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Face Recognition Using Backpropagation Algorithm (Supervised Learning)

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ABSTRACT
Image processing plays a pretty important role. Much research has been carried out on image objects, where information from images can contribute to and benefit education, technological innovation, and information management. The face is a marker of recognizing someone. Facial recognition systems have difficulty with different facial orientations, lighting, haircuts, mustaches or beards, glasses, permanent blemishes or scars, and differences in conditions such as the person turning slightly, looking down, or looking up. The research aims to carry out digital image processing, specifically the process of scaling, grayscale, edge detection, and thresholding the image of a person's face as input. This research is crucial because image processing, especially facial recognition, is essential in health, education, economics, and security. The research uses the Artificial Neural Network method. Artificial Neural Networks are information processing systems designed to imitate how the human brain works in solving a problem by learning by changing the synapse weights. Research results in facial recognition using backpropagation show high accuracy and a fast average time. The suitability level of the recognition results depends on the combination of parameter values used in the learning process. The greater the epoch (repetition), the greater the learning rate; the smaller the error, the higher the known level.

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INTRODUCTION

Currently, image processing plays a pretty important role, where the processing does not just provide an effect that makes the image more artistic but must also be able to improve the quality of the image itself (Purba *et al.*, 2020; Sudhagar, Sakthivel and Daniel, 2020). Image processing is widely used in life. With image processing, the image becomes more apparent. Image processing cannot be separated from computers, thus encouraging computer companies to improve the quality of making software for processing images by providing a transparent effect on images. This software is widely popular, especially in photography and film (Purba, 2017; Khan *et al.*, 2024).

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Much research has been carried out on image objects, where the information obtained from these images can contribute to and benefit the world of education, technological innovation, and information management (Purba and Sondang, 2022). Its development may be widely used directly and indirectly, from games to security aspects such as jigsaw, face recognition, hand recognition, and fingerprints (Cahyo and Al-Ghiffary, 2024). We often meet many people at work, school, campus, market, and other places. Among these people are those we know closely or only know. Sometimes, somewhere, we pass someone on the street or meet someone we once knew, but we need to remember their name (Purba *et al.*, 2019). Likewise, when we see a photo of someone we once knew, we forget their name even though we know that we once knew someone by remembering their face.

The face is a marker for recognizing someone. As explained, if someone gets to know someone, the most memorable thing is the person's face (Purba, 2022). In addition to being used to recognize someone, the face is also used for other things, such as population data collection, attendance, and security systems using a facial recognition system (Chandran *et al.*, 2023). Because the human face represents something complex, developing an ideal computational model for facial recognition is still tricky. In addition, facial recognition systems also have difficulty with different facial orientations, lighting, haircuts, mustaches or beards, glasses, permanent defects or scars, and differences in conditions such as the person is slightly turned, looking down, or looking up (Purba and Verawardina, 2021; Manalu and Situmorang, 2024).

One branch of Artificial Intelligence is known as Artificial Neural Networks. Artificial Neural Networks are information processing systems designed to imitate how the human brain works in solving a problem by learning through changes in the weight of its synapses (Zhai, 2024). Artificial neural networks are capable of performing activity recognition based on past data. Past data will be studied by artificial neural networks so that they can make decisions on data that has never been studied (Niu and Wang, 2024). In this analysis, an attempt was made to study and try its application in image processing on digital images. The concept of Artificial Neural Networks, which is developing rapidly, has given rise to several methods for creating models of Artificial Neural Networks with their respective advantages and disadvantages (Aruna *et al.*, 2024). Some of the methods of Artificial Neural Networks are Backpropagation, Quickprop, Perceptron, and Learning Vector Quantization (LVQ).

In this case, image processing will be done using a digital camera, mobile phone, scanner, and webcam. The image will be processed with the initial step of creating a template. This template will later be tracked so that, finally, the feature points of the image can be identified (Purba, 2021). The points resulting from the tracking process are then depicted as a wireframe, and their texture is mapped according to their location. Back Propagation Neural Network is a method that plays a role in complex problems where a decision maker tries to simplify complex problems to the level where he is ready to understand them (Srivastava and Sharma, 2024). The thought process is directed at decision-making with limited rationality, simplifying the model by taking the essential core of the problem without involving all the concrete problems (Purba and Sembiring, 2016). In

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solving complex problems, a fast, precise, and accurate method is needed. Artificial Intelligence is a part of computer science that allows computers to work quickly, precisely, and accurately. One is the Backpropagation Artificial Neural Network (Supervised Learning) (Madasamy *et al*., 2024). This study aims to perform digital image processing, especially the scaling, grayscale, edge detection, and thresholding of a person's facial image as input. This research is crucial because image processing, especially facial recognition, is essential in health, education, economics, and security.

METHODS

The research design for the Backpropagation Artificial Neural Network for facial recognition can be seen in the research flowchart in Figure 1 below:

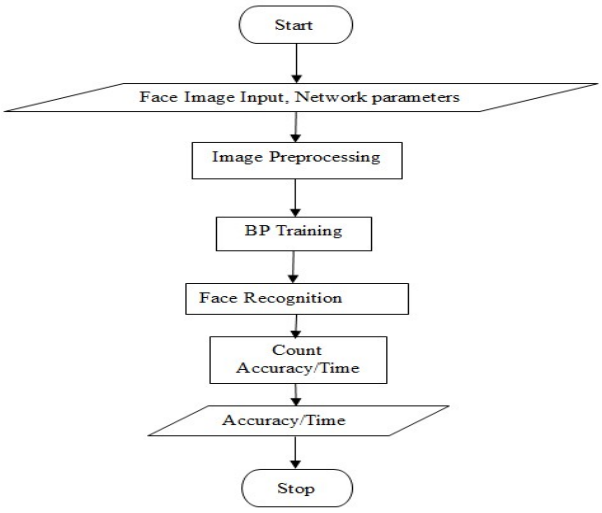

Figure 1. Research Flowchart (Peng, 2024)

There is no RGB palette in 24-bit color images (actual color) because RGB values are directly described in binary bitmap data. To read RGB values, it looks for the header and bitmap data containing information about the image's dimensions, format, and pixel values . Each bitmap data element consists of 3 bytes; each byte represents the Red, Green, and Blue (RGB) components. Each data byte represents 8 bits, so in a color image, there are 3 bytes * 8 bits = 24 bits of color content.

In a color image, each pixel contains 24-bit color content or 8-bits for each primary color (R, G, and B), with content values ranging from 0 (00000000) to 255 (11111111) for each color. For example, the pixel values of a color image are as shown in Figure 2 below:

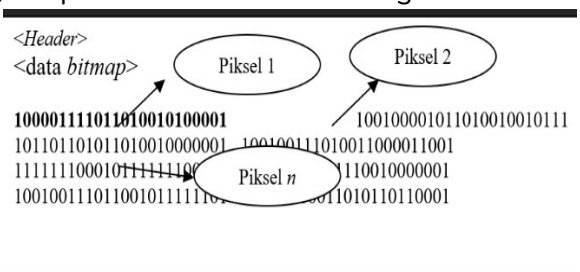

Figure 2. Image Color Pixel Value

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In the example image in Figure 2 above, the first data is the header containing information about the file name, format type, and image dimensions. Below the bitmap data is the first pixel with a value = 100001111011010010100001. To get the RGB value of each pixel, use the following formula:

R-value = c and 255 (1)

G value = (c and 65.280)/256 (2)

B value = (c and 16.711.680)/256) /256 (3)

Where c is the image pixel value

In Figure 2 above, the pixel value (0,0) is 111100001011010010111001 (24 bits). The R-value is calculated using equation (1) as follows:

R = 100001111011010010100001 and 11111111 = 10100001 (Binery) = 161 Decimal

The G component value is calculated using equation (2):

G value = (100001111011010010100001 and 1111111100000000) / 100000000 = 10110100 = 180 (decimal)

The B component value is calculated using equation (3):

B value = (100001111011010010100001 and 111111110000000000000000)/ 100000000/100000000 = 10000111 = 135 (decimal)

So that the pixel value is obtained (0,0) 11110000 11110000 11111111:

R = 11110001 = 161 (decimal)

G = 10110100 = 180 (decimal)

B = 10010000 = 135 (decimal)

In this analysis, the number of pixels calculated is only 25 pixels, and to get the RGB value of the other pixels is done in the same way as above. Then, the RGB value of all pixel values in the image is entered into a matrix, as shown below:

161,180,135	152,140,110	182,166,210	166,112,178	170,177,166
202,189,134	201,180,111	140,173,110	192,120,200	112,167,162
133,200,152	165,100,155	124,110,167	140,180,126	200,160,200
141,204,104	134, 80,144	140,110,115	150,180,150	160,210,220
56,100,110	147,140,165	143,230,173	140,212,210	150,212,150

As an example of calculating the gray scale value of an image is as follows:

f(0,0) = ((161+ 180+135)/3) = 158

f(0,1) = ((152+140+110)/3) = 134

f(0,2) = ((182+166+210)/3) = 186

f(0,3) = ((166+112+178)/3) = 152

f(0,4) = ((170+177+166)/3) = 171

Calculating the grayscale value of the next pixel is done in the same way as above, and then the grayscale value of the colored image matrix is entered into the grayscale value matrix. Edge detection emphasizes the image's boundaries or improves the appearance of

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facial boundaries. In facial images, edge detection is done by taking one block of image measuring 3 x 3 Pixels.

sx = 158(-1) + 134(-2) + 186(-1) +166(1) +100(2) + 155(1) = 478

sy = 158(1) +110(2) +166(1) +186(-1) +111(-2) +155(-1) = 452

The calculation of the magnitude value (M) is as follows:

M = |sx| + |sy|

M = |478| + |452|

M = 930

The convolution image was obtained from the edge detection calculation for 3*3 block pixels. From the convolution results, the magnitude value is divided equally for 9 pixels, namely 930:9 = 103. The separation of the grayscale image above functions to take the part of the image that is the dark point (0) and white (1). Binarization is done by dividing the image into 8*8 sub-image parts; the average intensity value of the lowest sub-image is used as the threshold value T. After that, the image binarization process is carried out using the threshold value T. The threshold calculation for the binarization process is where if the grayscale value <128, then it will be entered into the value 0, while if the grayscale value> T, it will be entered into the value 1.

Pixel value (0.0) = 158, Pixel value 158 > 128, then the binary value = 1

Pixel value (0.1) = 134, Pixel value 134 > 128, then the binary value = 1

Pixel value (0.2) = 186, Pixel value 186 > 128, then the binary value = 1

Pixel value (0.3) = 152, Pixel value 152 > 128, then the binary value = 1

Pixel value (1.0) = 171, Pixel value 171 > 128, then the binary value = 1

The training process and introduction of the Backpropagation algorithm on image images can be seen in Figure 3.

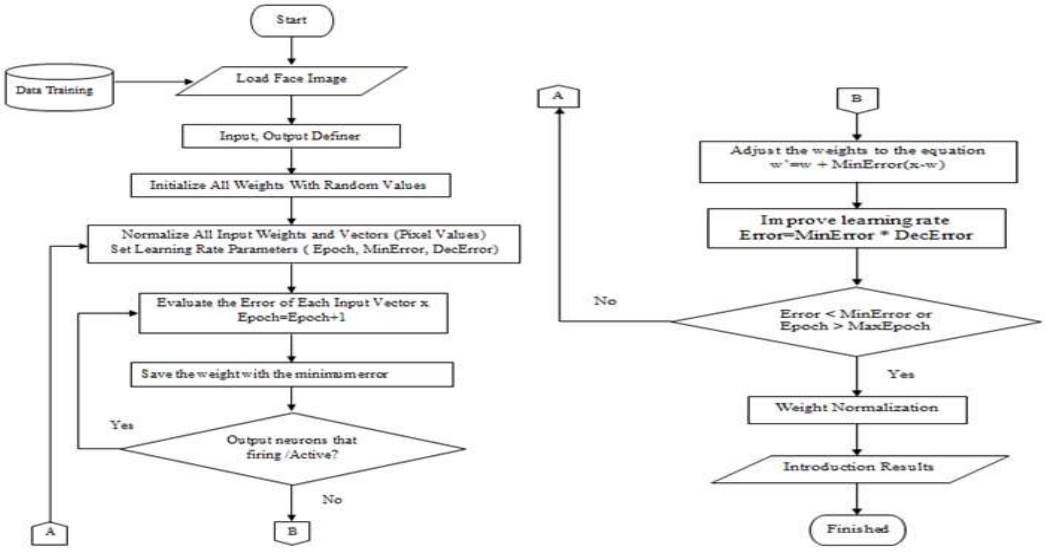

Figure 3. Backpropagation Algorithm Training and Introduction Flowchart

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RESULTS AND DISCUSSION

Results

The face file to be recognized must first be input into the database as shown in Figure 4.

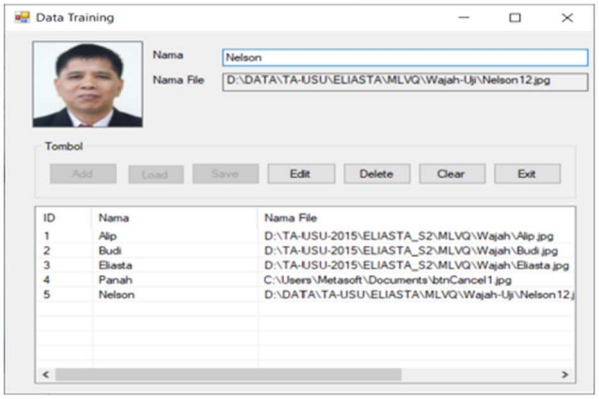

Figure 4. Input Face Image Data

Backpropagation Algorithm Training is a module that implements the process of training or learning facial patterns using the Backpropagation algorithm. After the face selector name appears, then select the Load face button. The Backpropagation algorithm training process can be seen in Figure 5.

Figure 5. Backpropagation Training Process

The Backpropagation Algorithm Recognition Module is a module that implements the facial pattern recognition process using the Backpropagation algorithm as seen in Figure 6.

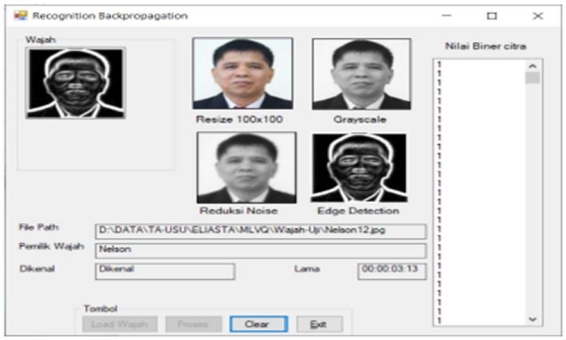

Figure 6. Backpropagation Introduction Process

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Discussion

Testing uses ten digital images of different sizes, and the network will train each image. The network parameters used are Maximum error, Learning rate, and number of Epochs, as seen in Table 1:

Table 1. Parameters

Parameters	Value
Epoch (Repetition)	50, 100
Learning Rate	0.5, 1
Minimum Error	0.01, 0.001

Information:
A = Maximum Epoch; B = Learning Rate; C = Minimum Error; D = Known; E = Unknown; T = Average time

Table 2. Test Results

No	A	B	C	BP		
				D	E	T
1	50	0.5	0.01	6	4	3.43
2	50	0.5	0.001	5	5	3.42
3	50	1	0.01	8	2	3.47
4	50	1	0.001	9	1	3.51
5	100	0.5	0.01	6	4	4.22
6	100	0.5	0.001	5	5	4.28
7	100	1	0.01	10	0	4.54
8	100	1	0.001	10	0	4.27
	Amount			59	21	3.89

So, the percentage of successful face recognition with the Backpropagation algorithm = 59/80*100% = 73.75%, with an average duration of the recognition process of 3.89 seconds.

CONCLUSION

Face recognition using the Backpropagation algorithm has a relatively high accuracy and a reasonably fast average time. The level of match between the recognition results depends on the combination of parameter values used in the learning process. The greater the Epoch (repetition), the greater the Learning rate, and the smaller the error, the higher the level of recognition.

REFERENCE

Aruna, S. *et al.* (2024) 'Analysis of Object Recognition Using Back Propagation-Based Algorithms', in *Emerging Advancements in AI and Big Data Technologies in Business and Society*. IGI Global, pp. 313–327.

Cahyo, N.R.D. and Al-Ghiffary, M.M.I. (2024) 'An Image Processing Study: Image Enhancement, Image Segmentation, and Image Classification using Milkfish Freshness Images', *International Journal of Engineering Computing Advanced Research*, 1(1), pp. 11–22.

Chandran, P. *et al.* (2023) 'Face Recognition Using LBPH, Haar Cascade Classifier and Back Propagation Neural Network', in *International Conference on Recent Advances in Artificial Intelligence & Smart Applications*. Springer, pp. 207–219.

Khan, U. *et al.* (2024) 'Four decades of image processing: a bibliometric analysis', *Library Hi Tech*, 42(1), pp. 180–202.

Madasamy, N.S. *et al.* (2024) 'A Novel Back-Propagation Neural Network for Intelligent Cyber-Physical Systems for Wireless Communications', *IETE Journal of Research*, 70(2), pp. 1361–1373.

Manalu, P.D. and Situmorang, Z. (2024) 'Face Recognition Using Support Vector Machine (SVM) and Backpropagation Neural Network (BNN) Methods to Identify Gender on Student Identity Cards', in *Proceeding of International Conference on Information Science and Technology Innovation (ICoSTEC)*.

Niu, Y. and Wang, Z. (2024) 'Face Recognition with Siamese Networks', in *Journal of Physics: Conference Series*. IOP Publishing, p. 12008.

Peng, J. (2024) 'Application of Backpropagation Neural Network based on Pytorch Framework in Handwritten Digit Recognition', in *2024 5th International Conference on Computer Vision, Image and Deep Learning (CVIDL)*. IEEE, pp. 549–553.

Purba, R.A. (2017) 'Pendeteksian Sisi Tepi Objek Citra Digital Menggunakan Operator Laplace Dengan Teknik Konvolusi Untuk Menghasilkan Bahan Dasar Menggambar Anak', *Semnasteknomedia Online*, 5(1), pp. 2–4.

Purba, R.A. *et al.* (2019) 'Edge image detection combines Laplace operation with convolution technique to produce drawing materials for children', *Journal of Physics: Conference Series*, 1402, p. 066097. doi:10.1088/1742-6596/1402/6/066097.

Purba, R.A. *et al.* (2020) 'The optimalization of backpropagation neural networks to simplify decision making', in *IOP Conference Series: Materials Science and Engineering*. doi:10.1088/1757-899X/830/2/022091.

Purba, R.A. (2021) 'Application design to help predict market demand using the waterfall method', *Matrix: Jurnal Manajemen Teknologi dan Informatika*, 11(3), pp. 140–149.

Purba, R.A. (2022) 'Hybrid Models with Technology: Is it Effective for Learning in Abnormal Situations?', *Journal of Education Research and Evaluation*, 6(1).

Purba, R.A. and Sembiring, J. (2016) 'Selection of scholarship recipients by using Promethee method in Polytechnic Unggul LP3M Medan', *2016 International Seminar on Application for Technology of Information and Communication (ISemantic)*, pp. 86–92. doi:10.1109/ISEMANTIC.2016.7873815.

Purba, R.A. and Sondang, S. (2022) 'Design and Build Monitoring System for Pregnant

Mothers and Newborns using the Waterfall Model', *INTENSIF: Jurnal Ilmiah Penelitian dan Penerapan Teknologi Sistem Informasi*, 6(1), pp. 29–42.

Purba, R.A. and Verawardina, U. (2021) 'Deteksi Mahasiswa Yang Dapat Menyusun Tugas Akhir dengan Metode Visekriterijumsko Kompromisno Rangiranje (VIKOR)', *Techno. Com*, 20(2), pp. 210–220.

Srivastava, S. and Sharma, H. (2024) 'Face recognition for human identification through integration of complex domain unsupervised and supervised frameworks', *Multimedia Tools and Applications*, 83(5), pp. 14085–14109.

Sudhagar, S., Sakthivel, M. and Daniel, S.A.A. (2020) 'Application of image processing to radiographic image for quantitative assessment of friction stir welding quality of aluminium 2024 alloy', *Measurement*, 152, p. 107294.

Zhai, M. (2024) 'Human Action Recognition Based on Back Propagation Neural Network', in *2024 20th International Conference on Natural Computation, Fuzzy Systems and Knowledge Discovery (ICNC-FSKD)*. IEEE, pp. 1–6.