Batu Aceh Typology Identification

AZLINAH MOHAMED, SOFIANITA MUTALIB, NOOR HABIBAH ARSHAD
Faculty of Information Technology & Quantitative Sciences
Universiti Teknologi MARA
40450 Shah Alam, Selangor
MALAYSIA

Abstract: - Nowadays, the history of Batu Aceh has been forgotten through the centuries. If this happens, future generations will not know the absence of this creative heritage. Even to an expert, it takes time for them to recognize and memorize each type easily. To solve this difficulty, a prototype is devised to guide future generation to appreciate these precious cultural heritage artifacts in the Islamic-Malay civilization. A neural network approach is employed for supervised classification of this Batu Aceh object images. In this research, back propagation algorithm is applied. In order to classify the type, several images of each type of Batu Aceh are used as training samples. The image samples would be processed to extract useful information to be fed into each type of Batu Aceh. The network will be trained first with data samples that have been converted into binary forms. Then, network parameters such as momentum value, learning rate and number of hidden neuron will be set to ensure the performance of the system. After several experiments were conducted, 0.04 learning rate value with 40 hidden neurons in the hidden layer was found to be the optimal parameter values for the neural network. The learning curve is smooth and the performance goal is met.

Keywords: - Artificial Neural Network, Back Propagation, Batu Aceh, Image Processing, Image Classification and Pattern Recognition.

1 Introduction

With the advances in computer technology today, most of the human activities involve machines. The growth of computers mimicking the human visual system applications in robotics, biology, medicine, computer science, and engineering has contributed a lot in this technology [1]. Human brain captures and learns much faster when it comes to vision and images [9, 10]. Building a computer vision system has proven to be difficult and complex [7].

The pattern recognition system such as face recognition, thumbprint recognition [3], character recognition [2] and speech recognition are identified to be the most common application developed today. However, this research focuses on developing a shape recognition application. The objects that are represented are Batu Aceh images within the Peninsular Malaysia. This research would encourage young generation in knowing Batu Aceh as a historical artifact as it is no longer being made [6].

2 Batu Aceh Historical Artifact

Batu Aceh can be easily found in the early Southeast Asian Islamic gravestones and it is manufactured in Aceh, North Sumatra from the late 13th century to the 19th century. Batu Aceh was widely distributed in the Malay-Indonesia Archipelago and was used to make beautiful and decorative graves of the Malay royal families and chieftains and also wealthy people. Although they were produced to mark Muslim graves, the motifs are drawn from Hindu and Buddhist religious philosophy [8]. Batu Aceh has a very complex shape and structure. Due to this, it is hard for someone to know and identify each of them. Over the early decades, many studies and researchers have been conducted. However, different interpretations were used by different researchers in making such classification.

Due to various entitlement, Associate Professor Dr. Othman Mohd. Yatim have done a research on classifying the Batu Aceh based on the similarities of each type [4]. Each type of Batu Aceh are classified by centuries. Historically and culturally the gravestone

deserve to be regarded as a important heritage of Malay civilization, especially when one considers the fact that other items of Malay civilization have long been damaged due to environmental factors and time. Batu Aceh is one of the gravestones group type. It is a sculptured stones as it has an elaborate decoration carved on them. While unsculptured stones are stones that comes from river pebbles, which are left in their natural state with no attempt to reshape them.

2.1 Difficulties in finding the Batu Aceh monument

Currently, there are several problems faced by the Malaysian archaeologist mainly in finding the location of the historical sites and monuments [4]. Below are the difficulties in finding Batu aceh monument:

1. There had been many changes in Malaysia, politically, naturally and geographically. These changes either taken place naturally or deliberately. The term naturally means that the disasters such as successive floods experienced by many states in Peninsular Malaysia. This floods cause changes to many items of historical and cultural importance being either damaged or lost forever.
2. Before Malaysia gain independence, many villages that contain Batu Aceh were not yet developed and these places were frequented by wild animals. Some of this Batu Aceh was partly damaged because of rampaging elephant. Some was knocked down by a buffalo, when it tried to scratch its back against the Batu Aceh. Some are buried naturally.
3. Many of the former capital of Malay states were located along rivers and most of these places are now abandoned together with the gravestone. The place can only be reached by boat, sometimes hours of walking and tracking the hills.
4. Other problem is that they were exposed to tropical climate for many centuries causing the Batu Aceh carve deteriorated.
5. Some Batu Aceh was destroyed as result of the ignorance of people of their historical and aesthetical values.

2.2 Batu Aceh Typologies

A significant fact about Batu Aceh is that it has a variety of shapes, decorations and sizes. The variety of shapes and decorations of Batu Aceh presented descriptive problems. Therefore, Dr. Othman Mohd Yatim, in his book titled *Batu Aceh: Early Islamic gravestones in Peninsular Malaysia* have introduced his own typology system of Batu Aceh. His writing has been the most established and represent the main reference of researchers in his area until now. The typology systems consist of fourteen types of typology. Each typology is named using Roman letters starting from A until N.

These fourteen sub types were designated as Othman Types. Each particular Othman Type has in its shape, certain unique features or certain unique combination of features not found on the other types. This would enable it to be differentiated. Before it is able to be differentiated, each Batu Aceh is divided into six parts. The parts are top, head, shoulder, body, foot or base and shaft. Each part has its unique features. The types are differentiated by distinguishing all of the features of each part. In his writing, he mentioned that the clearest way of distinguishing the Othman Type is to take into account the shape of Batu Aceh.

The centuries of each type are distinguished due to the changes of the Batu Aceh shape from slab to pillar and the chronology of the historical existence. According to several historical evidence founded [4, 6], it is believes that the changes of Batu Aceh shape from slab (A-F) to pillar (G-N) probably occurred in the sixteenth centuries. Some of the images are not available enough for the purpose of recognition process because of the poor understanding of historical and aesthetical values or uncontrollable effects of nature.

Figure 1 shows the type of topology available and selected for the recognition process of the devised system.

3 Approach and Method

In strategizing this research, there are five major phases involved. The discussion of each phase would be described in the next sections.

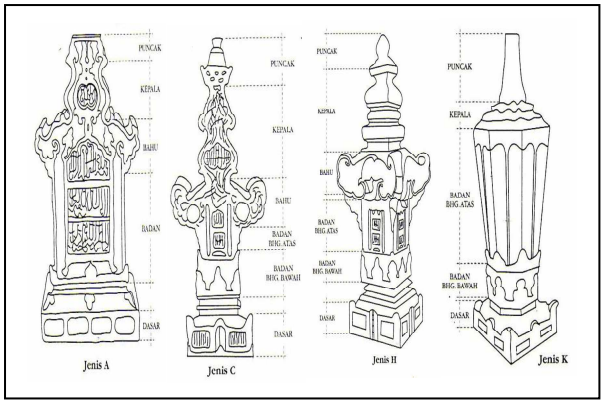

Figure 1. Type of typology selected for the system [6]

3.1 Image Acquisition

Image acquisition involves the process of obtaining the raw data. This is the most critical and important stage in any studies. As mention earlier in the article, the writer only focuses on the existence of Batu Aceh within the Peninsular Malaysia. The example of the images used is referred to Batu Aceh found in Johor [8]. The image is then converted to digital image by scanning the image into the computer. The type of Batu Aceh to be recognized are A, C, H and K, please refer to figure 1. Although each have different type of shapes, but not all of them are perfect as the characteristics describes. Therefore it is important to have enough set of training data in order to increase the recognition rate.

The network has to be train in order to get the accurate result. In this case, 65 images have been scanned. The training data consist of 10 images of each type of typology. The testing data consist of 5 images of type A, 10 images of type C, 2 images of type H and 8 images of type K. The reason for the different amount of data being tested is because this is the amount of images that are left for each type, after 10 images have been used for training. The difficulties of gaining enough images for testing is due to, not many researches were done on Batu Aceh, as it is a historical artifact and no longer made available. Other reasons are as mentioned earlier in section 2.1.

3.2 Preprocessing

The Batu Aceh images obtained are manipulated before being input into the prototype developed. This stage involves four processes which are shown below:

Process 1:Image Enhancement

- Some of the Batu Aceh images are selected to be enhanced using Adobe Photoshop.

Process 2 : Image Normalization

- All of the images were normalized to image size of 192 pixels x 330 pixels, resolution of 150 and kept in an image file Joint Photographic Experts Group (*.jpeg).

Process 3 : Image Segmentation

- The image is first converted into grey-scale image. By using the Matlab command, the true-colour image RGB is converted to the grey-scale.
- Thresholding process will convert the greyscale image into binary image. Thresholding is also called binarization. The output binary image has values of 0 (black) for all pixels in the input image with luminance less than threshold and 1 (white) for all other pixels. Figure 2 shows the conversion of grey-scale image to binary image.

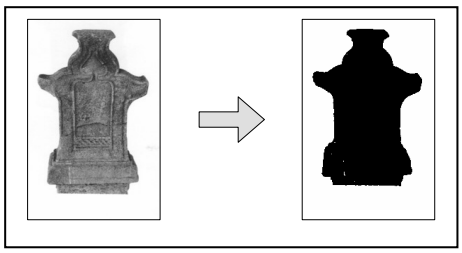

Figure 2. Grey-scale to Binary image

Process 4 : Image Representation

- The raw data is processed by transforming it into a suitable image for processing. The processes involves in image representation are Edge Thickening, Image Negative and Resize.
- After the image has been converted to the binary image, the image is then edge in order to find the outline of the shape. Then the edge is being thickening to make the outline clearer and wider. Figure 3 shows the edge thickening.

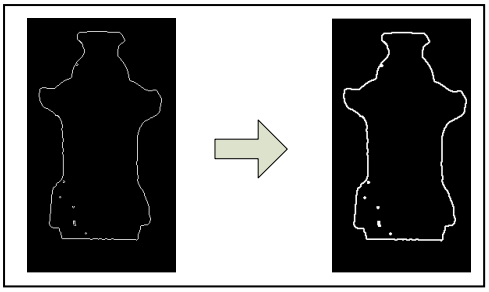

Figure 3: Edge Thickening

- The process continues to fill the shape area for holes elimination and then the not fill process to get back the shape of binary image. After that, it follows by reversing the intensity levels of an image to produce a photographic negative. Figure 4 shows the image negative.

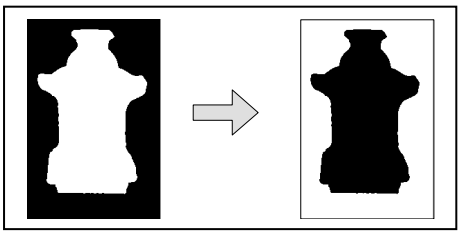

Figure 4. Image Negative

- The image negative would then goes through the image resize process. This process will make the image to have different sizes which the images are then resized to 19 x 33 pixels to standardize the input. This made it easier for the input to be feed through the network. Figure 5 below shows image resize.

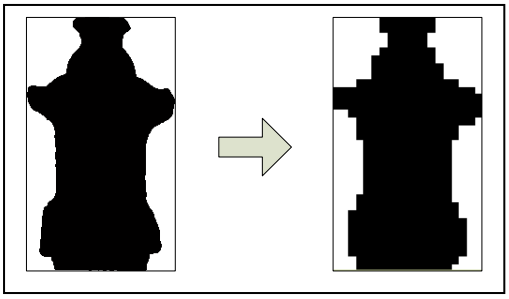

Figure 5. Image Resize

3.3 Network Architecture

The approach of back propagation neural network algorithm will be used for both training and classification task. The neural network developed consist of 627 input nodes corresponds to the number of pixels on input of the Batu Aceh image that is 19 x 33 pixels. While the number of output node, corresponds to the number of typology to be identified. After several experiments conducted, the best number of hidden node defined was 40 nodes with learning rate 0.04. Table 1 shows the properties of the neural network developed.

Table 1. The properties of neural network developed

Layer	Number of Layers	Number of Node
Input	1	627
Hidden	1	40
Output	1	4

The first output node corresponds to Type A, second for Type C, third for Type H and fourth for Type K. Table 2 shows the target value of each output node.

Table 2: The Target Value for each output node

Typology Type to be Recognized	**Output value**
A	[1 0 0 0]
C	[0 1 0 0]
H	[0 0 1 0]
K	[0 0 0 1]

3.4 Backpropagation Algorithm

The next explanation shows the workflow of the back propagation algorithm that was used for training.

- Step 1: Define the data vector for the 40 Batu Aceh images and the target vector or desired output.
- Step 2: Define the network activation function by setting the number of hidden node, sigmoid transfer function and the weight in the range [-0.5, 0.5] and bias.
- Step 3: Define the network training function and the actual output are calculated.
- Step 4: The error gradient and the network performance are computed.
- Step 5: The weight and bias are updated until the performance goal is met.

4 Findings and result

Several experiments have been conducted in order to achieve the desired and targeted results.

4.1 Performance of Neural Network Training

The most critical phase in designing a network is to determine the network parameter in the network. In measuring the network performance a repetitive experiment and testing was done. The number of epoch is monitored in order to indicate the network performance of image trained. The number of neuron in the hidden unit affects both the accuracy of recognition and speed of training the network [5]. Complex pattern cannot be detected by a small number of hidden neuron, however too many of them can increase the computational burden. The greater number of hidden neurons, the greater the ability of the network to recognize existing patterns. However, if it is too big it would lead the network to memorize all training example. This might prevent it from generalizing or producing the incorrect output when the network presented with the data that was not used in training. This problem is called overfitting [5].

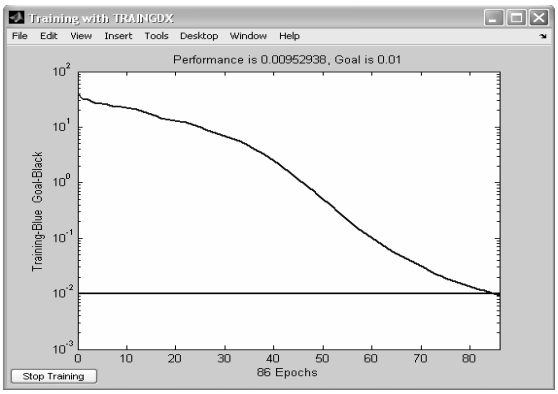

Figure 6 The successful network performance

According to Negnevitsky [5], the small learning parameter, causes the small ranges of weights in the network and leads to smooth learning curve. While large learning rate parameter will make the training process to speed up and may cause instability or become oscillatory. Therefore, several experiments were done in order to get the optimal number of hidden node and learning rate. In designing the neural network there are several parameters that have to be determined. After several experiment conducted, 0.04 learning rate value with 40 hidden layers was found to be the optimal value to set in the neural network parameters. Figure 6 shows the successful network performance. The learning curve is smooth and the performance goal is met.

4.2 The Accuracy of Typology Identification

In order to find the accuracy of typology identification a set of 25 testing data are used to measure the performance of the neural network. The performance of the network will vary each time the data are being input because of the learning process. Due to this, each of the data are being tested 3 times corresponds to the number of 3 days. Table 3 below summarizes the average recognition rate for each Batu Aceh typology. The total recognition rate is about 72.5%.

Table 3. The Average Recognition Rate of Batu Aceh Typology

Typology Type	Day 1	Day 2	Day 3	Average Recognition Percentage
A	80%	80%	80%	80%
C	70%	90%	70%	76.67%
H	50%	50%	50%	50%
K	87.5 %	87.5 %	75%	83.33%
Total Recognition rate				72.5%

4.3 Implementation

In the implementation phase, all the algorithms defined previously are transformed into coding**.** The transformation of coding begins from the pre-processing stage that is image segmentation and image representation, and then continued to the neural network design until the prototype was developed.

4.4 Prototyping

The prototype was built using the Matlab Graphical User Interface (GUI). Programming the prototype using this application is an advantage as it is mainly designed with intelligent features to help in solving many processes in recognition. Figure 7 shows an example of a successful recognition of Batu Aceh typology using the testing image. The lowest result value from output 1 until output 4 would determine the type of the Batu Aceh. Output 1 is the value for type A, output 2 for type C, output 3 for type H and output 4 for

type K. As shown in table 2, output value 1 is the lowest. This determines that it is recognized as type A and classified in 1400AD.

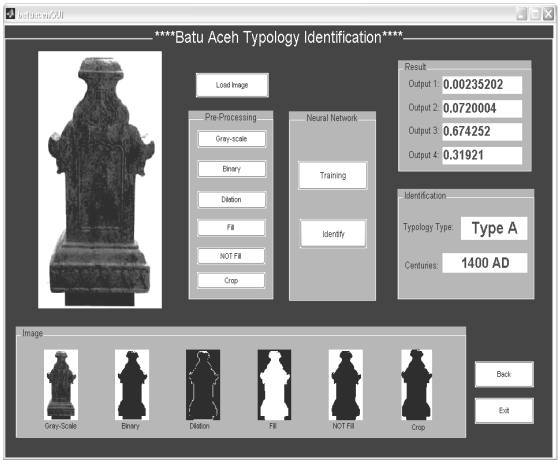

Figure 7 Recognition of Batu Aceh Type A

During the training process, at the same time the graph of training performance will appear representing the plotted learning curve of the network performance towards the goal of sum squared error. This shows the successful network performance. Meanwhile, the learning curve is smooth and the performance goal is met.

5 Conclusion and future works

The developed prototype is capable of pre-processing a true-colour image that have various size of images, the image would then goes through the other processes until the image are resized back to an appropriate size to able to be fed in the network designed. Besides that, the prototype is able to identify the four type of Batu Aceh typology with a reasonable percentage of accuracy.

From the analysis and discussions done on the results of the research, there are several recommendations and suggestions for future references and guidance for similar research. The first suggestion is to obtain enough data for training, at least 100 images for each type. If the training data is enough, the neural network can learn better and increase the accuracy of recognition percentage. The second recommendation is by using a different problem of data in recognizing certain patterns and redesigns the network using the same technique. For this Batu Aceh identification task, the neural network can be design using other learning algorithm besides backpropagation. The third suggestions is to do a lot of research an gain as much knowledge on how to find best value in setting the value of parameters. Although there are no specific rules proven but the results and analysis from the previous research should be as references and guidance for future research.

6 Acknowledgement

The authors would like to sincerely thank to our research student, Faizatul Huda Mat for her valuable work that support this research.

References:

[1] Avrithis, Y., Yiannis, S. X., Stefanos, D., Affine Invariant Representation and Classification of Object Contours for Image and Video Retrieval, *Computational Intelligence and Applications*, World Scientific and Engineering Society Press, pp. 342-347. 1999

[2] Belongie, S., Malik, J., and Puzicha, J., Matching Shape, Technical Report UCB//CSD-00-1128, *UC Berkeley*, July 2001.

[3] Gonzalez, R.C.,Woods,R.E., Digital Image Processing, United State of America: *Addison-Wesley Publishing,* 1992

[4] Mohd Yatim, O., Batu Aceh: Early Islamic gravestones in Peninsular Malaysia**,** *Kuala Lumpur: United Selangor Press*, 1987.

[5] Negnevitsky, M., Artificial Intelligence: A Guide to Intelligent Systems*, Addison-Wesley.England*, 2005.

[6] Perret, D., Kamarudin A.R., Batu Aceh: Warisan sejarah Johor, *Yayasan Warisan Johor*, 1999.

[7] Scott, E.U., Computer Vision and Image Processing: a practical approach using CVIPtools, *United State: Prentice Hall*, 1999.

[8] Tajudeen, I., Batu Aceh's Syncretism - The Role of the Community in Artistic Endeavour, *National University of Singapore*, 24 June 2003.

[9] Whelan, P.F., Molloy, D., .Machine Vision using Java: Tecnique and Implementation, *London (GB):Springer-Verlag*, 2001.

[10] Young, I.T., Gerbrands, J.J,, Van Villet, L.J., Image Processing Fundamental. Department of imaging science and technology, *Faculty of Applied Science: Deflt University of Technology*, 1999.