Batu Aceh Typology Identification Using Back Propagation Algorithm

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Abstract: - Historical and cultural artifacts have defined the existence of humankind all over the world. It is therefore important to preserve this heritage for future endeavors. In the Malay-Indonesia Archipelago, the forgotten and extinct artifact is the Islamic gravestone that originated in Aceh known as Batu Aceh. This research is an attempt to preserve our heritage by developing a prototype to guide the future generation to appreciate these precious cultural heritage artifacts. Back propagation algorithm is applied on a supervised classification of Batu Aceh object images. Several images of each type of Batu Aceh are used as training samples. Data samples were converted into binary forms and used to train the network. To ensure the performance of the system, network parameters such as momentum value, learning rate and number of hidden neuron would be adjusted to get the appropriate setting. It is found that the prototype devised can identify the type of Batu Aceh presented and its century. This research would provide experts in this field an alternative to identify damaged or unclear images of Batu Aceh.

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

1 Introduction

Computer vision is computer imaging where application does not involve human beings in the visual loop. In other words, the images are examined and acted by a computer. Although people are involved in the development of the system, the final application requires a computer to use the visual information directly [8]. The human visual system application such as robotics, biology, medicine, computer science, and engineering helps in increasing the technology of human visual system [1].

One of the major topics within the field of computer vision is image analysis. Image analysis involves the examination of the image data to facilitate solving a vision problem [10]. The image analysis process involves two topics: *feature extraction* and *pattern classification*. Feature extraction is the process of acquiring higher-level image information, such as shape or colour information while pattern classification is the act of taking the higher-level information and identifying objects within the image.

Building a computer vision system has proven to be difficult and complex [13]. The pattern recognition system such as face recognition, thumbprint recognition, 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 presented are Batu Aceh images within the Peninsular Malaysia. This research would encourage the younger generation in knowing Batu Aceh as a historical artifact as it is no longer being made [7].

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 13^{th} century to the 19^{th} 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 [12]. 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 researchers in making such classification used different interpretations.

Due to various entitlements, Associate Professor Dr. Othman Mohd. Yatim have conducted a research on classifying the Batu Aceh based on the similarities of each type [5]. Each type of Batu Aceh is classified by centuries. Historically and culturally the gravestone deserves to be regarded as an 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. These sculptured stone have elaborate decorations carved on them. While unsculptured stones are stones that come 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

There are several problems faced by the Malaysian archaeologist mainly in finding the location of the historical sites and monuments [5]. Below are the difficulties in finding Batu Aceh monuments:

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

2.2 Batu Aceh Typologies

A significant fact about the 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.

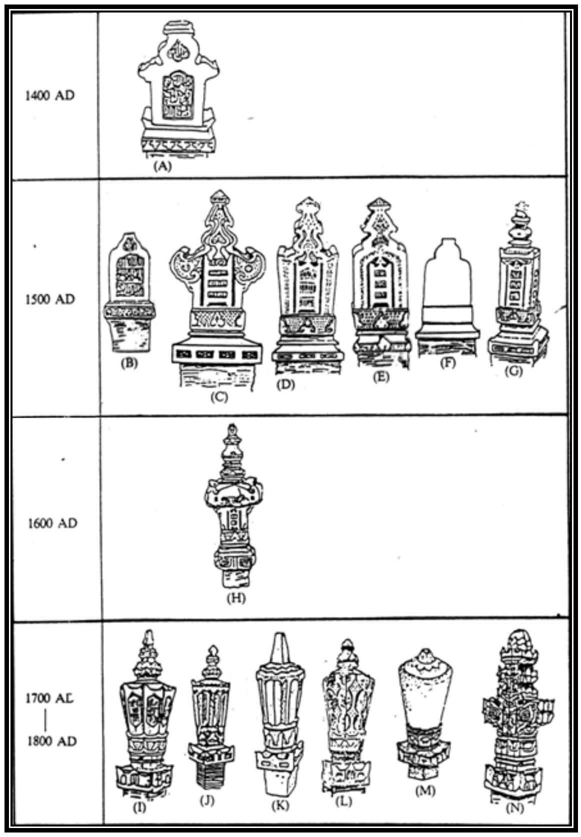

Figure 1 The fourteen types of Batu Aceh according to its century [5]

Therefore, Dr. Othman Mohd Yatim, the writer of the book titled *Batu Aceh: Early Islamic gravestones in Peninsular Malaysia* has introduced his own typology system of Batu Aceh [5]. His writing has been the most established and main reference of researchers in his area until now. The typology system consists of fourteen types of typology. Each typology is named using Roman letters starting from A until N as shown in Figure 1.

Each of the fourteen sub types was designated as Othman Types. Each particular Othman Type has in its shape, certain unique features or certain combination of features not found on the other types. This would enable it to be differentiated.

Before differentiating it, each Batu Aceh is divided into six parts. The parts are top, head, shoulder, body, foot or base and shaft as shown in figure 2. Each part has its different features. Distinguishing all features of its parts would differentiate each type. The writer pointed out that the clearest way of distinguishing the Othman Type is to take into account the shape of Batu Aceh.

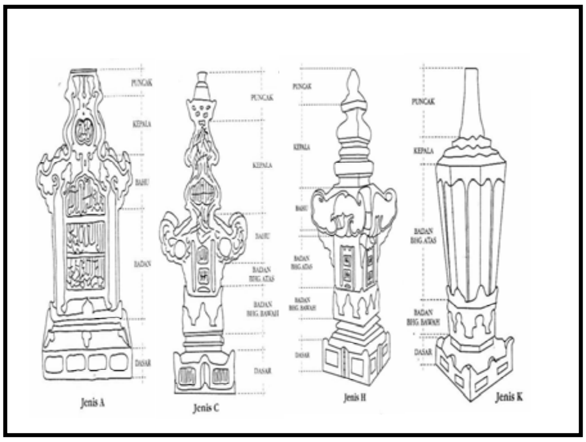

Figure 2 Type of typology selected for the system [7]

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 believed that the changes of Batu Aceh shape from slab (A-F) to pillar (G-N) probably occurred in the sixteenth centuries. Figure 1 shows the fourteen types of Batu Aceh according to its century. Meanwhile Figure 2 shows the selected type of topology to be recognized in the system.

3 Approach and Methods

In strategizing this research, five major phases are involved. The discussion of each phase would be described in the next sections. The detailed diagram of the development is shown in Figure 3.

3.1 Image Acquisition

Image acquisition involves the process of obtaining raw data for this research. This is the most critical and important stage in any study. To acquire a digital image, an image sensor and the capability to digitize the signal produced by the sensor is required. The sensor could be a monochrome or colour TV camera, a video camera, a scanner or other image sensor that would be able to produce a digitized image [3].

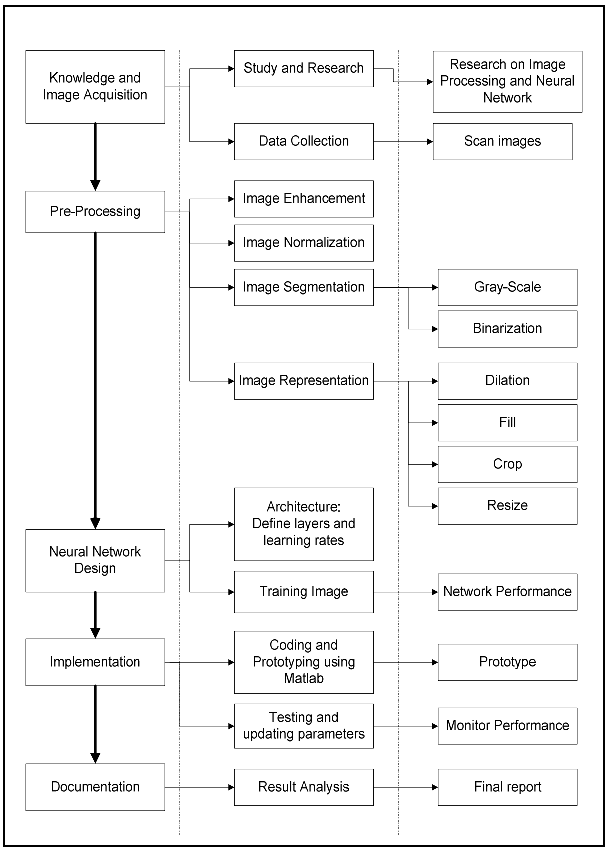

Figure 3 Methodology and Research Approach

As mentioned earlier, 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 and it is obtained from the book titled *Batu Aceh: Warisan Sejarah Johor* [7]. The image is then converted to digital image by scanning the image into the computer. The types of Batu Aceh to be recognized are A, C, H and K, please refer to Figure 2. Although each type has different type of shapes, not all of them are perfect as the characteristics describes. Therefore it is important to have an appropriate set of training data in order to increase the recognition rate.

The network has to be trained 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 more images for testing is due to not many researches were done on Batu Aceh, as it is a historical artifact and no longer made. Other reasons are as mentioned earlier in section 2.1.

3.2 Preprocessing

The key function of pre-processing is to improve the image in order to increase the success of the other processes [9, 14]. Referring to Figure 3, the Batu Aceh images obtained are manipulated before it is used as an input in the prototype development. This stage involves four processes as discussed 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

- Segmentation is defined as a technique that is used to find the object of interest [4, 11]. For this research, 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 would convert the greyscale image into binary image. Thresholding is also called binarization [6]. 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 4 shows the conversion of grey-scale image to binary image.

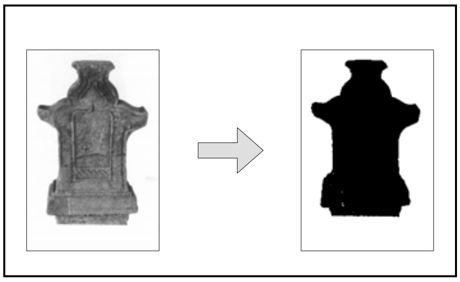

Figure 4 Grey-scale to Binary image

Process 4: Image Representation

- The raw data is processed by transforming it into a suitable computer process. The processes involved in image representation are:
    i. Edge Thickening
    ii. Image Negative and
    iii. Resize

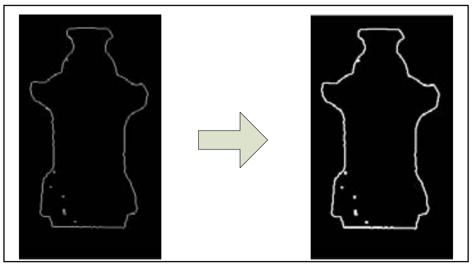

Figure 5 Edge Thickening

- After the image has been converted to the binary image, the image is then edged in order to find the outline of the shape. Then the image is dilated to make the outline clearer and wider. Figure 5 shows the edge thickening process.
- The conversion continues with image negative process. The process would than fill the image and helps to eliminate the holes by filling the area of the shape. After that, it follows by reversing the intensity levels of an image to produce a photographic negative of the Batu Aceh binary image. Figure 6 shows the image negative process.

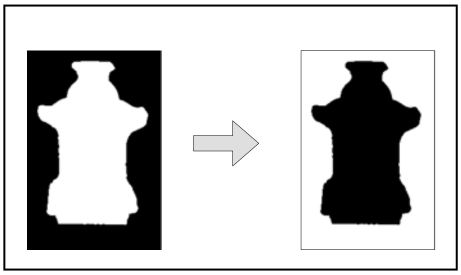

Figure 6 Image Negative

- The filled image would then go through the image crop process. This process would make the image have different sizes. To solve this problem, the images are then resized to 19 x 33 pixels to standardize the input. This would be easier for the input to be fed through the network. Figure 7 below shows the conversion from cropped image to resized image.

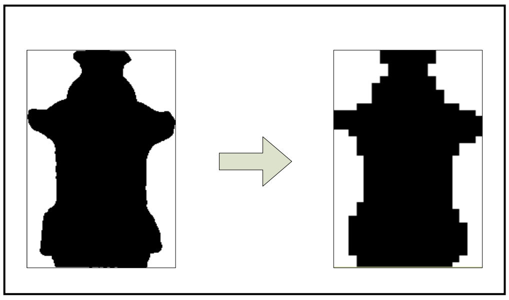

Figure 7 Image Resize

3.3 Network Architecture

The approach of back propagation neural network algorithm would 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 type of typology to be recognized. 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 neural network developed.

Table 1 The properties of NN 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]

Figure 8 shows the architecture of neural network developed.

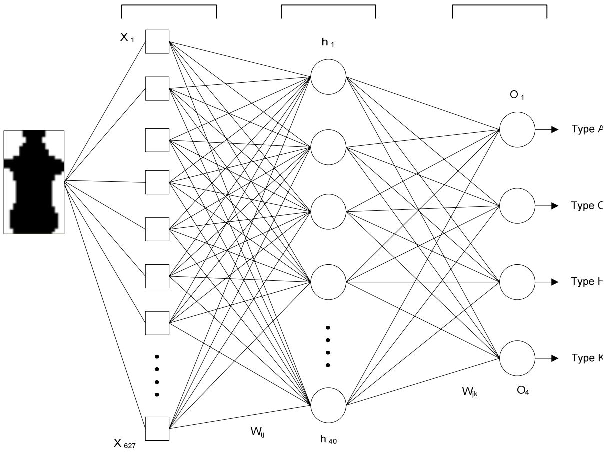

Figure 8 The architecture of neural network developed

3.4 Backpropagation Algorithm

The next explanation shows the workflow of 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 calculated.
- Step 4: The error gradient and the network performance are computed.
- Step 5: The weight and bias are updated until it 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 [6]. The 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 is presented with the data that was not used in training. This problem is called overfitting [6].

According to Negnevitsky [6], the small learning parameter, causes the small ranges to weights in the network and leads to smooth learning curve. While large learning rate parameter would 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.

Table 3. Parameter Setting

Hidden Node	Learning rate	Epoch	Squared of error
10	0.01	100	0.15318101
	0.02	100	0.01580440
	0.03	100	0.01637897
	0.04	100	0.01118626
	0.05	90	0.00970183
	0.06	100	0.01417742
20	0.01	100	0.03066025
	0.02	100	0.02983373
	0.03	88	0.00999344
	0.04	100	0.01269001
	0.05	100	0.00983382
	0.06	99	0.00994191
30	0.06	86	0.00933528
	0.07	74	0.00937079
	0.08	80	0.00981998
	0.09	77	0.00978282
40	0.01	100	0.01404241
	0.02	95	0.00956026
	0.03	97	0.00988516
	0.04	**73**	**0.00942075**
	0.05	79	0.00994514
50	0.01	100	0.01668248
	0.02	96	0.00986079
	0.03	94	0.00934485
	0.04	100	0.03480919
60	0.01	100	0.01236221
	0.02	100	0.01529243
	0.03	85	0.00969692

Table 3 shows the result of the testing. The highlighted rows are the parameters that have met the performance goal of 0.01. The highlighted rows that have been bold are the optimal value of hidden layer and learning. Referring to Table 3, 0.04 learning rate value with 40 hidden nodes was found to be the optimal value to be set in the neural network parameters. Figure 9 shows the successful network performance. The learning curve is smooth and the performance goal is met.

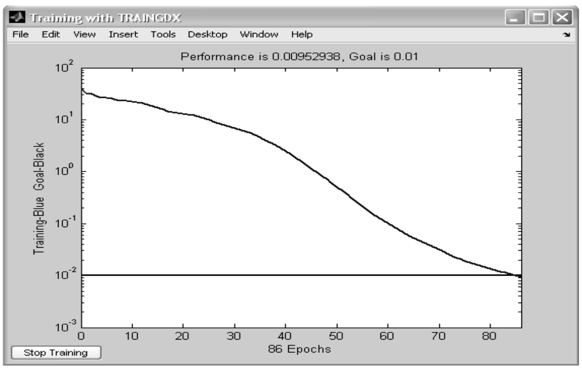

Figure 9 The successful network performance

4.2 Recognition Rate

After the training process is completed, the network is then tested to determine the recognition rate of typology identification. The network is being tested by a new Batu Aceh image that has not being used in the training process. The recognition rate is calculated using a standard percentage (%) calculation formula as shown in Figure 10.

Recognition rate =
$$\frac{\text{Total number of successful image}}{\text{Total number of testing image}} \times 100\ \%$$

Figure 10 Calculation of Recognition rate

4.1 The Accuracy of Typology Identification

In order to find the accuracy of typology identification a set of 25 testing data were used to measure the performance of the neural network. The performance of the network would vary each time 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 4 below summarizes the average recognition rate for each Batu Aceh typology. The total recognition rate is about 72.5%.

Table 4 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, the algorithm defined previously is transformed into C++ programming language**.** The transformation of coding begins from the pre-processing stage that is from the image segmentation and image representation, and then continued to the neural network design until a 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 11 shows the Batu Aceh Typology identification interface.

Figure 12 below shows the example of successful recognition of each Batu Aceh typology using the testing image. The lowest output 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.

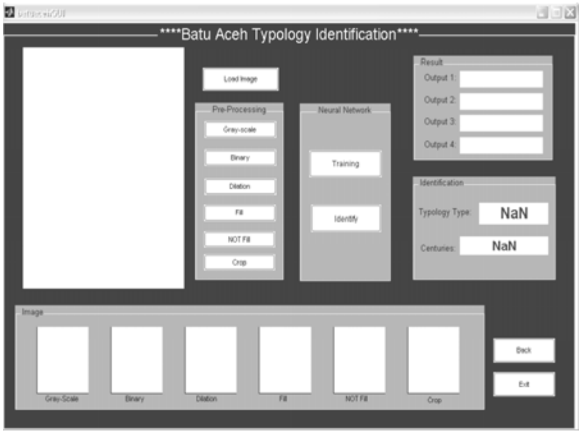

Figure 11 The Batu Aceh Typology Identification Interface

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

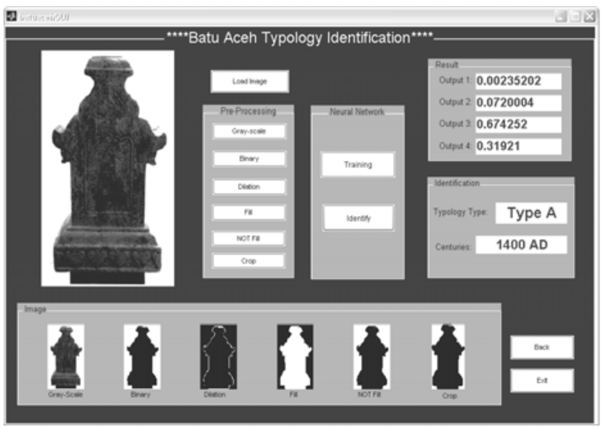

Figure 12 Recognition of Batu Aceh Type A

During the training process and at the same time the graph of the training performance would appear representing the plotted learning curve of the network performance towards the goal of sum squared error. Figure 13 below shows the sample graph of the training performance involved in this system.

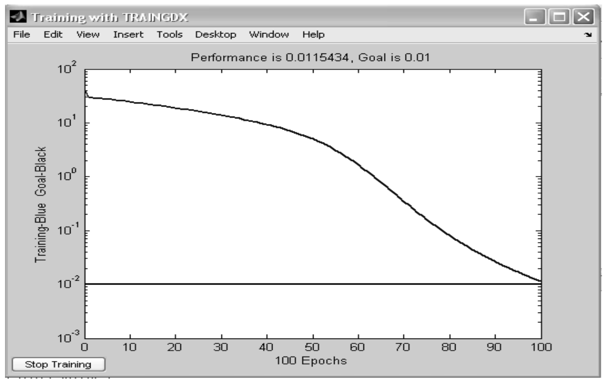

Figure 13 Sample of graph training performance

5 Conclusion and future works

This research was conducted to develop a prototype that would be able to identify the four types of Batu Aceh typology. The work involves an image pre-processing and designing of the neural network to ensure the desired result achieved. Thus, this reserach focuses on finding the appropriate method of image pre-processing and designing of the neural network and setting of the network parameter for solving Batu Aceh recognition problem.

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

The major constraint in doing this research is not having more images for training and also for testing. It is believed that the accuracy of the recognition would be higher and designing of proper neural network architecture would be sound if more images are obtained. Finally, it is hoped that the developed prototype would encourage the younger generation in knowing Batu Aceh as a historical artifact and provide insight in preserving this historical artifact.

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