A Classification: using Back Propagation Neural Network Algorithm to Identify Cataract Disease

W S Simamora¹, R S Lubis¹, and E M Zamzami²

¹Master Programme in Informatics, Universitas Sumatera Utara.
²Faculty of Computer Science and Information Technology, Universitas Sumatera Utara.

Email: windi.saputri55@gmail.com

Abstract. Artificial Neural Networks are often used in the fields of pattern recognition, speech, and image recognition, where high levels of computation are needed. One method that can be used is the Back-propagation Neural Network. The method can be used to identify several diseases, one of which is a cataract. A cataract is one of the most significant diseases that can cause blindness. Cataracts consist of three levels, namely mature cataracts, immature cataracts, and hyper-mature cataracts. The testing method uses two parameter values, namely epoch with value 1000, 5000, 10000 and learning rate with value 0.01, 0.05, 0.1. From the test, it was found that the best parameters of the above trial results were epoch with a value of 10000 and learning rate with a value of 0.1 on 80 experimental data. In experiments conducted to identify normal, mature, immature, and hyper mature obtained an accuracy of 100%, 95%, 85%, and 90%. The percentage value of the accuracy of the test results using the BPN method is 92.5%.

1. Introduction

Visual impairment and blindness are still a health problem in Indonesia. Based on sensory health surveys from 1993 to 1996 conducted by the Ministry of Health of the Republic of Indonesia showed that 1.5% of the Indonesian population experienced blindness caused by cataracts (52%), glaucoma (13.4%), refractive abnormalities (9.5%), disorders retina (8.5%), corneal abnormalities (8.4%), and other eye diseases.

The cataract is a disease that can cause blindness. This disease is characterized by blurred vision, blurry or dim, difficulty seeing at night, sensitive to light, seeing “halos” around lights, double vision in one eye, white stains that will continue to cover the lens so that the black part of the eye will become white. Generally, cataracts are related to aging[1],[2]. Cataracts often occur in older people. Cataracts are divided into three levels, namely mature cataracts, immature cataracts, and hyper-mature cataracts[3]. Therefore, there is a system that can be used to diagnose cataracts and can reduce errors in diagnosis. In this case, a method is needed to identify the cataract using the Artificial Neural Network. Artificial neural networks are widely used to solve complex problems and the backpropagation algorithm has great advantage of simple implementation.

Artificial Neural Networks (ANN) is a unit of information processing in the fields of pattern recognition, speech, and image recognition where a high level of computation is needed. ANN has been studied for years in the hope that it can resemble the performance of the human brain[3],[4]. ANN has many algorithms to identify one of them is the Back-propagation Neural Network[7]. A backpropagation
neural network (BPN) is an algorithm in ANN that is often used in finding optimal weights. BPN is a learning algorithm that is used to classify several criteria by trying to learn a data set[8]. BPN learning also has special criteria, namely learning to reduce the level of error by adjusting the weight based on differences in output and desired targets[7]. Artificial neural networks are widely used to solve complex problems and the backpropagation algorithm has great advantage of simple implementation [14].

This paper consists of several sections. The first section discusses the background, and the method used to detect cataracts. The second section discusses previous research on the detection of cataracts and the application of the BPN algorithm. The third section discusses the method used in this research. The fourth section is about experimenting using the BPN method to get the result. The fifth is about an explanation or summary based on the result of this research.

2. Related Work

Based on [1], the application is used to detect cataracts to calculate accuracy values. Based on the test results on 50 data cases, an accuracy value of 78% was obtained[1]. This application uses preprocessing to improve the image and segmentation of all images to classify cataracts. The classification has been done on 30 data and has 3.33% error[2]. In [9] using Back Neural Network Propagation in the Classification of High-Resolution Remote Sensing Image. This application is used for image classification of High-Resolution Remote Sensing Image on the BP neural network can output the simulation results quickly by setting the momentum constant and the learning rate, and the total classification reaches 93%[9].

3. Research Methodology

3.1. Digital Image

Digital images are images that have image file types and sizes that can be processed by a computer. Each pixel has x and y coordinates. X-axis (horizontal): column and y-axis (vertical): line. Each pixel has a value that indicates a gray intensity of the pixel[10].

3.2. Grayscale

Grayscale is a series of monochromatic (gray) patterns, ranging from pure white at the brightest end to pure black at the opposite end. Therefore, a grayscale image contains only shades of gray and no color. Grayscale only contains lighting information (brightness), which is why maximum white lighting and zero black lightings; everything in between is gray.

3.3. Thresholding

Thresholding is a simple but effective way of partitioning an image into a foreground and background. Image thresholding is most effective in images with high levels of contrast. This image analysis method is a type of image segmentation that isolates objects by converting grayscale images into binary images.

3.4. Zoning

Zoning is a technique where the image of a character is divided into several areas, then its density is calculated by the number of foreground pixels divided by the total pixels in the zone. From this zoning technique, a feature with a size of a predetermined area is produced[11].

\[
d(i) = \frac{\text{Number of foreground pixels in zone} \; i}{\text{Total number of pixels in zone} \; i}
\]  

(1)

3.5. Back-propagation Neural Network
In Back-propagation Neural Network procedures of model identification using are initialize parameters, normalization process, and backpropagation process[12]. The procedures are explained as follows[13]:

3.5.1. Initialize Parameters.
In back-propagation process must including the weights and biases as parameter initialization.

3.5.2. Normalization Process.
Apply the normalization process so that the data is converted to the interval (-1,1) using the equation below.

\[ x = \frac{2(x_p - \text{min}(x_p))}{\text{max}(x_p) - \text{min}(x_p)} - 1 \]  

(2)

Where \( x \) is data normalization value, \( x_p \) is data value before normalization process, \( \text{min}(x_p) \) is minimum data value before normalization process, and \( \text{max}(x_p) \) is maximum data value before normalization process.

3.5.3. Backpropagation Process.
Back-propagation consists of feed-forward and back-propagation of the error process.

- **Feedforward.** The steps of the feedforward process are explained as follows:
  a. Each hidden unit is a sum of the input signal with its weight and bias:

\[ z_{inj} = v_{0j} + \sum_{i=1}^{n} x_i v_{ij} \]  

(3)

And then using the activation function that is used to calculate the output signal and hidden unit:

\[ z_j = f(z_{inj}) \]  

(4)

Then send the output signal to the entire output unit.

b. Each output unit is a sum of the input signal with its weight and bias:

\[ y_{in_k} = w_{0k} + \sum_{j=1}^{p} z_j w_{jk} \]  

(5)

Furthermore, using the activation function to calculate the output signal and the output unit:

\[ y_k = f(y_{in_k}) \]  

(6)

- **Back-propagation of Error.** The steps of the back-propagation of error process are as follows:
  a. Each output unit receives a certain target that is qualified as a fit to training input data to calculate the error between target and output:

\[ \delta_k = (t_k - y_k)f'(y_{in_k}) \]  

(7)

As the input data of training, output data of training \( t_k \) has also been scaled according to the activation function that is currently used. Factor \( \delta_k \) is used to calculate the error correction \( (\Delta w_{jk}) \) that is used to update the weights, \( w_{jk} \):

\[ \Delta w_{jk} = \alpha \delta_k z_j \]  

(8)
Furthermore, \( \Delta w_{0k} \), weight correction is calculated to be used to update weights, \( w_{0k} \):

\[
\Delta w_{0k} = \alpha \delta_k
\]  

(9)

b. Each hidden unit sums the delta input:

\[
\delta_{in_j} = \sum_{k=1}^{m} \delta_k w_{jk}
\]  

(10)

Then multiplied with a differential of the activation function to calculate the error information:

\[
\delta_j = \delta_{in_j} f'(z_{in_j})
\]  

(11)

Then calculate weights correction:

\[
\Delta v_{ij} = \alpha \delta_j x_i
\]  

(12)

The bias weights correction, \( \Delta v_{0j} \), is also calculated to update \( v_{0j} \):

\[
\Delta v_{0j} = \alpha \delta_j
\]  

(13)

c. Each output unit updates the weights and bias:

\[
\Delta w_{jk}(new) = w_{jk}(old) + \Delta w_{jk}
\]  

(14)

Moreover, each input unit updates the weights and bias:

\[
\Delta v_{ij}(new) = v_{ij}(old) + \Delta v_{ij}
\]  

(15)

4. Results and Discussion

The accuracy measurement is performed to measure the correct output following medical record data from experts. Testing phase is done by using one digital image where each image will be training by a network. The network parameters used are learning rate and epoch number, as can be seen in table 1.

| Table 1. Network Parameters Testing Algorithm |
|-----------------|-----------------|
| Network Parameters | Value           |
| Epoch            | 1000, 5000, 10000 |
| Learning Rate    | 0.01, 0.05, 0.1  |

The test results are done by using parameters in table 1, with the number of tests 80 patient data for all parameters can be seen as in table 2.

| Table 2. Cataract Identification Testing Result |
Inaccuracy testing 80 patient data were used by comparing them with expert data on the system. Testing the accuracy of the BPN algorithm in the detection of cataracts can be seen in the table. To calculate the percentage of data that is appropriate or accurate can be calculated using the formula:

\[
\% \text{Accuracy} = \frac{\text{True Data}}{\text{Amount of test data}} \times 100\% \tag{16}
\]

| No | E    | LR  | R  | N |
|----|------|-----|----|---|
| 1  | 1000 | 0.01| 70 | 10|
| 2  | 1000 | 0.05| 60 | 20|
| 3  | 1000 | 0.1 | 50 | 30|
| 4  | 5000 | 0.01| 55 | 25|
| 5  | 5000 | 0.05| 73 | 7 |
| 6  | 5000 | 0.1 | 65 | 15|
| 7  | 10000| 0.01| 72 | 8 |
| 8  | 10000| 0.05| 62 | 18|
| 9  | 10000| 0.1 | 74 | 6 |

Explanation:
E = Epoch\hspace{1cm} LR = Learning Rate\hspace{1cm} R = Recognized\hspace{1cm} NR = Not Recognized

From the test results in table 3, data can be obtained as follows:

\[
\% \text{Accuracy} = \frac{20}{20} \times 100\% = 100\% \tag{17}
\]

| No | Name  | Output | Result |
|----|-------|--------|--------|
| 1  | Ms. Hipsah | Normal | True   |
| 2  | Ms. Ifnah | Normal | True   |
| 3  | Mr. Dimas | Normal | True   |
| 4  | Mr. Hermawan | Normal | True   |
| ... | ... | ... | ... |
| 18 | Ms. Elmawati | Normal | True   |
| 19 | Ms. Lina | Normal | True   |
| 20 | Mr. Rio | Normal | True   |

From the test results in table 4, data can be obtained as follows:

\[
\% \text{Accuracy} = \frac{20}{20} \times 100\% = 100\% \tag{17}
\]

| No | Name   | Output | Result |
|----|--------|--------|--------|
| 1  | Ms. Nanda | Mature | True   |
| 2  | Ms. Ira | Mature | True   |
| 3  | Mr. Putra | Mature | True   |
| 4  | Mr. Tiko | Mature | True   |
| ... | ... | ... | ... |
| 18 | Mr. Radit | Normal | False  |
| 19 | Ms. Tika | Mature | True   |
| 20 | Mr. Surya | Mature | True   |
\[ \text{%Accuracy} = \frac{19}{20} \times 100\% = 95\% \] (18)

**Table 5. Data Test Accuracy Immature**

| No | Name   | Output       | Result |
|----|--------|--------------|--------|
| 1  | Mr. Anto | Immature     | True   |
| 2  | Ms. Tuti | Immature     | True   |
| 3  | Mr. Gilang | Hyper-mature | False  |
| 4  | Mr. Rodhi | Immature     | True   |
| ...| ...     | ...          | ...    |
| 18 | Ms. Risma | Hyper-mature | False  |
| 19 | Ms. Lena  | Hyper-mature | False  |
| 20 | Mr. Adit  | Immature     | True   |

From the test results in table 5, data can be obtained as follows:

\[ \text{Accuracy} = \frac{17}{20} \times 100\% = 85\% \] (19)

**Table 6. Data Test Accuracy Hyper-mature**

| No | Name   | Output       | Result |
|----|--------|--------------|--------|
| 1  | Ms. Layla | Hyper-mature | True   |
| 2  | Ms. Citra | Immature     | False  |
| 3  | Mr. Santo | Hyper-mature | True   |
| 4  | Mr. Julian | Hyper-mature | True   |
| ...| ...     | ...          | ...    |
| 18 | Ms. Nina  | Immature     | True   |
| 19 | Ms. Lola  | Hyper-mature | True   |
| 20 | Mr. Benny  | Hyper-mature | True   |

From the test results in table 6, data can be obtained as follows:

\[ \text{Accuracy} = \frac{18}{20} \times 100\% = 90\% \] (20)

From the test results, all data can be obtained as follows:

\[ \text{Accuracy} = \frac{74}{80} \times 100\% = 92.5\% \] (21)

From the above calculation, the percentage value of the accuracy of the test results using the BPN method is 92.5%.

### 5. Conclusion

Based on the table of the implementation and testing of the Back-propagation Neural Network to identify eye disease cataracts, we conclude several point as follows:

- In this experiment we use two parameters epoch with value 1000,5000,10000 and learning rate with value 0.01, 0.05, 0.1. The best parameters of trial results are epoch with a value of 10000 and learning rate with a value of 0.1 on 80 experimental data. In experiments conducted to identify normal, mature, immature, and hyper mature obtained an accuracy of 100%, 95%, 85%, and 90%.
Experiments on immature cataracts have lower accuracy than mature and hyper mature cataracts because the data sets of immature and hyper mature cataracts have similarities to its thick cataract membranes. The percentage value of the accuracy of the test results using the BPN method is 92.5%.

References
[1] I. Santos, L. Romla, and S. Herawati 2018 Expert System Diagnosis of Cataract Eyes Using Fuzzy Mamdani Method J. Phys. Conf. Ser. 953 012138
[2] R. Sigit, M. Bayu Satmoko, and D. Kurnia Basuki 2018 Classification of Cataract Slit-Lamp Image Based on Machine Learning Int. Seminar on Application for Technology of Information and Communication 597–602
[3] Y. Dong, Q. Zhang, Z. Qiao, and J. J. Yang 2017 Classification of cataract fundus image based on deep learning Proc. Int. Conf. on Imaging Systems and Techniques p.1–5
[4] M. Pethick, M. Liddle, P. Werstein, and Z. Huang 2016 Parallelization of a Backpropagation Neural Network on a Cluster Computer,” p. 9
[5] R. A. Dilruba, N. Chowdhury, F. F. Liza, and C. K. Karmakar 2006 Data Pattern Recognition using Neural Network with Back-Propagation Training Proc. Int. Conf. on Electrical and Computer Engineering Dhaka, Bangladesh, 2006, p. 451–455
[6] Alaeldin S. and Yun Z 2015 A Review on Back-Propagation Neural Networks in the Application of Remote Sensing Image Classification J. Earth Sci. Eng 5 1
[7] N. Mohd. Nawi, A. Khan, and M. Z. Rehman 2013 A New Back-Propagation Neural Network Optimized with Cuckoo Search Algorithm in Computational Science and Its Applications – ICCSA 2013 vol. 7971 (B. Murgante, S. Misra, M. Carlini, C. M.Torre, H.-Q. Nguyen, D. Taniar, B. O. Apduhan, and O. Gervasi, Eds.) Berlin, Heidelberg: Springer Berlin Heidelberg pp. 413–426
[8] V. Jaiganesh, P. Sumathi, and S. Mangayarkarasi 2013 An analysis of intrusion detection system using backpropagation neural network Proc. Int. Conf. on Information Communication and Embedded Systems (ICICES) Chennai pp. 232–236
[9] J. Jiang, J. Zhang, G. Yang, D. Zhang, and L. Zhang 2010 Application of backpropagation neural network in the classification of high-resolution remote sensing image: Take remote sensing image of Beijing for instance Proc. Int. Conf. on Geoinformatics Beijing, China pp. 1–6
[10] Parini, H. Mawengkang, and S. Efendi 2018 Hybrid learning vector quantization (LVQ) algorithm on face recognition using the webcam IOP Conf. Ser. Mater. Sci. Eng. 420, p. 012126
[11] A. M. M. O. Chacko and P. M. Dhanya 2015 A Comparative Study of Different Feature Extraction Techniques for Offline Malayalam Character Recognition in Computational Intelligence in Data Mining vol 2, 32, ed: L. C. Jain, H. S. Behera, J. K. Mandal, and D. P. Mohapatra (New Delhi: Springer) pp. 9–18.
[12] N. A. Al-Sammarrai, Y. M. H. Al-Mayali, and Y. A. Baker El-Ebiary 2018 Classification and diagnosis using backpropagation Artificial Neural Networks (ANN) Intl. Conf. on Smart Computing and Electronic Enterprise Shah Alam pp. 1–5.
[13] S. A. Fitania, A. Damayanti, and A. B. Pratiwi 2019 Model-identification of dengue fever spreading using firefly algorithm and backpropagation neural network IOP Conf. Ser. Mater. Sci. Eng., vol. 546, p. 032008
[14] I. Sutrisno, M. Firmansyah, R. B. Widodo, Ardiansyah A. 2019 Implementation of backpropagation neural network and extreme learning machine of pH neutralization prototype J. Phys. Conf. Ser., vol. 1196, no. 1 doi: 10.1088/1742-6596/1196/1/012048