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Handwritten English Character Recognition Using Gradient Feature Extraction

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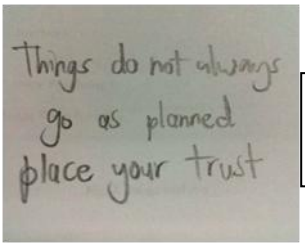
***Abstract**: Handwritten recognition measures the computer's ability to receive and interpret the image input from sources such as documents, pictures or touch screen and turn it into a digital format that can be read and edited. The usefulness of this technology are among others to extract information from postal address envelopes, banking transactions, reading various forms from tax forms, insurance, registration and so on. These days there are a number of methods and researches that has been carried out to identify handwritten characters each having their own credits and successes. In this project handwritten recognition system has been developed using artificial neural network. Images must first undergo some pre-processing process image before the feature characteristics of the image are extracted by using gradient feature. Recognition tests carried out on the images of written English sentences and characters indicates that the neural network with gradient feature extraction provides good recognition accuracy at an average of 86.2% for individual characters in sentences.*

***Keywords:** Artificial Neural Network, Gradient Feature, Handwritten Recognition*

1. INTRODUCTION

Handwritten character recognition (HCR) has become one of the most exciting and challenging research in the area of areas of computer vision and pattern recognition in recent years [1],[2]. The demand of this technology continues to increase since there is high advancement in the human-computer interaction that requires automatic or semi-automatic system in various applications. HCR is a computer's ability to process and interpret handwritten input from a source like still images, scanner, digital cameras and other devices to eventually produce a digital version of the handwritten – Figure 1. HCR system involves several phases of digital processing technique that includes pre-processing of raw images, feature extraction and classification. In general, HCR can be classified into two types which are online and offline [3],[1].

Off-line character recognition includes automatic conversion of characters within an image into digital characters that can be edited and manipulated using computer applications and text-processing. On the contrary on-line character recognition consists of the automatic conversion of text that is written on specific application like tablet or smart phone, where a sensor that detects the pen-tip movements generate signals that are being processed to produces digital characters used in computer applications and text-processing. Both off-line and on-line methods have their own challenge in character recognition but due to unique style and on-set training, on-line method proved to be superior to their off-line counterparts.



Things do not always go
as planned
Place your trust

Figure 1: Ideal handwritten recognition. Handwriting (left), digital version of the handwiting (right)

However recent researches using neural network proved successful and high recognition accuracy of off-line system as well [4]. Based on the current demand for variety of applications, off-line method continues to growth with the advancement of new techniques with different challenges.
Variation in handwriting leads to great difficulty in identifying the character patterns [5]. Various studies and researches have been conducted in designing hand written character recognition system. Many findings of recognition using artificial neural network have been reported in many publications [1],[3],[6], [7],[8] neural network remains as a popular choice due to its simplicity, fast and reliable tools for recognition with most report claim an average more than 90% accuracy. Some used single layer [5] while others used multilayer neural network in order to get optimum results. Variety of feature extraction methods were used in conjunction with the neural network classification. Besides neural network, other method includes the application of fuzzy logic into the recognition [9],[10], which also reported

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WINGS TO YOUR THOUGHTS.....

high accuracy rates at the average of more than 80% accuracy.

In this paper we emphasize the recognition for a constraint handwritten English characters that include 26 symbols. A sample of the characters is shown in Figure 2. Constraint handwritten means that the style of the handwritten are not too difficult to read and bear a resemblance to the standard look. The main objective is to take in the image of English characters as the input, process and train the images using gradient feature extraction to finally recognize image of sentences as well as individual characters. Neural network is playing an important role in the overall framework. Although many reports of character recognition in English have been published recognition accuracy of handwritten English characters using neural network still remain an open problem and subject for further improvement.

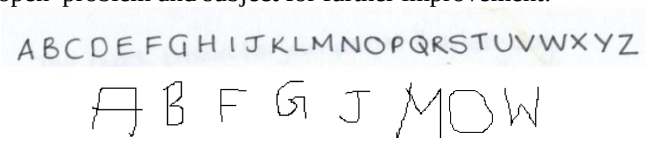

Figure 2: Sample of handwritten characters.

2. METHODOLOGY

The methodology consists of two major parts, (1) image pre-processing and (2) feature extraction and classification.

PRE-PROCESSING

Pre-processing combined several image processing techniques in a specific order that aim to eliminate background noise and making it appropriate for input for feature extraction and recognition. Major steps under pre-processing comprises of five phases:

- Binarization
- Edge detection
- Morphological
- Segmentation

a. Binarization

The image was converted to grayscale prior to binarization. The conversion to grayscale is to eliminate information and saturated colors while maintaining the luminance.

Binarization changed the grayscale image to binary image using threshold. The output black and white binary image has values 1 (white) for all pixels in the input image with luminance greater than the specified threshold and 0 (black) for all other pixels.

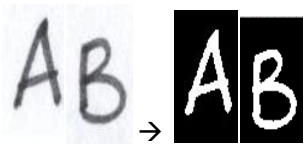

Figure 3: Image binarization

b. Edge Detection

Sobel method was used to detect the edge of the letters in the image. Edge detection function is to detect the edges of an object in an image. In Sobel approximation, it returns the edge at the area where the gradient is a maximum at the neighboring pixel. To detect the edge of a binary image is very easy and accurate due to the significant difference between black and white pixels. For an input, Sobel will restore the image with pixel 1 where the edge is detected and 0 in place otherwise.

c. Morphological

The purpose of morphological operation is to find the shape or feature of the input image and it includes image dilation and image filling. A square element was used to scan through the image while applying image dilation on the grayscale image returning the dilated image.

Next, image filling will fill a set of background pixels into the inside edge of the image.

Figure 4: Image dilation (left) and image filling (right)

d. Segmentation

In the segmentation phase, the image was scanned and a technique called labeling technique was used to identify the locations of the desired characters that were to be separated and processed. The labeling process will give information about the number of characters detected in the image and size of the identified character will be standardized. Once identified, the separated character will be normalized based on the size of the characters itself in order to optimize the process. This is because each character varies in size with some are very significant.

FEATURE EXTRACTION AND CLASSIFICATION

A. Feature Extraction

The main purpose of feature extraction is to get a set of features that can maximize detection rates using the fewest number of elements. Each alphabet's feature was extracted based on its gradient with respect to background image. The gradient measures the magnitude and direction of the biggest changes in the intensity image within the neighborhood pixels. Just as edge detection, gradient measured based on Sobel operator. Sobel template used to calculate the horizontal (x) and vertical (y) components of a slope is shown in the figure below [11]:

1	2	1
0	0	0
−1	−2	−1

−1	0	1
−2	0	2
−1	0	1

Figure 5: Template of gradient component for horizontal and vertical components

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INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY

WINGS TO YOUR THOUGHTS.....

For every input image, each neighborhood pixel will be convolved with the template to get gradients for X and Y components, Cx and Cy each and finally provide gradient features of the desired character. The resulting gradient vector [Cx,Cy] will give indication of the gradient strength and its direction. The vector can be decomposed into eight direction planes as shown below:

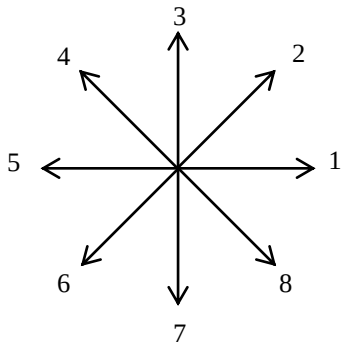


Figure 6: Direction of gradient vector

Each image will be divided into 9 vertical and horizontal sections that makes up all together 81 blocks. The gradient vector will be computed and accumulated for each of the block. By down sampling the vertical and horizontal to 5 sections for each once respectively, Gaussian filter then being applied in order to obtain a feature vector of size 200, 8 gradient direction in each block. This is the feature that store each character's feature.

$$Gv[i] = [Cx, Cy]i \times 8\, planes \quad (1)$$

$$fv = Gaussian\ filter(Gv[i]) \quad (2)$$

Where i is the number of block, Gv the is the gradient vectors and fv is the feature vector of an image. The applied Gaussian filter is from the image processing toolbox in Matlab.

B. Artificial Neural Network Classifier

Based on its well-known classification performance in pattern recognition field, artificial neural network was used to classify the character based on the feature weight of the character image. The nodes that symbolized the brain neurons contain weight feature information of each image. The nodes are interconnected in some way that will determine the output of each node in a varying degree. Eventually these weights will be compared to those stored in the trained set so as to match to the character that is having the similar feature. This project utilized two-layer neural network, one is hidden layer and the other is the output layer. Hidden layer will process the feature weight based on feature extraction algorithm while output layer will compare the weights of the hidden nodes to those in the database and finally recognize the character. The multilayer of this ANN is depicted in Figure 7 below:

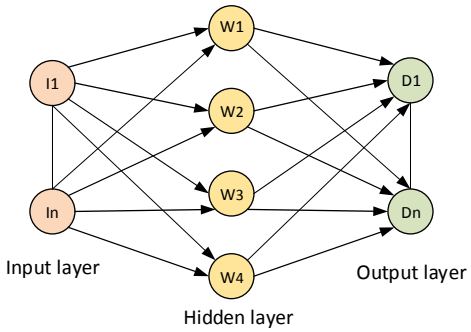


Figure 7: Artificial neural network structure.

I_n is the input neurons
W_n is the weight feature input neurons.
D_n is the weight distance between input and trained set.

The procedure and calculations are as follow:

$$W_i = \sum |fv_j|^2 \quad (3)$$

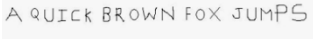
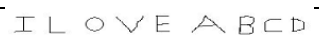
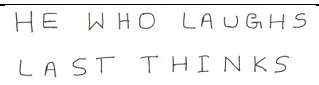
$$D_E = (W_{te}{}^2 - W_{tr}{}^2)^{\frac{1}{2}} \quad (4)$$

Where D_E is the feature distance, W_i is the feature weight and W_{te} and W_{tr} are the test and train weight feature respectively for each character image.

3. RESULTS

Many of the steps consumed in the process of recognizing a character are the feature extraction and classification. Table below shows a sample result of some handwritten sentences classification with the output and accuracy rate. The accuracy is calculated from the correct character classification over total character in the sentence.

Table 1: Sample result of English sentences.

Input Images	Output in digital character	Accuracy rate (%)
	EA QUICW SROWN FOX JUMPS	84.21
	DONT OPEN YOUN SOOK	87.50
	I LOVE ASCD	88.89
	REAL MAORIO WINS CHAMPION LEAGUEE	96.40
	HE WHO LAUGHS LAST THINKS SLOWEST	92.87
	HU HELLO GOOO	81.8

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WINGS TO YOUR THOUGHTS…..

From the test of 100 test samples, the average accuracy for individual characters were obtained, as depicted in Figure 8. It is shown that certain characters like 'A', 'C', 'E', 'P', 'S', and 'Y' were classified with high accuracy rate while classification for letter 'B', 'D' and 'I' were poorly classified with less than 50% correct. The system mostly recognize letter 'B' to letter 'S' and letter 'D' to letter 'O'. This may indicates that the feature of the letter pair are about the same.

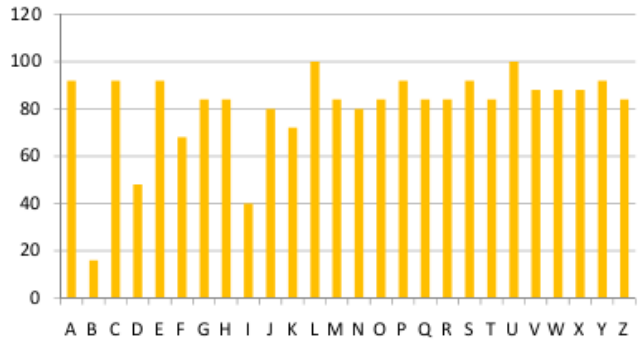

Figure 8: Accuracy of recognizing an individual character (%).

4. CONCLUSION & FUTURE WORKS

This paper proposed a method of recognizing English character by using artificial neural network with gradient function as its feature extraction. It was shown that under proper training dan testing of various English sentences, the rate of accuracy varies from 65% to 100% at an average of 86.2% depending on the complexity of the letter and the handwriting itself. It may also may be due to the fact that some letters were consistently misclassified. This results conclude that the developed system offer an acceptable recognition for English alphabets and thus suitable to be used in many applications. However weaknesses in classifying certain letters like 'B' and 'D' are still an issue and require further attention. The feature extraction could be improved by using multilayer perceptron i.e. using more than one feature but at the expense of processing power and the reading sentences may be combined with word suggestion algorithm. Apart from that, it is important to take into consideration that the training and test conducted in the project were limited to constrained hand-writing only due to the fact that free-style handwriting are quite difficult to be interpreted digitally hence open to further research in the future.

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