.
yk = f(y_ink) (4)
Step 6 Next conducted error calculation between target and output issued by using Mean Absolute Percentage Error Method. If the requirement is still not fulfilled yet, then error correction calculation (δk) is conducted by using the equation as follows:
δk = (tk – yk) f'(y_ink) (5)
Step 7 Hidden (Z1, Z2 …… Zj) conduct the weight calculation that has been sent by output unit. For the first condition then the equation used is:

$$\delta\_in_j = \sum_{k=1}^{n} \delta_k w_{jk} \quad (6)$$

Then multiplication is conducted towards the result of the equation above with derivative from activation function in order to get error factor. The equation used is as follows:

δj = δ_inj f'(z_inj) *(7)*

Step 8 Output (Y1, Y2 … Yk) conduct weight change from each hidden unit with the equation as follows:
Wjk(new) = Wjk(old) + ΔWjk (8)
Likewise with hidden (Z1, Z2 ….. Zj) conducted weight change with the equation as follows:
Vij(new) = Vij(old) + ΔVij (9)
Step 9 Conducting examination of stop condition.

3. Result and Discussion

In this research, testing is conducted through the design as follows:

1. The testing conducted is by grouping eye retina image to be four groups, they are; Normal, Diabetic Retinopathy Non-Proliferative, Diabetic Retinopathy Proliferative and Macular Edema.
2. The feature extraction used is HAAR wavelet at level 1 and level 4.
3. The data extraction with the choice of the number of data 612 and the choice of image size 2304 x 1536, 2204 x 1488, 1440 x 960.
4. Training with learning rate choice 0.1, 0.01, and 0,001. Epoch maximum 100.000 iteration. Error target 10-6 and choose the training percentage that wanted to be conducted 70%, 80%, 90% and 95%.
5. Testing with the choice of percentage number 30%, 20%, 10% and 5%.
6. The testing of this research is by using white box and accuracy testing.

The result of testing by using HAAR wavelet level 1 and 4. Learning rate 0.1, 0.01, and 0.001. Image size 2304 x 1536, 2240 x 1488 and 1440 x 960. The comparative percentage of testing data and training data are 70:30, 80:20, 90:10 and 95:5 which can be seen at Table 1 and 2 as follows:

Table 1 The Result of Feature Extraction Test HAAR Wavelet Level 4 and Backpropagation

Image Size	*Learning Rate*	Data 30%	Data 20%	Data 10%	Data 5%
2304 x 1536	0,1	46.74%	51.61%	51.67%	40.63%
	0,01				
	0,001				
2240 x 1488	0,1	49.46%	50.81%	51.67%	**56.25%**
	0,01				
	0,001				
1440 x 960	0,1	49.46%	50.00%	51.67%	40.63%
	0,01				

0,001

The result of the higher testing with HAAR wavelet extraction level 4 and backpropagation reaches 56,25% at the division percentage of training data and testing data 95:5, learning rate 0.1,0.01 and 0.001. The image size 2240 x 1536.

Table 2 The Result of Feature Extraction HAAR Wavelet Level 1 and Backpropagation

Image Size	*Learning Rate*	Data 30%	Data 20%	Data 10%	Data 5%
2304 x 1536	0,1	46.20%	45.16%	53.33%	53.13%
	0,01				
	0,001				
2240 x 1488	0,1	46.20%	45.16%	**55.00%**	53.13%
	0,01				
	0,001				
1440 x 960	0,1	46.20%	45.16%	**55.00%**	53.13%
	0,01				
	0,001				

The result of the highest testing with extraction of HAAR wavelet level 1 and backpropagation reaches 55% at learning rate 0.1, 0.01 and 0.001. Data division 90:10. Image size 2240 x 1536 and 140 x 960.

4. Conclusion

The level of testing accuracy with extraction of HAAR wavelet level 1, the highest reaches 55% at learning rate 0.1, 0.01 and 0.001. Data division 90:10. Image size 2240x1536 and 140 x 960.The level of testing accuracy with extraction of HAAR wavelet level 4, the highest reaches 56,25% at the percentage of data training division and testing data 95:5, learning rate 0.1, 0.01, and 0.001. The image size 2240 x 1536. The algorithm result of HAAR wavelet level 1 after conducted normalization generates the value with the closest difference between each classes, until it complicates the grouping process by using backpropagation neural network. Based on the research results obtained from the research, the results of the extraction algorithm that can't detect the features of diabetic retinopathy. HAAR wavelet algorithm cannot conduct retinopathy detection properly and correctly. This is because image decomposition process will eliminate many important features of that retinopathy. Future research is expected to add preprocessing such as only targeting to get the main characteristics of diabetic retinopathy.

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