

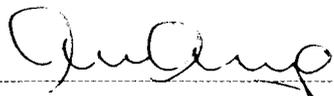
Laporan Projek Tahun Akhir berikut:

Tajuk : **OFF-LINE SIGNATURE VERIFICATION USING  
BACKPROPAGATION TECHNIQUE**

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# **OFF-LINE SIGNATURE VERIFICATION USING BACKPROPAGATION TECHNIQUE**

**P.KHIDMAT MAKLUMAT AKADEMIK  
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To my beloved family

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## **ABSTRACT**

An automated off-line signature verification is becoming an important technology due to most of the financial transaction and documents approval are still being carried out using a paper. This final year project presents a research for developing and designing an off-line signature verification system. Three important stages to develop and design the system are the pre-processing, feature extraction and artificial neural networks. The first stage involves image acquisition and binarization where the signature image is scanned to get the digital image representation and the data is converted to binary image (black pixel=1; white pixel = 0). The second stage is to extract the data into different methods so the system can verify the signature in many position and angle. Therefore, a research for feature extraction methods is needed to develop the system. Three methods of feature extraction that have been used in this project is the aspect ratio, projection profile in horizontal orientation and projection profile in vertical orientation. The third stage involving artificial neural networks that have been known used successfully in many areas especially in pattern recognition. The network is created by finding the best backpropagation function that is provided in MATLAB, which has the highest percentage of verifying each of the signatures. Finally, graphic user interface is used to represent the outcome of the system design.

## ABSTRAK

Sistem automatik mengenalpasti tandatangan secara 'off-line' telah menjadi suatu teknologi yang penting terutamanya dalam sistem transaksi kewangan dan pengesahan dokumen yang masih lagi menggunakan kertas. Projek tahun akhir ini mempersembahkan sebuah kajian untuk membangunkan dan mereka sistem mengenalpasti tandatangan secara 'off-line'. Tiga peringkat penting untuk membangunkan dan mereka sistem ini adalah pemprosesan imej, pengekstrakan data dan rangkaian neural secara artifisial. Peringkat pertama melibatkan cara pengambilan imej dan penukaran data kepada binari dimana imej tandatangan diskankan untuk mendapatkan imej secara digital dan data ini akan ditukarkan kepada imej binari (tompok hitam = 1; tompok putih = 0). Peringkat kedua ialah pengekstrakan data dalam beberapa metod supaya sistem dapat mengenalpasti tandatangan dalam lain-lain posisi dan sudut. Oleh itu, kajian untuk pengekstrakan data ini adalah diperlukan untuk membangunkan sistem ini. Tiga metod pengekstrakan data yang digunakan dalam projek ini adalah secara kadar perbandingan, profail projek secara melintang dan profail projek secara menegak. Peringkat ketiga melibatkan rangkaian neural secara artifisial yang sememangnya telah digunakan dengan jayanya terutamanya dalam bidang 'pattern recognition'. Rangkaian dibina untuk mencari teknik 'backpropagation' yang paling sesuai yang disediakan di MATLAB, dimana ianya mempunyai kadar peratusan yang tinggi dalam mengenalpasti tandatangan. Akhirnya, 'graphic user interface' digunakan untuk mempersembahkan hasil daripada ciptaan sistem ini.

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# CHAPTER 1

## INTRODUCTION

### 1.1 Overview

Signature has been used widely since early history as a proof of individual identity and also for various documents, papers or cheques authentications. Therefore, signature is very important for every person. However, problems may occur when determining whether the signature is genuine or forged. This is because signature is easier to forge than other biological traits of a person such as fingerprint, DNA, retinal or iris identification. Signature recognition and verification is in the area of biometrics technology.

In computer technology, biometrics relates to authentication and security techniques that rely on measurable, individual biological stamps to recognize or verify an individual's identity. For example, fingerprints, handprints, or voice-recognition might be used to enable access to a computer, to a room, or to an electronic commerce account. According to the Encarta World English Dictionary [1], security schemes are generally categorized into three levels:

i. Level 1

It relies on something the person carries, such as an ID badge with a photo or a computer cardkey

ii. Level 2

It relies on something the person knows, such as a password or a code number;

iii. Level 3,

The highest level, it relies on something that is a part of the person's biological makeup or behavior, such as a fingerprint, the pattern of blood vessels in a retina, or a signature.

### **1.1.1 Signature - Off-line versus On-line**

Simple signature comparison is basically using individual visual inspection while in automatic signature recognition using a computer intelligent; it depends on data acquisition methods, which are off-line and on-line methods. In off-line system, the signature's data is taken after the signing process is over, which is the signature's sample is scanned to get the digital image representation [2]. This data is static and only this data is used for analyzing the signature. In on-line system, the signature is dynamically taken using special hardware such as tablet pen and a digitizer to record the information of the changes in angle, direction, speed, pressure, acceleration or time taken during the process of signing [3, 4]. It gave more information and advantages where usually only the original signer can recreate the same motion of its signature [3].

As compare to on-line signature verification system, off-line system is difficult to design as many desirable characteristics such as the order of strokes; the velocity and other dynamic information are not available in the off-line case. The verification process has to

wholly rely to the features that can be extracted from the trace of the static signature image only. Although difficult to design, off-line signature verification is crucial for determining the writer identification as most of the financial transactions in present times are still carried out on paper. Therefore, it becomes all the more essential to verify a signature for its authenticity. [4]

### **1.1.2 Signature – Verification versus Recognition**

Using artificial neural networks approach does most of the handwritten signature recognition and verification [2, 5, 6]. Signature verification is different with signature recognition on its preprocessing step. This is because, in recognizing a handwritten signature, a segmentation technique is needed to recognize each character while in verification, it verifies as a complete image and not as a collection of alphabet or words and it doesn't need to do the segmentation process.

The goal of segmentation is to break the handwritten sample down into smaller entities. These entities may represent individual characters, or they may represent individual pieces of a character. In either case, segmentation allows the artificial neural networks to examine small pieces of handwritten samples. This will aids the artificial neural networks in its analysis, by allowing it to compare the local details of a suspected forgery to those of a known, genuine signature. [6]

## 1.2 Objectives

The objectives of this final year project are as follows:

- i. To do literature review on neural network basic concept and backpropagation method.
- ii. To identify the method for image preprocessing and feature extraction.
- iii. To develop method for off-line signature verification.
- iv. To assemble data for training.
- v. To train the backpropagation network.
- vi. To simulate and test the network response to new input.
- vii. To classify and verify to whom the signatures belong.

### 1.3 Paper Outline

Firstly, *Chapter 1* describes the general overview for signature verification and the objectives of the project. Artificial neural networks are introduced and as well as its history.

*Chapter 2* describes the literature review of the final year project which involving the basic theory of artificial neural networks such as the biological neuron and the artificial neuron model. In addition, this chapter also gives brief explanations about the backpropagation method that is used for training the samples.

*Chapter 3* deals with a general description about the design methodology for the off-line signature verification system. This part also stated the basic image understanding that is needed for the preprocessing step and also for the feature extraction. This chapter also explains about the graphical user interface (GUI) that will be created using MATLAB 6.5 program.

*Chapter 4* explains the procedure and the algorithms that have been used to create the source codes and also the result.

Finally, *Chapter 5* illustrates the conclusions of this project, some alternative and recommendation that are needed to improve this project for future.

## 1.4 Introduction to Artificial Neural Networks

The artificial neural networks (ANNs) or also referred as neural networks (NN) is one of the numerous advances that have been made in developing intelligent system. It is completely different from the von Neumann architecture or modern parallel computers because it can solve complex perceptual problems like in pattern recognition, prediction, optimization, associative memory and control [7].

ANNs can be defined as a type of artificial-intelligence system modeled after the neurons (nerve cells) in a biological nervous system and intended to simulate the way in which a brain processes information, learns, and remembers. A neural network is designed as an interconnected system of processing elements, each with a limited number of inputs and an output. These processing elements are able to "learn" by receiving weighted inputs that, with adjustment, time, and repetition, can be made to produce appropriate outputs.

Fausett [8] state that artificial neural network (ANN) is an information-processing system that is based on generalizations of human cognition or neural biology based on the assumptions as follows:

- Information processing occurs at many simple elements called neurons.
- Signals are passed between neurons over connection links.
- Each connection link has an associated weight, which, in a typical neural net, multiplies the signal transmitted.
- Each neuron applies an activation function (usually nonlinear) to its net input (sum of weighted input signals) to determine its output signal.

## 1.5 A Short History of Neural Networks

The limitation and failure of sequential rule-based programming to do simple things in the computers such as understand verbal commands (speech recognition), read (optical character recognition) and see and identify people, places and things (machine vision) has led to the study of neural networks[9].

Fausett [8] has divided the development of neural networks into four stages. The first stage established in the era of 1940s is known as *The Beginning of Neural Nets*. The first mathematical model of a biological neuron was published in 1943 by Warren McCulloch and Walter Pitts [10]. It is known as *McCulloch-Pitts neuron*. In 1949, the first learning law for artificial neural networks was introduced by Donald Hebb, known as *Hebb learning*.

The second stage established in 1950s and 1960s known as the era of *The First Golden Age of Neural Networks*. Late 1950s, Frank Rosenblatt [8] has achieved in creating neurocomputer which could identify visual patterns, such as letters of the alphabet. This lead to the development of the Mark I Perceptron neurocomputer by Frank Rosenblatt *et al* [9], Charles Wightman and others in 1957 and 1958. Apparently, Benard Widrow and his student, Marcian (Ted) Hoff [8] introduced another types of learning rule known as ADALINE. This learning paradigm is still being use today.

The third stage known as *The Quite Years* was established in 1970s. The reason of the “quite years” is due to the failure of the Rosenblatt’s Perceptron that could not implement the Exclusive OR (XOR) function. This has been proved mathematically by

Minsky and Papert's in the book untitled *Perceptions*. After that neural networks research didn't pick up again until 1982 [8, 9].

Finally, in 1980s known as the *Renewed Enthusiasm* era have made a major development in neural networks progress. Hopfield's energy approach in 1982 and the back-propagation learning algorithm for multilayer perceptrons (multilayer feed-forward networks) who first proposed by Werbos, reinvented several times, and then popularized by Rumelhart et al. in 1986 [7]. A series of neural nets for character recognition was developed by Kunihiro Fukushima and his colleagues at NHK Laboratories in Tokyo. Even though, the first research failed to recognize position- or rotation-distorted character (cognitron) [Fukushima, 1975], it then have been corrected in neocognitron, 1988 [8]. Many researchers have invented and develop neural nets such as the Boltzmann machine, the optical neural nets, VLSI implementation and many more.

# CHAPTER 2

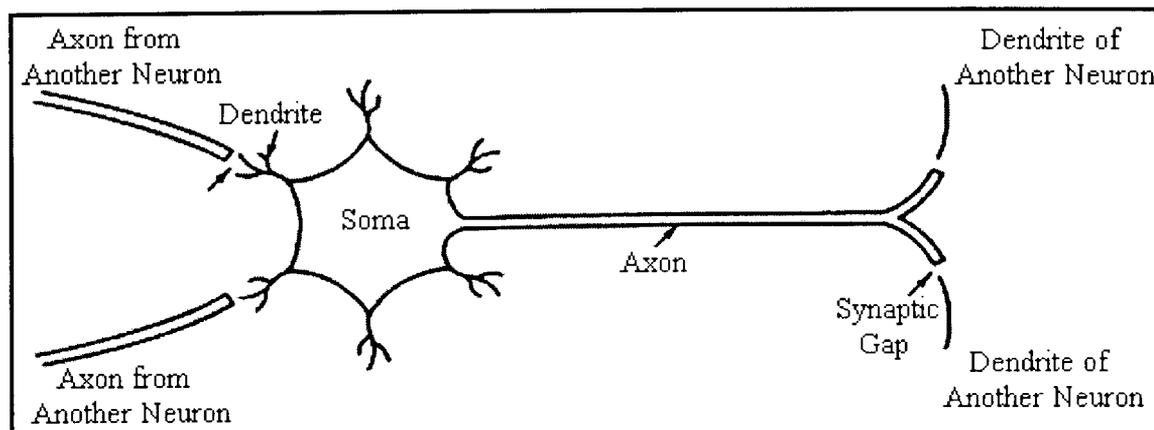
## LITERATURE REVIEW

### 2.1 Biological Neuron

Human brain is very powerful especially in recognizing or verifying patterns in a noisy image. Children learn to recognize and verify letters and number by just see and memorize the image pattern. No need to know any symbolic description of how the letter must look like. On the other hand, recognizing and verifying patterns using computer technology is still very hard and slow especially in handwritten or signature recognition and verification.

The human cerebral cortex has about twice the area of standard computer keyboard which is about 2, 200cm<sup>2</sup> surface area. Cerebral cortex contains about  $10^{11}$  neurons where each neuron is connected to  $10^3$  to  $10^4$  other neuron. Therefore, the total interconnections are approximately  $10^{14}$  to  $10^{15}$  [7]. Neuron acts like a small individual computer processor. It is a special biological cell that process information and is a basic functional unit of the nervous system. By using multiple neurons simultaneously, the brain can produce intelligence, the ability to learn from experience [8] and perform its function much faster than the fastest computers in existence today [10]. Neuron consists of three main parts, the

*soma* (cell body), *axon* and *dendrites* [6]. Figure 2.1 shows a generic biological neuron with its components.



**Figure 2.1** Biological neuron [8]

*Dendrite* is a branched extension of a nerve cell (neuron) that receives electrical signals from other neurons and conducts those signals to the *cell body*. The *cell body* has a nucleus that contains information about genetics traits and plasma that hold the molecular equipment for producing material needed by the neuron. The *cell body* or *soma* sums the incoming signals and transmits it along the *axon* (transmitter), which eventually branches into strands and sub strands. A *synapse*, which is located between an axon strand of one neuron and a dendrite of another neuron, release a certain chemical called neurotransmitter. This physical and neurochemical characteristic of each *synapse* determines the strength and polarity of the new input signals. Learning occurs by changing the effectiveness of the synapses so that the influence of one neuron on another changes.

The ability to learn through experience is the fundamental and essential characteristic that tried to be achieving in a computer. Therefore, the studied of ANNs is a