Signature Verification

By

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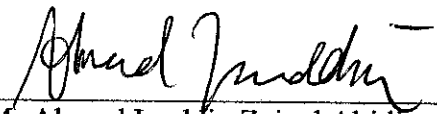
Certification of FYP Final Draft Submission

Herewith I, Nur Azlina Binti Mohd Yusoff 2380 , certify that I am responsible for the work submitted in this project, and I have done all the modifications according to my supervisor's advice.

Thank you.

	Submit by Student	Verify by Supervisor
Signature		
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ABSTRACT

Handwriting recognition is a process in recognizing handwritten letter images. For this project, the main purpose is to identify signature's owners to prevent from skilled forger. Therefore, the project is more focused on the signature verification rather than the character recognition. Signature verification can prevent falsification by detecting the flow of the curve of the signature and using the distance similarity. The main objective of this project is to verify the signature. The secondary objectives are to make life easier by having the signature verification system to identify the skilled forger from using someone else's credit card and to increase the security measure on credit card. The method that will be used in this project is using the neural network classification in the backpropagation network. This is because backpropagation can get the input to give the correct output, which has been used by many researchers. In implementing the prototype, a distance measure is used as the verification method but backpropagation is one of the suitable methods in designing it for future expansion. Matlab software is used in developing the system. Basically, this system will be using the Matlab software and for the hardware part by using the digitized tablet with the pen tip in order to capture the user signature image. Beside that, some calculations will be used in measuring the signature attributes and as for the error part; there will be the percentage of the error occurs.

ACKNOWLEDGEMENT

In completing this dissertation for the final year project for semester July 2004 in project entitled signature verification, there are some individuals who have played their roles in giving advice and cooperation which is important for me in developing a working prototype, in providing me the experience of a real project and giving me the full confidence in doing this project. Firstly, I would like to thank to my supervisor, Mr Ahmad Izuddin Zainal Abidin for his assistance throughout my final year project. Besides, I would also like to thank all the committee of final year project which I think that this subject is important for me before going to the real working environment by giving me the thought that there are still more that I need to gain in this world for learning new skills. Last but not least, I would like to thank all my lecturers in Universiti Teknologi Petronas and all my friends for supporting me.

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ABBREVIATIONS AND NOMENCLATURES

FRR = False rejection rate

FAR = False acceptance rate

ERD = Entity relationship diagram

UML = Unified modeling language

SVS = Signature Verification System

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND OF STUDY

The world is becoming more advanced technologically and development of intelligent system makes life easier. One of the technologies is developing the pattern recognition. From the oxford dictionary, pattern means an arrangement of lines, shapes, color etc and while recognition means the action of recognizing of somebody or something or of being recognized. Therefore, for the pattern recognition is to identify the pattern or unique characteristics of something that is recognized by the system when the capability of human eyes is limited such as when the pattern is similar or small to be recognized. The pattern recognition fields have evolved from time to time and pattern recognition involves scenes, pictures, symbols and characters. Pattern recognition is usually used in weather forecasting, recognition in hand printed character, speech recognition, medical activities, security application and biometric such as using the retina, signature, face, fingerprint and etc. With all that method used in recognizing field, it has made the scientists and researchers in a great deal in developing as pattern is unique and need many techniques and method in identifying the pattern. When is the pattern recognition is become applicable in real life, Sing-Tze Bow in his book had said that, pattern recognition is useful when simulation is ineffective, modeling is inadequate and normal analysis fails [12]. From that, pattern recognition is important and applicable in real life especially when it comes to security consideration.

This project is related the pattern recognition and entitles the handwriting recognition. Handwriting is unique between people as it differs in terms of the curve, the peak of the writing etc. Based in [3] by Plamondon they define that handwriting is the task of transforming a language that is represented in it spatial form of graphical mark into its symbolic representation. Handwriting recognition is still in research and many researchers have find ways in order to make the recognition faster and more accurate. As for this project, it more focused on the signature verification, as signature

is one of the images written by human that differs, have unique attributes, and have been widely used in identifying a person for the security. Signature is a person's name written by her or himself that has a distinctive character.

Then, there are still people trying to imitate the uniqueness of this signature and it can detect by comparing the originality of the signature with the original one. There are two types of method that are online and offline. Online is meaning the verification is doing concurrently with the writing process and the offline verification means more to recognize the pixel of the image. B.Fang said that human who is subject to the characteristics of handwritings draws a signature: intrapersonal variation and inter-personal difference [7]. Therefore, there will be no two identical signatures by different person. In addition, signature can give the characteristics of a person by analyzing the curve, loops, and the length of the signature itself. Because of that, signature is accepted as personal attributes for identity verification.

Moreover, this project also needs to study on how image of the signature is being constructed and extract in order to get the uniqueness of the signature and compare it to detect the forgery. Beside that, signature verification will need to go through some processes as inputs, which are background subtraction, threshold, noise cleaning and gap filling and thinning. Ke han points out that 3 factors that characterize signature verification which are signature representation, search organization and match scheme [8]. Signature representation is the description that the system extracts from the signature while search organization is on how the signature in the database is being indexed to retrieve a set of signature to be compared with the query signature. Then after the signature has been preprocess, then the system will search in the database for a set of signature to be identical with the query signature and as for that, one by one from the set will be match whether identical or not. Therefore, with the flow of the system in verifying the signature, so forgery can be avoid and detect.

The study of signature verification also involved using the neural network. Neural network is one of the suitable methods in signature verification. Dr. Thang Kah Fei said that neural network is an interconnected assembly of simple processing elements, units or nodes whose functionality is loosely based on the animal neuron [15]. With this, neural network is one part of the Matlab application that can be used as the application in implementing the prototype. The reason of using the neural network is because it can derive meaning from complicated or either humans or other computer techniques can use imprecise data to extract patterns and detect trends that are too complex to be noticed. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyze. This expert then used to provide projections given new situations of interest and answer "what if" questions.

1.2 PROBLEM STATEMENT

As developing any project, the basic thing is to identify the problem statements. Generally, problem means things that are did not understand and so it is important to identify the problems statements. From the preliminary report, the first problem stated is what is the method that need to be use in order to compare the signature produced by a person to detect whether it is real or forgery by the skilled forger. So, signature verification is needed to detect skilled forger, as signature verification is one of the security measure. Therefore, as for now, Matlab is the suitable ones. The second one is the calculation on comparing between the signatures such as the distance, loops, curve, correlation confidence, etc. Beside that, problems arise when there are two identical signatures and identifying the attributes needed to consider in detecting the forgery one.

Problems above are the problems that are being identified in the preliminary report. As more research have been done on signature verification, the technique to capture the image input of signature has been identified whether by image process or handwritten and for this system, digitized tablet pen and paint program have been chosen to capture the signature image. Problems arise when how the signature is going

to be process and analyse and how to produce the output. The output of the system identify whether the signature is true of forgery. Beside that, the signature image need to process by designing the image to be the same with training set in the database so that the system will not confused with the differences in image. This method is call to downsizing the signature image.

The significant of the project is this project will give a small contribution in artificial intelligence field. Beside that, this system will try to reduce the fake signature or the forgery as signature can analyzed subjective by our eyes itself. Therefore, it needs a system that can do it and will make life easier. This project can enhance the use of the signature as one of the security measure in life and many people can put a trust on using it.

1.3 OBJECTIVES AND SCOPE OF STUDY

Signature verification is becoming important in identifying a person because of the unique attributes that can differ between people, based on individual attitudes, and inter personal characteristics. As the signature verification one small part of the artificial intelligence field, this project hope can give small contribution to the field itself. Therefore, the objectives of this project are:

1) Security

   The signature verification is one of the steps in preventing the forger and with this, it can detect whether the signature is fake or written by the same person.

2) Enhance the use of digital signature

   As the input of this signature using the digital pen, it can enhance the use of the digital signature and can widely used by many people.

3) Increase the percentage of accepted signature

The system put a threshold that will accepted on how much rate the signature is accept as true or not which is the signature similarity percentage need to be larger than 95%.

4) Life easier

Usage of the signature verification can make life easier for example; user did not need to take less money outside when using the credit card

As the objectives of the project have identified, then we need to identify the scope of the project on how the project developed. The scope is on how broad is the project will done and the scopes are-

1) Credit card

The usage of the digital signature is to ensure the security of the credit card in order to prevent from the thief from using it and to detect forger.

2) Time

This project is going to be done within one semester so it will take about 4 month to complete it. This project need to done within that time to present it to the supervisor and to complete the semester.

CHAPTER 2
LITERATURE REVIEW AND/OR THEORY

Handwriting recognition is one part of the object recognition in the artificial intelligence field. Handwriting recognition involves in recognizing the image or object. The recognition need to extract some element of the image such as noise elimination, digitizing, normalizing and then need to match the image in order to identify the image. Researchers said that there are two types of handwriting recognition, which are on line and off line recognition. On line, recognition means that the recognition is done concurrently with the writing process while off line recognition more to recognizing the pixel of the image. Recognition is consisting of the program ability to realize a corect classification of the given objects. The recognition speed counts how many from the total number of the objects are classified correctly.

2.1 NEURAL NETWORK

Therefore, signature verification is one of the parts in the handwriting recognition. Signature verification is the activities in matching or comparing two similar signatures in order to verifying the originality. As in [3] by Plamondon had stated, with signature verification we are looking for reliable signs to prove that, even though two signatures appear similar, they were produced by different persons. This can proven as acceleration and pressure at the pen tip has found to be reliable in this case because a forger will work only from the image of a signature, and will fail to reproduce the proper dynamics. In developing the signature verification, most researchers are using the neural networks and hidden Markov model. Neural network is a network of many simple processors (units), each having a small amount of local memory. The units are connecting by communication channels, which usually carry numeric (as opposed to symbolic) data, encoded by a number of techniques. The units operate only on their local data and on the inputs they receive via the connections and the restriction to local

operations are often relaxed during training [4], which means that the neural networks train each node in the network to get the output by getting the input.

2.2 FEATURE EXTRACTION

As doing some research on the signature verification, most of the researchers have identified that feature extraction is important in developing the system as the first element in extracting the signature features. According to C.Quek, feature extraction is employed to reduce the image observation vector by measuring certain "properties" or "features" of the signature image [6]. Neural network can trained in order to recognize the signature and the more detail part in neural network is to use the backpropagation algorithm. Reena Bajaj used it in her article for the signature verification. Dr.Thang Kai Fei said in his book that properly trained backpropagation networks tend to give reasonable answer when presented with inputs [15]. Typically, a new input leads to an output similar to the correct output for input vectors used in training that are similar to the new input being presented. Moreover, as for that, the system will be using the neural network as the method in the system.

Then, we look into the characteristics of the signature that differentiated between them although it looks similar. From the signature image, we could see that curve, loop, crossing curve, start and end points of the signature and the concave curve. These are the attributes will used in verifying a signature and usually it used for the offline signature. These are because on line signature more concentrated on the speed of the writing, pressure applied by the pen, number of strokes etc. and as for the offline, it obtains the information using the attributes that have listed earlier. All these attributes are used in the feature extraction process in order to gain information before comparing the signature.

Feature selection or extraction has become one of the methods in signature verification system as it makes the verification easier. Ke han used feature extraction as

one its technique in handwritten signature retrieval which signature representation requires the transformation of a signature image into a compact and meaningful description through the extraction of certain features [8]. For Reena Bajaj used the feature extraction which used the global feature which mean include transform, image gradients and polygonal description said that it these feature obviously cannot capture the finer structural aspects of the signature images essential for detection of tracing forgeries or photocopies, but possess sufficient discriminatory power to eliminate substitution errors [11].

In addition, for that, we used all the information to do some calculation in order to get the maximum, minimum and the average of the distance between all the attributes. This method that have used in [16] by Anil K.Jain, Friederike D. Griess and Scott D. Conmell in their paper stated that they have used three basic methods to combine the individual dissimilarity values (between the input and one of the templates) into one value are investigated which are:-

1) The minimum of all the dissimilarity values
2) The average of all the dissimilarity values
3) The maximum of all the dissimilarity values.

Dinesh P.Mital has used the distance measure of peaks and valleys in order to know the differences in coordinates between the peaks and valleys [17]. So from that I could say, these people will get this one value and try to evaluate with a threshold that they have put such as the result of the methods need to exceed the 95% of accuracy so that they can accept the signature or not. Although these people used this method in the online signature, but I could used it for the offline but in difference measure, which is the distance of the peaks of the signature.

Moreover, there is a signature verification using the camera based tracking, which used the camera based acquisition system. This system is developed by a student named Mario E. Munich which for him that the used of electronic tablet or scanners in

verifying the signature is bulky and complicated to use. Then, it is still the same method when recognizing the signature as he still used the distance similarity and dynamic time warping in order to compare the signature. It just the difference on how the signature image is captured.

2.3 TYPES OF ERROR

Percentage of accepted in signature verification is used in order to know the rate of accepted or rejected of the signature. B.Fang stated in paper that there are two types of errors being defined, which are, Type I error rate or the false rejection rate (FRR), and Type II error rate or false acceptance rate (FAR) and the average rate is defined to be the average of FRR and FAR [7]. Most of the researchers used this type of error in their paper, as it is important in order to know on how much their system is accurately in verifying signature and the accuracy of the signature compared with the training set with the query one.

2.4 EXISTING SYSTEM

Although many people are still searching the most applicable method or technique for verifying the signature, it not prevent the others to build the system. Signature verification system (SVS) is one of the system exist in the market. This system has been launched in 1995. The purpose of this system is to deliver digital signature and verifying the identification of the customer. From this, it shows that signature has been become essential in one of the security measure. SVS work by collecting the signature of the customer and all information needed about the customer and store it on their server. SVS system uses the scanning and digital camera in verifying the signature. SVS system needs to compare the query signature with the stored signature in their server that contains all the information about the customer. SVS system uses the biometric matching that focus on the similarity of the signature such as the curve, start point or end point of the signature. Then, it is not possible that the

signature is changing a bit, as it cannot be the same, each time customer sign their signature.

One Source Solution LLC has make improvement in signature verification from the above company. This company is also verifying the signature in securing the protecting document, authorizing the payment bank using the signature measure. The system is build based on the low false acceptance/rejections rate compared to the objectives of this system, which quite high as for securing feature as it will be based on the distance similarity. However, the system has a unique feature, which it is learnable system to changing of the signature and measuring the pressure of the pen.

From these two systems, some of the technique and method being discussed is used for developing the system. It depends on the need of the signature verification in verifying the signature and level of security that applied to the system.

7) Implementing and evaluating the system

This is the last phase of the system, which involve on using the system and training the user on how to use the system. Evaluation also occurred in order to see how the system works so far after being implemented to the real system.

Methodology will specify the process of the development of this project. The methodology created will be based on what are the task that is going to be accomplished, how they are going to be done and also how they are related with each other. The waterfall takes the fundamental process activities of specification, development, validation and evolution and represents them as separate process phase. There are will be four main phases in this model but the model have been modified in order to meet the suitability in developing this project. Below is the model of the methodology:-

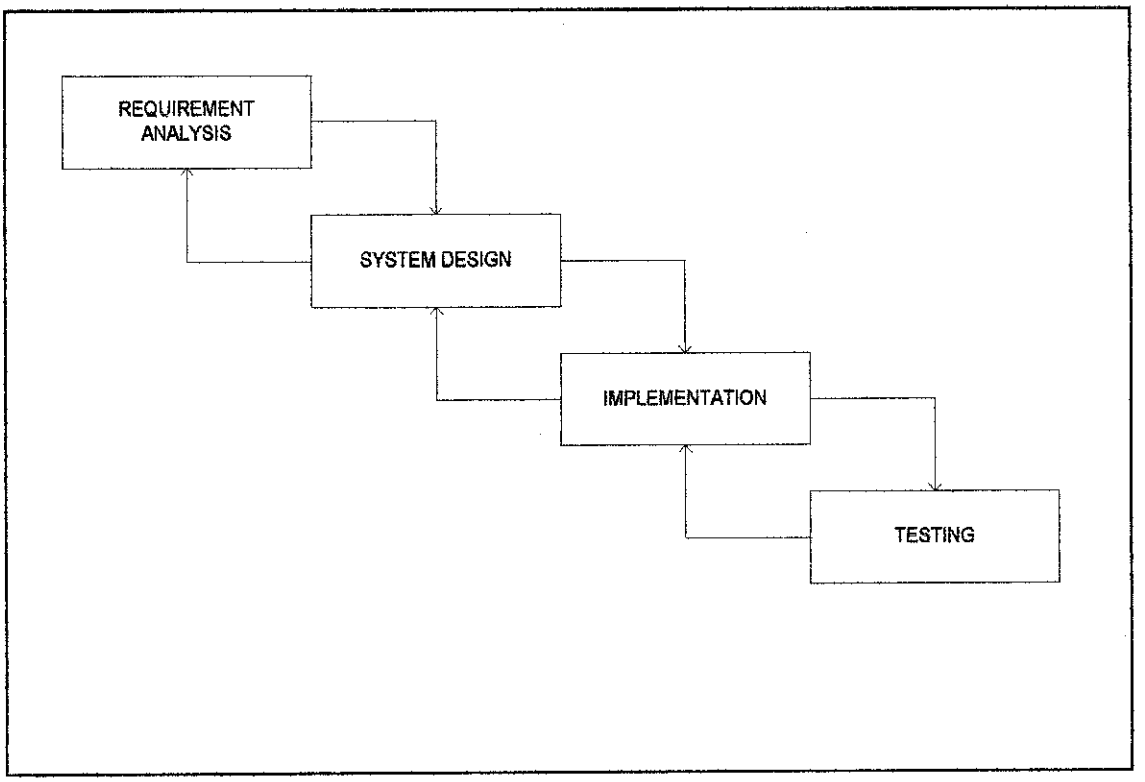

Figure 3.1: Methodology model

3.1 REQUIREMENT ANALYSIS

In the early stage, at first the system needs to identify what are the problem statement and the requirement in developing this project by establishing the system's objectives and scope. Therefore, the problem statement had been identified earlier. Moreover, in this phase the scope and objectives of the system need to be identified which have been explained earlier. Then the system requirement will be analysed. This is to know the exact needs and requirement that need to be display and to be implemented to the user. This is because to make sure the system can be accepted by user, as they will be using the system not me as the system developers.

As for the requirement part, the system need to deal with the signature by identifying the attributes and character that differentiate between the original and the forgery one. Beside that, requirement of the system is to do the pre processing by features extraction so that the system could identify the unique attributes of the system in term of the geometric and topological features from the signature. The system also can give the accuracy of the genuine signature in terms of the percentage by evaluating the similarity and the accepted rate. All the requirements are identified as functional requirement, which are-

1) Able to identify the original signature with the forgery one
2) Have high accuracy by having high accepted rate
3) Able to capture the signature image into the system using the digital pen tip
4) The system can match the query signature with the stored signature.
5) Need Matlab software and paint program to capture the signature image

As the requirements of the system have been identified, then system requirement also need to be consider, which will be used in the system. User requirement is intended for which the user will define what are the system function, the input, and the output of the system and the flow of the data. This system will used hardware, digitized tablet pen to capture the signature image so the medium that will be interacting with them is the pen itself. The pen is used to capture the signature image and transfers it to the system to be process and train. Therefore, the system will do the feature extraction and the distance similarity and done the verification. Then, the system will produce the output verifying whether it is the same or most accurate rate of the query signature with the stored one.

Then, as the system is analysed, the tools have been identified that will be used in developing the system which are:-

1) Matlab software in building the system
2) Digitized tablet pen and paint program to capture the signature image
3) Microsoft project software for developing the system Gannt chart
4) Microsoft Visio in modeling the conceptual design of the system such as use case diagram, UML design and etc.

For the documentation part, the research of the system is by getting form many resources such as:-

1) Books on pattern recognition
2) Journal on related on this system from many electronic library
3) Sources from the Matlab website such as www.mathswork.com
4) Search engine on www.yahoo.com

3.2 SYSTEM DESIGN

This is the stage, which need to identify the requirement for the hardware and software needed by designing the overall system architecture. System design is involved with many diagram and flow of the data design. This focuses on high level design (what are we going to need and how are they going to interact), low level design (how the individual programs are going to work), interface design (what are the interfaces going to look like) and data design (what data are we going to need). As designing this system, goals in designing the system have been identified which are:-

1) Usability – The system will be created using the Matlab software and paint program to input the signature.
2) Portability – The system will support both the hardware, digitized tablet with pen tip and the software Matlab.
3) Reliability – The system is reliable in verifying the signature based on the training set and algorithm used.

In detailed system design, system models and conceptual design will be needed in designing the system. A system model is giving the detail of the system developed. A system model is an abstraction of the giving system being studied rather than an alternative representation of the system. So, the basic flow of this system is being described in a diagram below: -

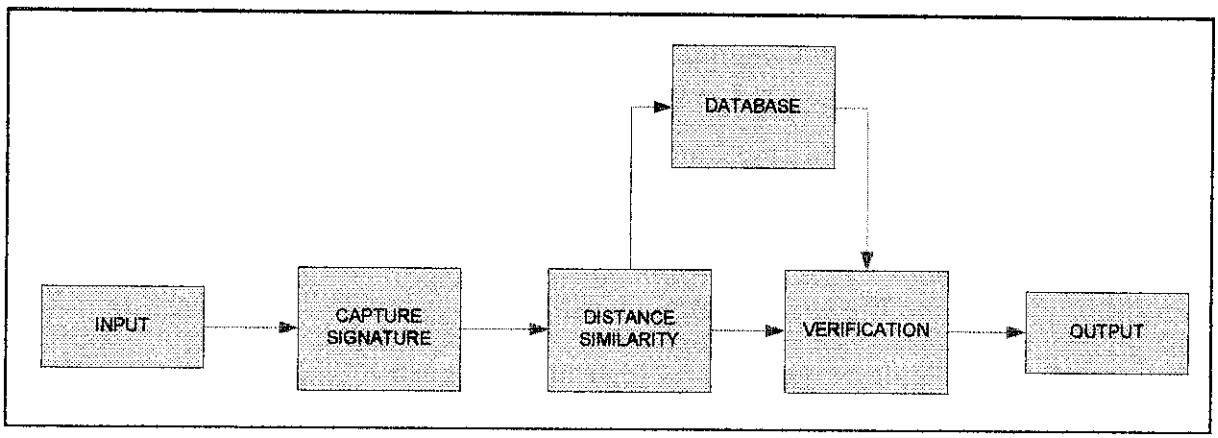

Figure 3.2: Basic flow the system

This diagram is the basic flow of how the system will interact and works from the system receive the input until it produces the output. This is the current phase where the project is being developed. The reason of the system architecture such as diagram flow, ERD or UML design is to have a clear view on the system on terms of the diagram view. UML diagram is used to show the relationship of modules to each other and communications between modules. Then, the conceptual design is used to create an abstract database structure that represents real world objects in the most realistic way possible. In this design, all the data needed are in the model and all data elements required by the database transactions need to be defined in model. Moreover, use case diagram also has been developed to make the system have a clear view on designing the system:-

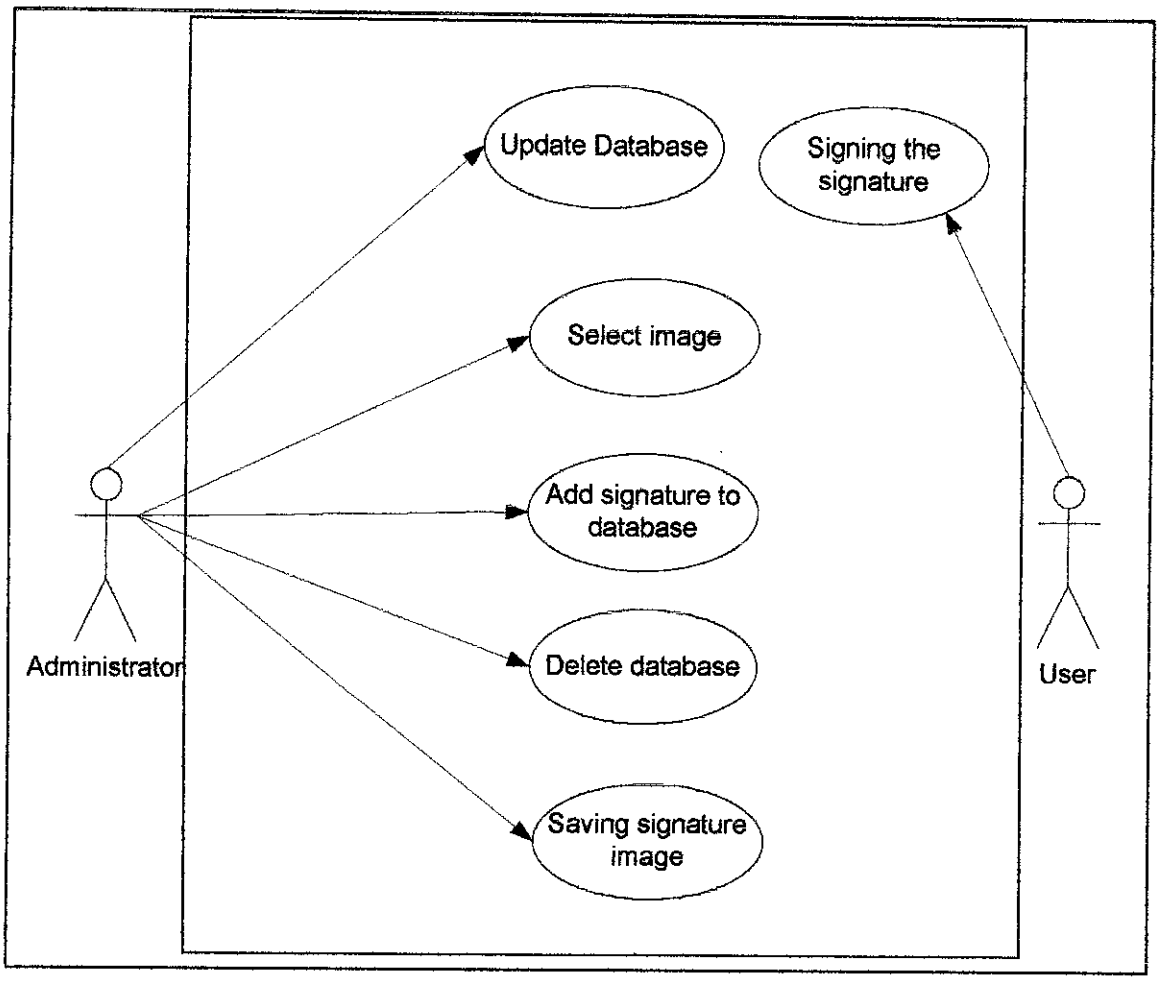

Figure 3.3: Use Case Diagram

Beside that, to know the process of the system, a flow chart have been designed in figure 3.3 below:-

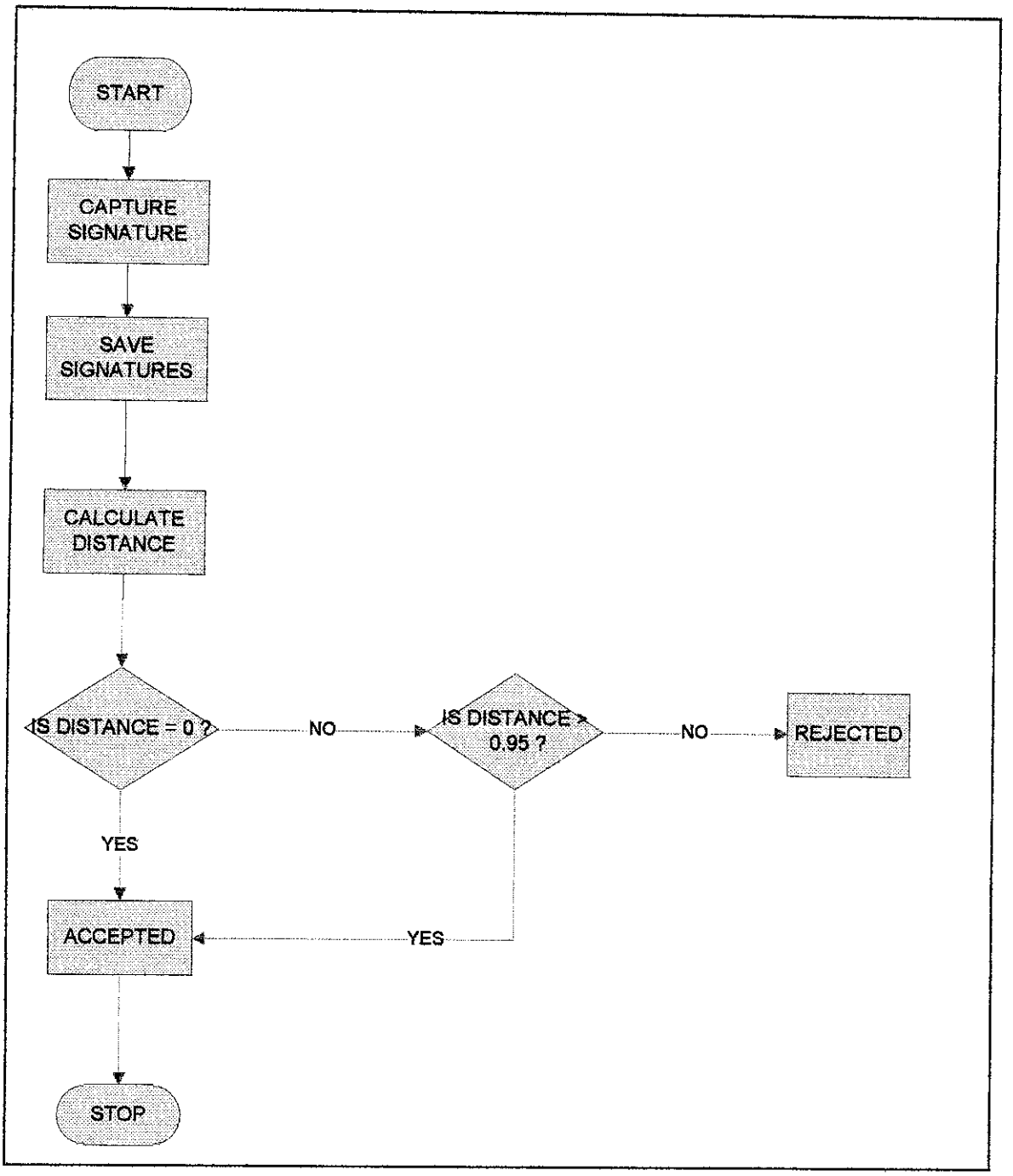

Figure 3.4: Flow chart

Then, in the designing phases is where the user interface of this system will be developed, which is using the Matlab coding. The functions of each user interface are: -

1) Select image – read the input image
2) Add signature to database – the signature image is added to database and will be used for training.
3) Database info – show information of the image in database
4) Verify – verify the signature
5) Delete database – remove the database
6) Info – information of the software
7) Exit – quit program

The user interface is like below:-

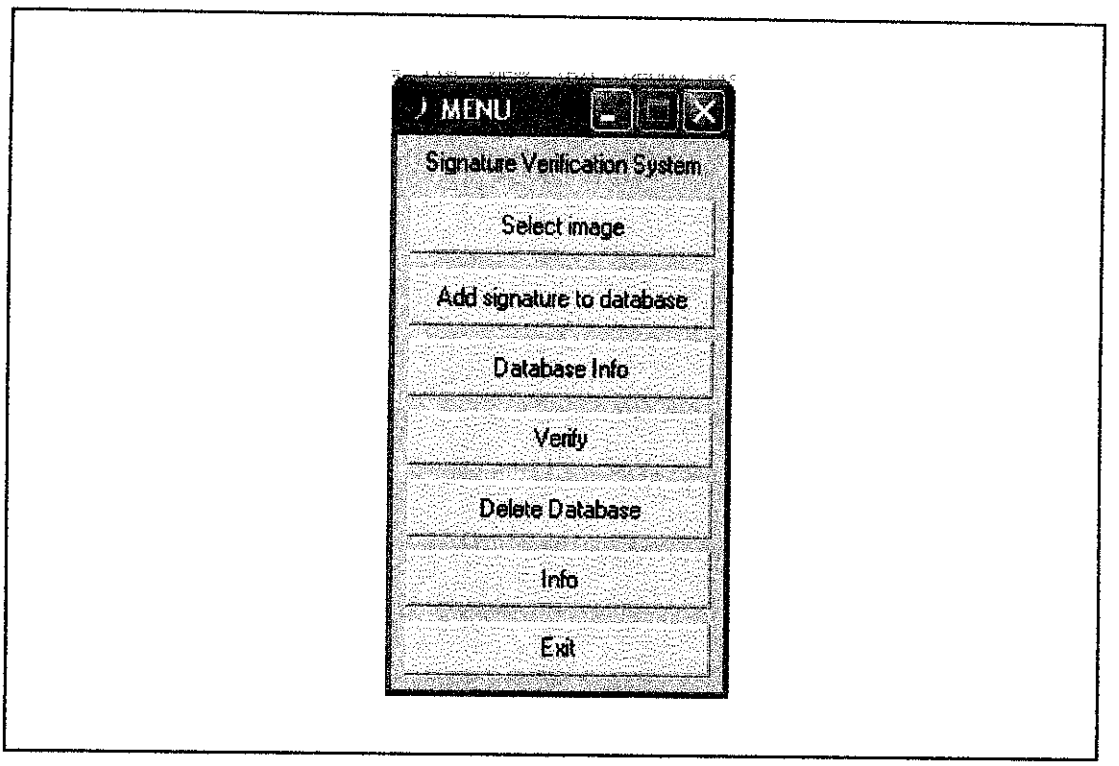

Figure 3.5: User Interface

The system work firstly by selecting the signature image which being captured by the digital pen or digitized tablet. The image that has been captured will be saved in paint program. Then after that, the system will select from the folder by clicking the *Select image* button in order to resize the signature image to make it easier for the system to process the signature. As the signature has been selected, then the user will click on the *Add signature to database* to the system database so that when the signature is being recognized, the system will used this database to compare whether the query signature is recognize and similar with the one in the database. So the database of the signature has been created. The button *Database Info* is basically will tell the person on how many signatures has been stored in the database. Then, *Verify* button is the one which doing the verification of the signature. Verify button will verify the signature by comparing the query one with the one in the database using the distance similarity. *Delete Database* is where the person want delete the signature database. *Info* button pop up a message tells that this system is being implemented for the purpose of final year project in semester July 2004. Then the *Exit* button design to quit the program or system.

As this system is more concentrate on the distance similarity, so we will look into the Euclidian distance. Euclidian distance is in clustering analysis, which is the process of grouping objects into subsets that have meaning in the context of a particular problem. The comparison of the signature will be using the distance method, which is the Euclidian distance. Euclidian distance is a measure of the distance between two vertices used in computer go. It is determined as the number of horizontal and vertical steps one has to take to go from one stone to another. For the sketch, calculation distance will be used to calculate the distance between the peaks of the signature and between the vertices of the neuron in the signature image. It will determine the similarity between the signatures. For basic idea, the calculation of the Euclidian distance is like the calculation in E.q. 3.1:-

$$\text{Euclidian distance} = \sqrt{|xi1 - xi2| + |xj1 - xj2| + |\ldots\ldots|} \qquad \text{(E.q 3.1)}$$

Moreover, the calculation will be used for the signature comparison and try to modify it based on the need of the calculation if needed.

As the system have get the distance of the signature image, then in order to get the accepted rate of the genuine signature is by doing this like calculation in Eq 3.2:-

$$\text{Accepted rate} = (1 - \text{Euclidian distance}) * 100 \qquad \text{(E.q. 3.2)}$$

And if the percentage is below than 95 %, then the signature is considered rejected as it below the accepted rate but if vice versa, so the signature is considered true by the system or prototype. Before the distance measure is being calculated, the image needs to be resizing to the same size of image. Therefore, as the select image button is click, the prototype will automatically will resize the image to 30912 X 1 bytes. As the signature is being verified by the system or prototype, it will be converted to double precision. The rate which is 95% is chose as the distribution of the distance is minimum and have the higher accepted rate of distance percentage.

Therefore, we look into why 95% and not 80% or etc. Of course, the system could use other percentage to accept the percentage rate of the signature. This is because it need it a value that is not low and too high to the signature system to apply. 95% is a good threshold to the system to accept the signature percentage rate. More likely, the 95% is the confidence interval of this system. The confidence interval is likely the range of the true value of the percentage rate. For example, look into the equation 3.3 below:-

$$\text{Level} = 0.05 = 5\%$$

$$\text{Distance} = (1 - 0.05) = 0.95 \qquad \text{(E.q. 3.3)}$$

Therefore, the 95% accepted rate will eventually is the rate to know the confidence interval of the distance. Beside that, the confidence level of the 95% can be shown just like in figure 3.5 below:-

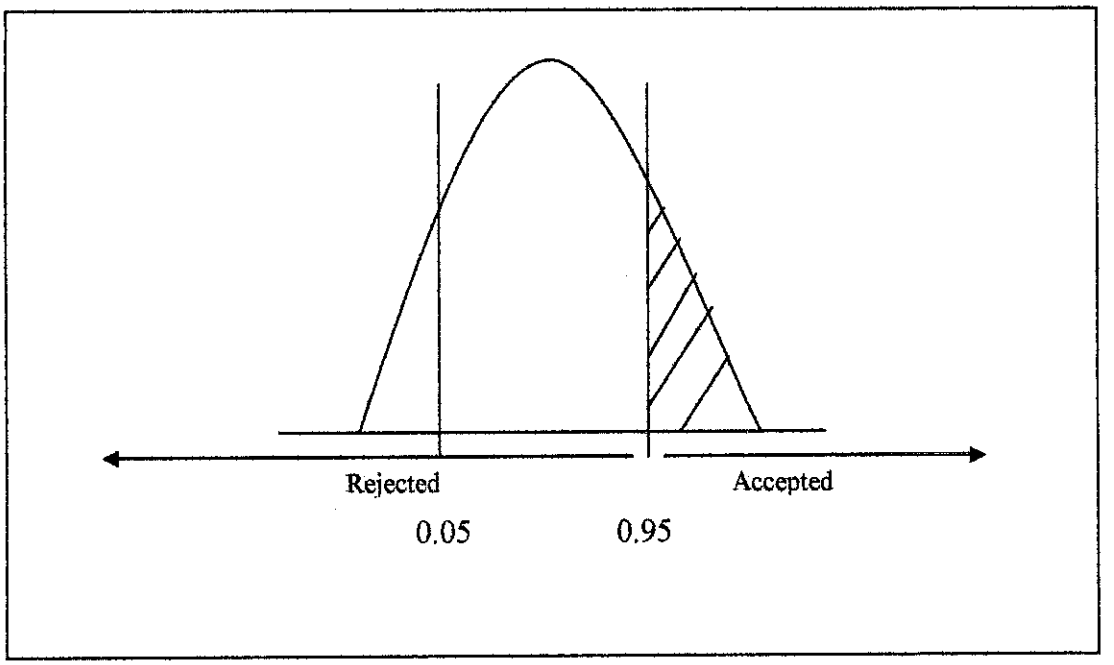

Figure 3.6: Confidence Interval

From the above figure 3.5, the system had limited the percentage rate to be 95% to be accepted.

3.3 IMPLEMENTATION

In this stage, the system design will implement by doing the prototype by using the suitable hardware and software needed. Prototype is the basic model produced that show the basic functionality of a system that is required from the user before being implemented to the real system. This prototype will involved the interaction with the user itself, the use of the digitized tablet and pen tip to capture the signature image and the database of the stored signature.

The advantage of the prototype is that it can give potential for any changes in the early of the system development; it can be stopped if it had any error occur and also

being developed system that closed to the user requirement satisfaction. The system is involve the tablet pc with the pen tip to capture the signature image, system developed in Matlab software, CPU and also a monitor to view the system.

The implementation of this system is based on the distance similarity whether it could satisfy if the signature is verified correctly it or not. So, for future expansion, this system could do some feature extraction and using the back propagation as added method in verifying the signature. Distance similarity has been already discussed in design phases on how the system calculated the matrix of the signature image. Beside that, in Matlab software, dist is a build in functions to calculate the Euclidian distance. Implementation of this system is implemented after doing some research on signature verification and also doing some, literature review in order to know what is signature verification is all about.

3.4 TESTING

This is the stage, which the prototype will be tested to ensure the prototype is working properly and meet the specifications that have been identified. Moreover, testing is done in order to identify any flaws or imperfection by the system involved with the hardware and software itself. For the testing for this prototype, the training set that stored in the database is going to be used so that the query signature could be compared with it. The training set is classified into class so that the system will be train to compare the signature when looking the nearest class to the query signature. The training has about 10 signatures, which gotten from 10 student in the university. This signature then will be stored in the database as the training set. Then they will try to sign on the digitized tablet again and the latest signature will be verified using the prototype. This testing will be done several times to see the accurately of the prototype in verifying the signature.

The testing also be done in order to know if the distance is being calculated correctly by the prototype and being able to identify the class of the signature correctly.

CHAPTER 4
RESULTS AND DISCUSSION

This system is involve in developing the signature verification which involve the input of the signature itself by giving unique attributes to it for the security measure. By signing the signature, users have put the intra personal or attribute that differentiae them form the others although it look the same from eye comparison. However, if we analyse more carefully, there is uniqueness and it could have been done using a system that could calculate and compare between the query signature and genuine signature. Below is the flow for this system in the state diagram:-

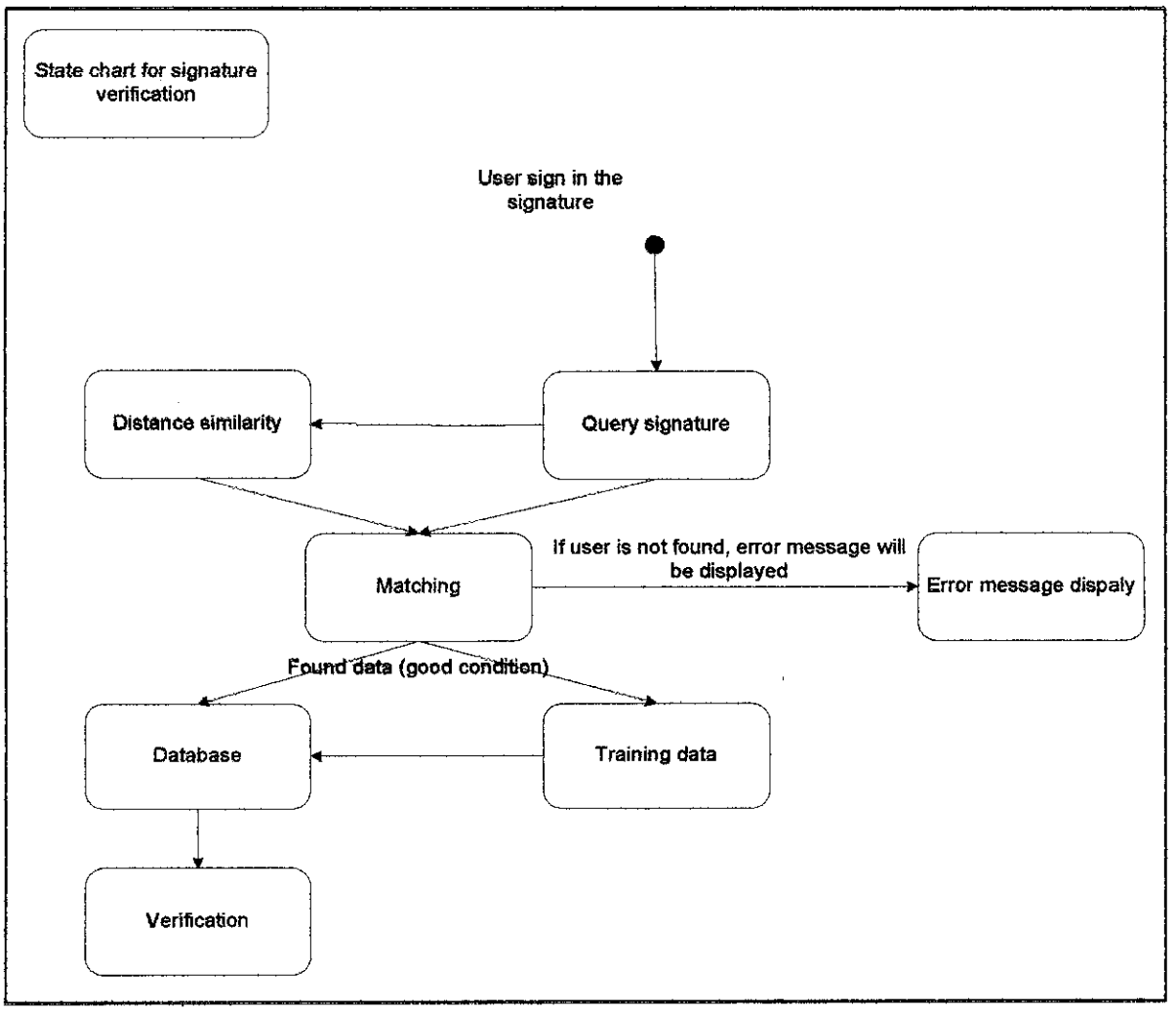

Figure 4.1: State diagram

As developing this system, the research of this system have identified that most of the writers have used the same flow in verifying the signature which can conclude that, the signature verification will need to go some of these process which are preprocessing, feature extraction, matching, and evaluation. In addition, as for this project, state diagram also being drawn out so that to make it clearer to view for the process from the above model. Moreover, UML also being designed in order to has more understanding on the flow of the system.

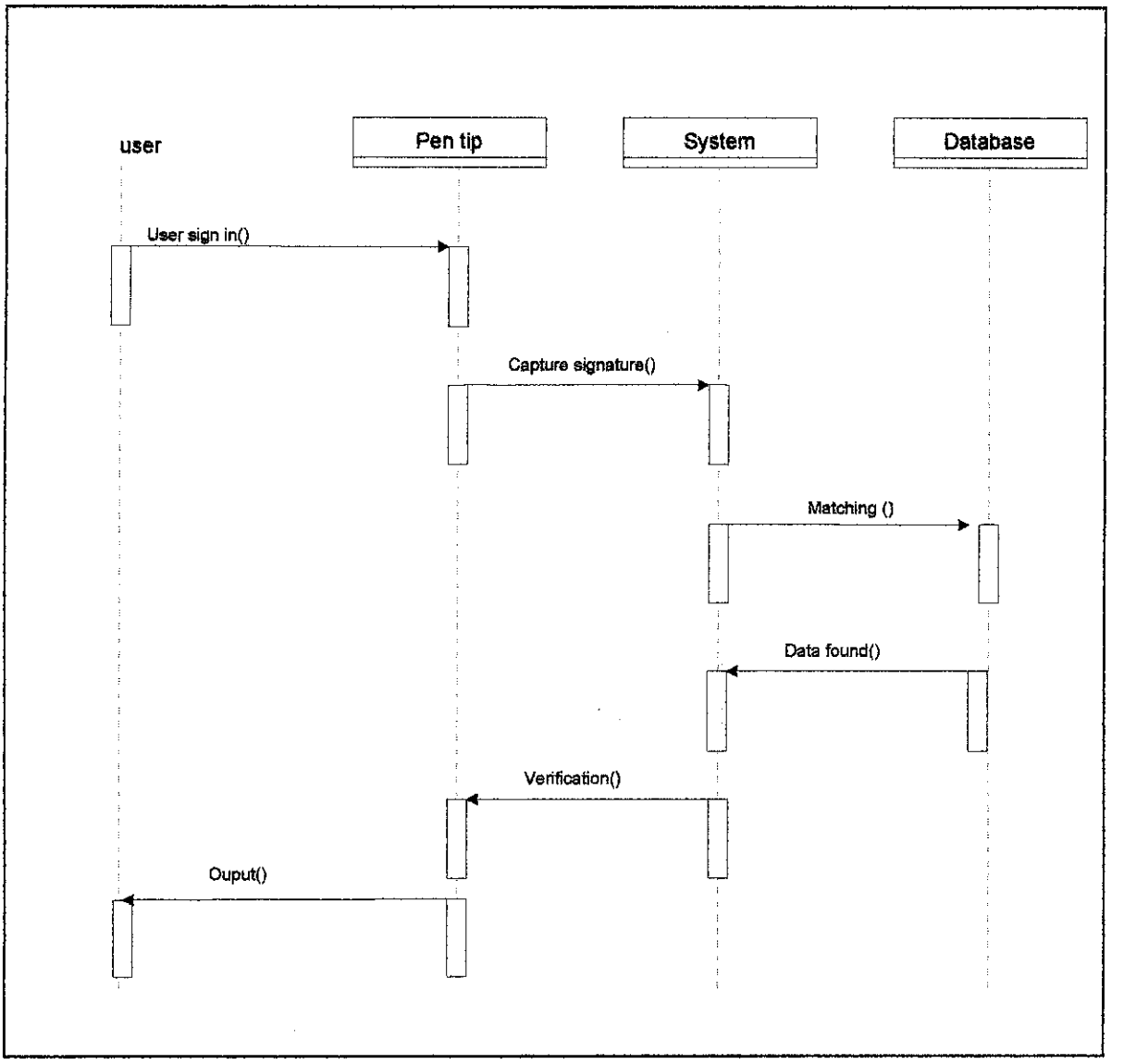

Figure 4.2: Sequence diagram

From these two diagrams, it shows how the system work and flow. Beside that, some training set of signature will need to be collected in order to train the neural network for the comparison purpose and some distance calculation using the Manhattan distance or Euclidean distance. As the system needs to accept the signature, some analysis on the error of the signature will be needed. From the analysis, there are two type of error, which are Type I, and Type II. Type I error is the percentage of genuine signature that incorrectly rejected by the system and Type II is the percentage of incorrectly accepted forgeries.

In addition, we will look into how the system works. The system will save the signatures into the database and then use as the training data. The signatures in the database will be calculated to know the distance and then the distance figure will be compared with the query signature. Therefore, to analysis the efficiency of the system, so some testing will take place by using a group of people consist of 10 people to use this system. The purpose of this analysis is to know the subjective and comparative analysis. The subjective analysis is where a person will compare the two signatures using the naked eye to determine the similarity without using the system evaluation. The comparative analysis is where the two signatures are verified using the system to know the similarity of the signature.

Therefore, at first we look into the subjective analysis. The group will be asked to sign their signatures at the digitizing tablet so that it can save in the database. After that, as all the signatures have been saved in the database, the group will be asking again to sign in for second time. Then, they will look both of the signatures whether it is same or not. If they satisfied will be signature, then the signature is quite similar. Then, we go into the comparative analysis, as the signature have been saved in the database, then the second signature will be verify using the system to compare the distance and the system will eventually calculated the distance of both the signatures. If the signature is identical, then the distance is zero, while the system also gives the distance of the signature if the distance is quite similar with the one in the database. This is where the

confidence interval takes place whether to accept and reject the signatures. After the testing takes place, then the satisfaction of these peoples toward the system will be evaluated. The table of evaluation of satisfaction of the system will be analyzed using the table 4.1 below:-

No of people	5 (Most satisfy)	4 (Satisfy)	3 (Likely satisfy)	2 (Less satisfy)	1 (Not Satisfy)
1	x				
2		x			
3		x			
4		x			
5			x		
6		x			
7			x		
8			x		
9		x			
10	x				

Table 4.1: Evaluation analysis

From the result of the table 4.1 above, we could say that the group of people is mostly satisfied with the performance of the system, which is the main strength of this system verifying the system. So, from the evaluation analysis table, we could say that, only two people in group is most satisfy with the system which they think that this system have meet the objectives of developing the system. Most of the people are satisfied with the system which mean there still weaknesses in the system or need to be upgrade. Moreover, three is likely satisfy with the system and they think that this system is good but need to include more features and to be more focus on how to save other data such as the data of the owner of signature. From the graph of the result, we will look into figure 4.3 below:-

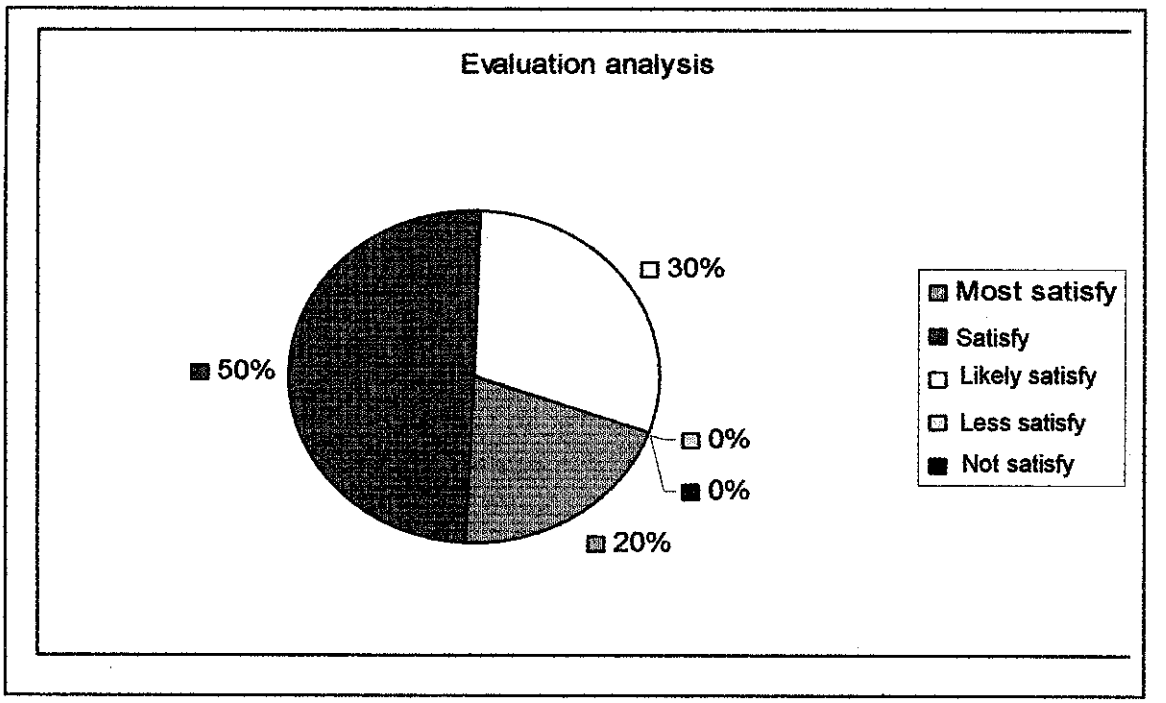

Figure 4.3

Therefore, from the graph, we could see the result of efficiency of this system in verifying the signature. The strength of this system is more focus on how it captures the signature and verifying the signature that exist in the database. Of course, the system had satisfy the user but it need to be improved more in term of the user interface design, more technique include such as feature extraction, string matching to make the verification more acceptable. Nevertheless, from this project, it shows that, distance can be one of the techniques apply in signature verification.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

As for the conclusion, the flows of the system and type of hardware and software that need to be used have been identified. The toolset that will be used when developing the signature verification system is digitized tablet pen. As for the signature itself, many things need to take for consideration for the comparison purpose. The signature is a unique attribute from a person, which they put their intra personal characteristics by the way they sign in terms of the curve, peak of the curve, on how many crossing point etc.

Beside that, problem statement, the objectives and even the design goals have been identified earlier so that the system can be developed smoothly and successfully. Moreover, for the method, neural networks have been identified is the most suitable method in designing the signature verification. For this purpose, neural networks are using the Matlab software, which have many functions for performing mathematical operations and analyzing data such as matrices and linear algebra, polynomials and interpolation, data analysis and statistics.

Moreover, Gantt chart has been produced for this project so that project can be completed on time. The Gantt can be seen at the appendices. Beside that, diagrams have been developed for easy understanding on how the system will work and flow. In addition, for the literature review part, there is addition on it to know on how others doing the signature verification system based on their view. This project can be developed by having a good algorithm and get the calculation correctly.

As for the recommendation part, this project is concerned about the signature verification, which is one of the parts in the pattern recognition field. However, the prototype is being developed focuses only on the distance similarity between the signature images in order to find the minimum distance of the signature. If the

minimum distance between these two signature images is zero, it means that the query signature is the same with the one in the database. So in order to enhance the prototype, many other methods can be included such as the feature extraction, using the Konohen neural network and other method discussed by the other researcher. The signature verification field has expanded and it can improve if there is any other method that makes the system faster and easier. But then, this system have meet the objectives of this project as to verify the signature is true or false and put the threshold to 95% to accept the signature.

From the studies in [8] by Ke Han, he proposed a system, which uses a set of geometric and topologic features to map a signature image into two strings of finite symbols which local associative indexing scheme is then used on the strings to organize and search the signature image database. While in [7] by B.Fang proposed by tracking the propositional variations of the projections profiles of the signatures and the second track the actual positional variations of individual strokes of the two dimensional signatures patterns.

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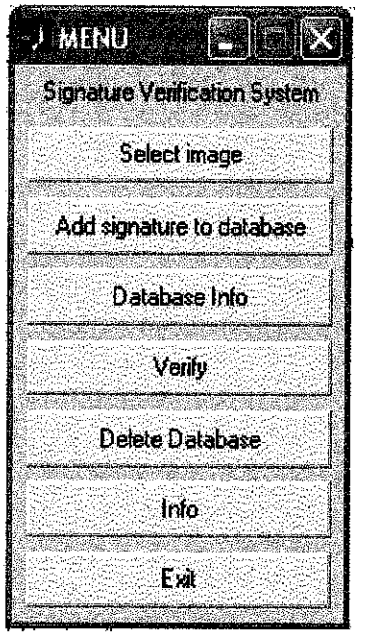
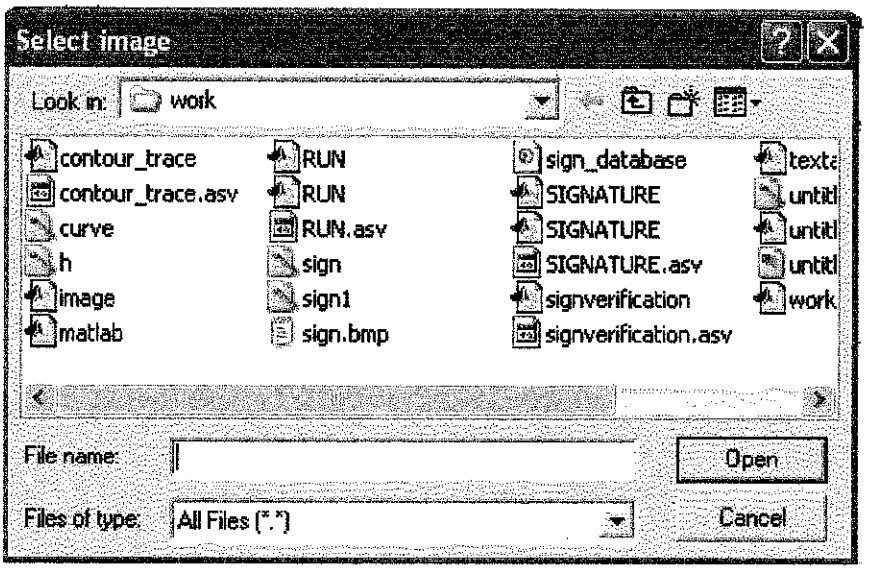
APPENDICES

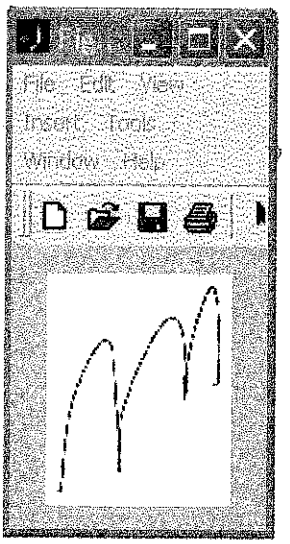
SNAPSHOT OF THE USER INTERFACE



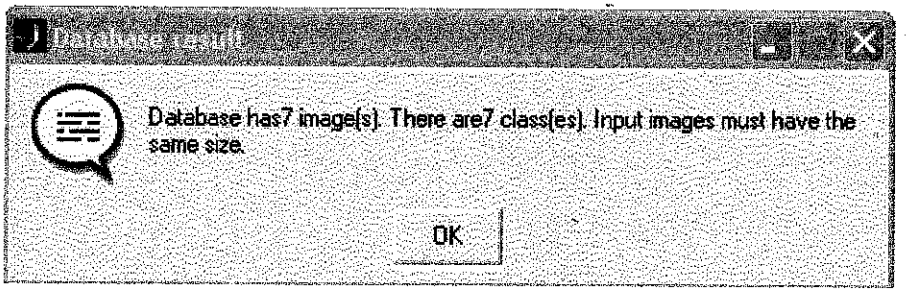
Main menu



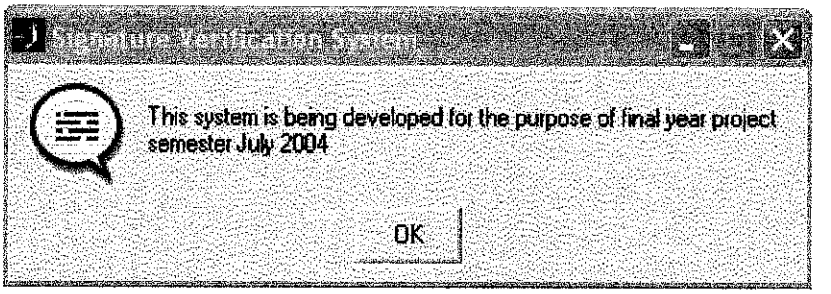
Select signature image



Selected signature



Database info

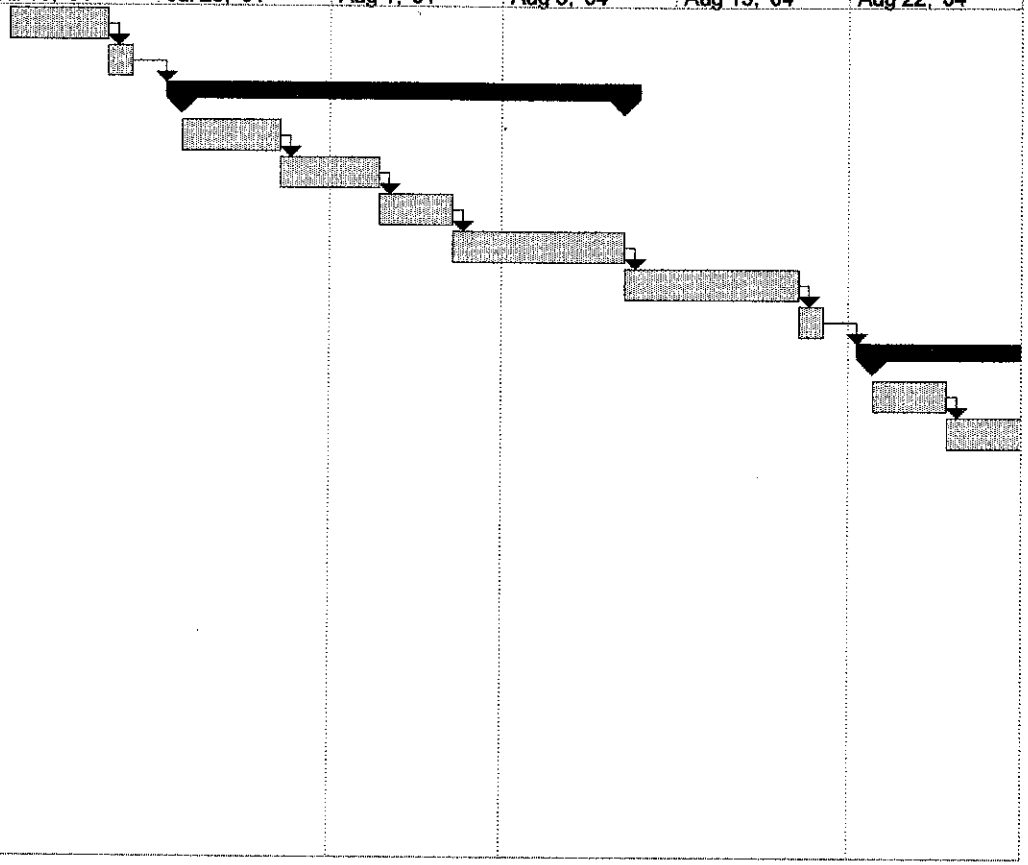


System info

The result of the system will be displayed as the verify button click on the Matlab command.

FINAL YEAR PROJECT TIMELINES

ID	Task Name
1	Completing preliminary report
2	Submit preliminary report
3	**Requirement analysis**
4	Analyze the system goals
5	Revise scope and objectives
6	Analyze problem statements
7	Gathering information
8	Completing project progress report
9	Submit project progress report
10	**System Design**
11	Produce system area model
12	Develop system outline design
13	Obtain approval for construction
14	**Implementation**
15	Building the prototype
16	Prepare for transition
17	**Testing**
18	Test prototype
19	User feedback
20	Final draft submission
21	**System evaluation**
22	Oral presentation
23	Project dissertation submission



Project: SIGNATURE VERIFICATION
Date: 29 July 2004

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

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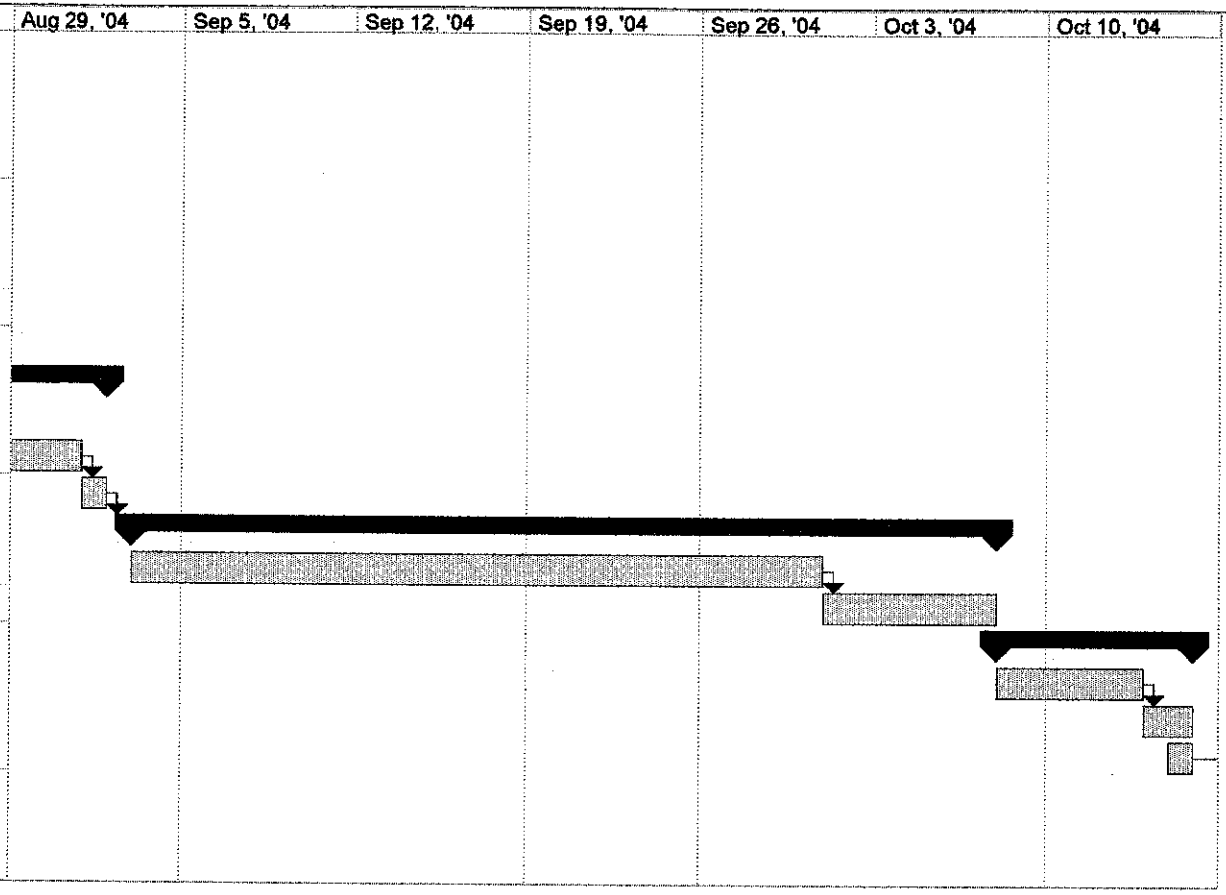

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Signature Verification

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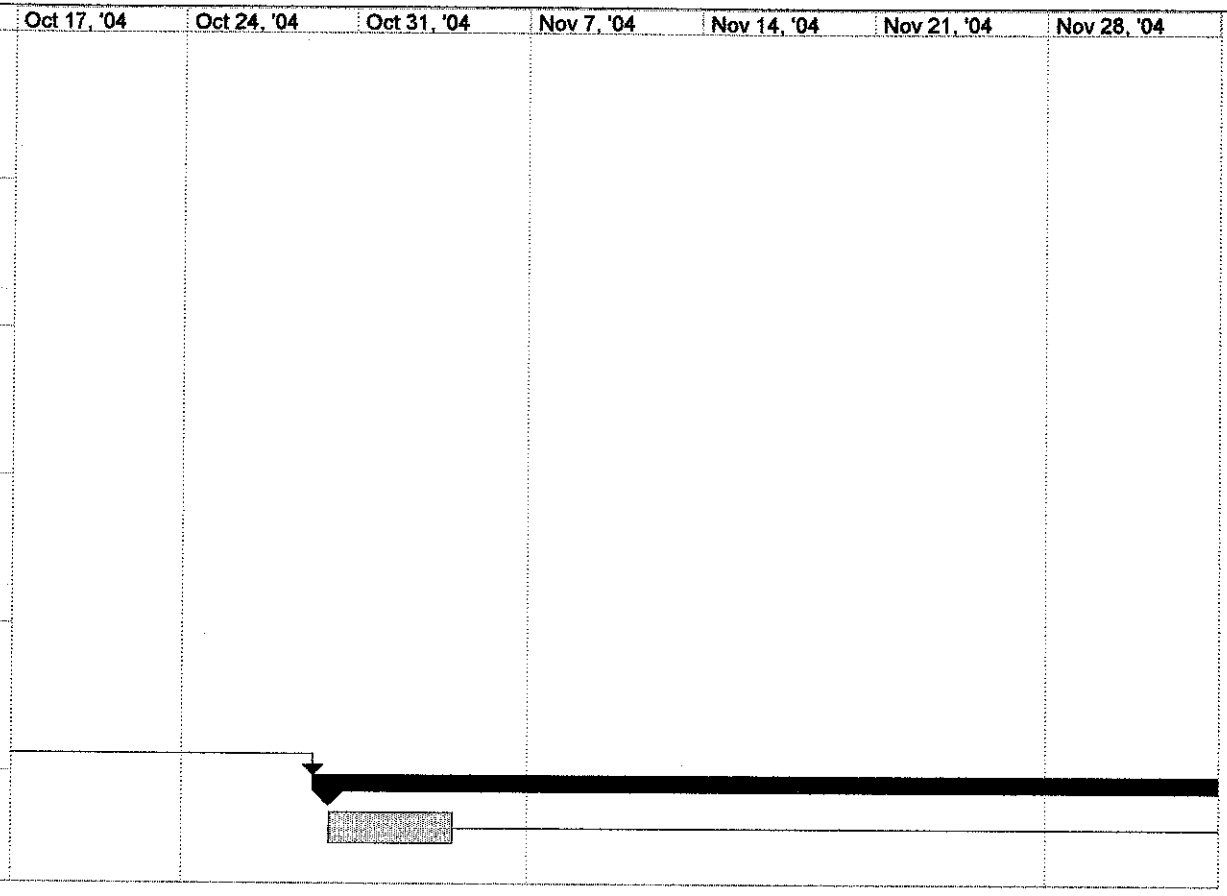

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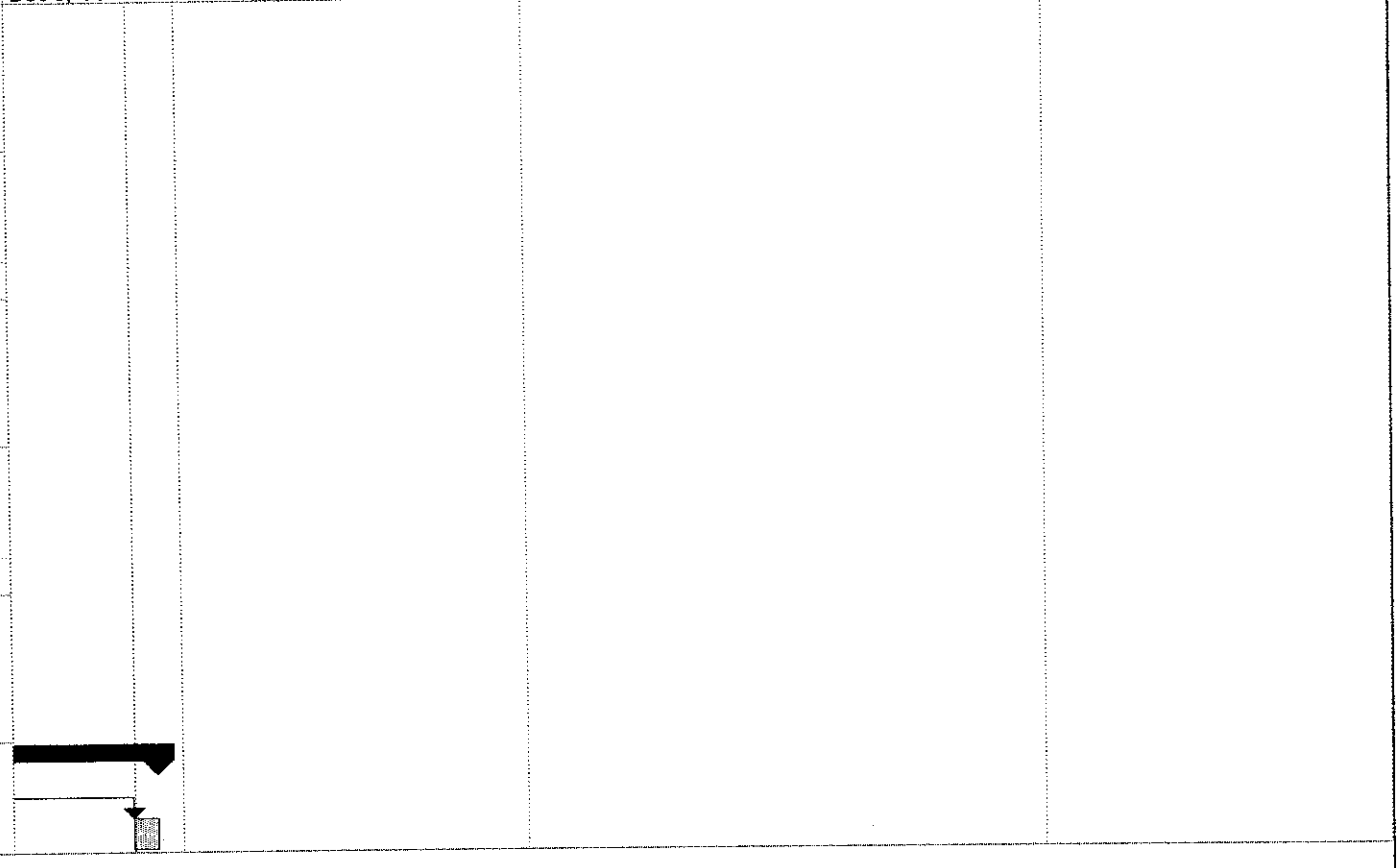

Project: SIGNATURE VERIFICATION
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Task
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% Selecting the image of the database

```
if ButtonNo==1,
    clc;
    [namefile,pathname]=uigetfile('*.*','Select image');
    if namefile~=0
      [img,map]=imread(strcat(pathname,namefile));
      img = imresize (img, [112,92]);
      imshow(img);
    else
      warndlg('Input image must be selected.',' Warning ')
    end
  end
```

%Saving data into the database

```
if class_number==max_class;
    max_class=class_number+1;
end
    data{sign_number,2}=class_number;
    save('sign_database.dat','data','sign_number','max_class','-append');
    n = msgbox(strcat('Database already exists: image succesfully added to class
    number ',num2str(class_number)),'Database result','help');
    close all;
     clear('img')

     close (n);
      prompt = {'Enter the name of signature owner'};
      dlgtitle = 'Signature';
      lineNo = 1;
      def = {'name'};
      name = inputdlg (prompt,dlgtitle,lineNo,def);
```

```
data{sign_number,3}=char(name);
save('sign_database.dat','data','sign_number','max_class','-append');
```

% Display the database info

```
if ButtonNo==3,
    clc;
    close all;
    clear('img');
    if (exist('sign_database.dat')==2)
      load('sign_database.dat','-mat');
       msgbox(strcat('Database has ',num2str(sign_number),' image(s). There
      are',num2str(max_class-1),' class(es). Input images must have the same
      size.'),'Database result','help');
    else
      msgbox('Database is empty.','Database result','help');
    end
  end
```

% Evaluating eigenvalues

```
  if ButtonNo==4,
   clc;
   close all;
        if exist('img')
            ingresso=double(img(:));
        if (exist('sign_database.dat')==2)
            load('sign_database.dat','-mat');
            matrice=zeros(size(data{1,1},1),sign_number);
       for ii=1:sign_number
            matrice(:,ii)=double(data{ii,1});
       end
```

```
somma=sum(matrice,2);
media=somma/sign_number;
for ii=1:sign_number
   matrice(:,ii)=matrice(:,ii)-media;
end

matrice=matrice/sqrt(sign_number);

Image=matrice'*matrice;

[V,D] = eig(Image);

Vtrue=matrice*V;
Dtrue=diag(D);
end
end
```

% Evaluating the percentage rate of 95%

```
distanze_pesi=zeros(max_class-1,1);
   for ii=1:(max_class-1)
      distanze_pesi(ii)=norm(pesi-pesi_database_mediati(:,ii));
   end

[minimum_dis,position_minimum_dis]=min(distanze_pesi);

for ii=1:sign_number
      if  position_minimum_dis == data {ii,2} ;
         h = msgbox(strcat(' This signature is owned by  ', data{ii,3} ), 'Signature
          Owner', 'help');
```

```
        end
    end

    if minimum_dis ~= 0
        rate = ( minimum_dis /10000000 );
        msgbox(strcat(' The distance is equal to ',num2str(rate)), 'Database
        result', 'help');
            if rate > 0.5
                msgbox('The signature is rejected or is not exist in the
                database', 'Database result', 'help');
                 close (h);
            else
                msgbox('The signature is accepted ','Database result',
                'help');
            end
      end

      if minimum_dis == 0
        msgbox(strcat(' The signature is belong to class
        ',num2str(position_minimum_dis)), 'Database result', 'help');
        msgbox('The signature is accepted ', 'Database result', 'help');
      end
```

% Remove the database

```
if ButtonNo==5,
    clc;
    close all;
    if (exist('sign_database.dat')==2)
      button = questdlg('Do you want to remove the Database?');
      if strcmp(button,'Yes')
```

```
        delete('sign_database.dat');
        msgbox('Database was succesfully removed.','Database removed','help');
      end
    else
      warndlg('Database is empty.',' Warning ')
    end
  end
```

% Display system information

```
if ButtonNo==6,
    clc;
    close all;
    msgbox('This system is being developed for the purpose of final year project
    semester July 2004','Signature Verification System','help');
end
```

Basic functions for calculating Euclidian distance

```
d = boxdist('img');
data {sign_number,4}=d;
save('sign_database.dat','data','sign_number','max_class','d','-append');
```