

REPUBLIC OF TURKEY
FIRAT UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES



**BIOMETRIC IDENTIFICATION SYSTEM BASED
ON HAND GEOMETRY**

Master Thesis

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ABBREVIATIONS

- ANN** : artificial neural network
- K-NN** : k-nearest neighbors
- SSE** : Sum squared error
- SCG** : Scaled conjugate gradient



OZET

El Geometrisine Dayalı Biyometrik Tanımlama Sistemi

Bu çalışmada, biyometrik tanımlama veya doğrulama sistemleri için el geometrisine dayanan etkili bir biyometrik yöntem sunulmuştur. Özellik vektörleri uzunluk, genişlik ve parmak alanı gibi ölçülebilir el geometrilerinden oluşturulmuştur. Gürültü azaltma için el görüntüleri alçak geçiren filtreden geçirildikten sonra, şekillerin eğrilikleri hesapmaktadır. Ardından, el imgesindeki vadileri, özellik vektörü olarak tanımlanmak üzere çıkarılır. Etkili özellikler olarak bir el şekli geometrisinden yirmi dört ölçüm kullanılmıştır. Tanıma için sınıflayıcı olarak yapay sinir ağı ve k-en yakın komşu algoritması kullanılmıştır. Deneysel sonuçlar, sinir ağı için % 95.3 ve k-en yakın komşu algoritması için % 91.2'ye doğru tanıma oranlarına ulaşmaktadır.

Anahtar Kelimeler: El geometrisi, biometric tanımlama sistemi

ABSTRACT

In this study, an effective biometric method based on hand geometry is presented for biometric identification or verification systems. Feature vectors have been constructed from measurable hand geometrics such as length, width and area of fingers. After low-pass filter input hand images for noise reduction, curvature of the shapes is computed. Then, the valleys of a hand are extracted for identification as feature vector. Twenty-four measurement from a hand shape geometry are used as effective features. Artificial neural network and k-nearest neighbor's algorithm are used as classifiers for Identification. The experimental result reaches to the performance of 95.3% for neural network and 91.2% for k-nearest neighbor's algorithm as correct recognition rates.

Key words: Hand geometry, biometric identification system

1. INTRODUCTION

The word biometrics is derived from a Greek word “bios” meaning natural life and “metrics” meaning measurement. In recent years, the researchers study biometric technology to identify person individually in especially security field applications. Biometric identification uses physiological or behavioral of human characteristics [1]. A development of various biometrics technologies is preferred because of its uniqueness, stability, permanence and ease of acquisition. Biometric identification system refers to the recognition of difference in pattern of human characteristics, which is called as personal authentication or access control. The idea to create a biometric system for personal identification can collect measurable characteristics of human body like face, iris, palm print, hand geometry, fingerprint, hand vein, signature etc. in order to constitute feature vector. The kind of biometric systems is chosen according to the security type. This study focuses on hand geometry to construct a biometric identification system.

The recent progress of various technologies in computer field in many areas it was been needs and has become an absolute necessary to develop new methods for authentication or identification of a personal in services link internet Account registration form or ATM cards and other password required password form, the biometric Identification based system will good alternative to the classical username and password registration form in all kind of communication and authentication applications. The internet account been proven to be weak and broken, social network and emails been widely cracked. password cracking been appeared widely because of rising technic of guess password and other statistical tools, because of that IT field must focus on alternative solution for information security authentication and access control [2], Additional to that biometric measure is easy to use.

Human have used various methods as well as physical characteristics such as voice, face and body to identify fellow human beings. In the 19th century, a notable chief police officer by the name Alphonse Bertillon practiced a notion of identifying criminals by using measurements of their body parts. Whilst this idea was gaining popularity in the 19th century, researchers then discovered the unique features of human fingerprints. This discovery led to the record keeping of fingerprints for criminals and storing them in

databases for future reference. The process would go like this, after a criminal act e.g. burglary, the police would trace for fragments left and examine them to trace fingerprints which later on would be put into the system and the system would match the fingerprints to a person and the criminal would be identified. Biometric identification has been used in various ways such as in DNA tests to identify the father of a child, security clearance, for criminal clearance as well as forensics. Below the researcher explains the biometric measurements which should be taken into consideration when determining a biometric.

- The following requirements ought to be met when using physiological or behavioral characteristics of human beings in determining biometric measures:
 - *Universality*: Every human ought to have similar physical characteristics e.g. hands, eyes etc.
 - *Distinctiveness*: The scale to be used should make it easy to distinguish two separate individuals.
 - *Permanence*: The measurement taken should not vary or change after a period of time.
 - *Collectability*: The distinct measurement to be taken should be measurable.
- In addition to the above features, biometric systems should encompass the following issues should be taken into consideration:
 - *Performance*: This refers to how fast in terms of speed and how accurate the biometric will be in terms of recognition.
 - *Acceptability*: This refers to the extent that users are willing to adapt to new technology and use biometric recognition.
 - *Circumvention*: This refers to the extent to which a system can be deceived by users and criminal activities conducted.
 - A typical biometric system should be accurate, reliable, meet user expectations, be harmless, should meet resource requirements and it should

be secure enough so that no criminal activities are conducted by deceiving the system.

Below are the requirements to be met for any physical or behavioral human characteristic to be used under a biometric system:

- **Universality:** The characteristic should be common among all people.
- **Distinctiveness:** The biometric feature to be used must permit the unique characteristics among different people to be identified.
- **Permanence:** Measurement used must be permanent and should not vary over a period of time.
- **Collectability:** Data collected from the system should be measurable and it must be quantifiable.

A biometric system put in place to for practical reasons of merely recognizing individuals the following issues should be taken into consideration:

- Performance is recognized as a key factor and should be measured in terms of speed and accuracy as well as other environmental factors that may affect the performance of the system.
- Acceptability should also be considered in terms of measuring the extent to which individuals are willing to adapt to the system.
- The system should be set in such a way that fraudulent activities are detected.

A functional biometric framework must meet predefined acknowledgment precision, velocity, and asset prerequisites, be innocuous to the clients, be acknowledged by the proposed populace, and be adequately vigorous to different fake techniques and assaults to the framework.

There was been many related research of hand geometry features extraction and many methods of identification or verifications [3] This study will be Attempt to develop a

good performance and accuracy and quality of Identification System based on Hand Geometry

This work been done in three stage, data preprocessing, create classifier and testing phase, data preprocessing consists of image processing and feature extraction [7]. Image processing will be image acquisition, image filtering, Crop and Resize Images. Feature extraction process are Fourier transform, low pass filter, image boundary selection.... etc.

Next is create classifier and modelling the experiment prepare to the test, two classifiers been suggested Neural network and k-Nearest Neighbors, then the model was being ready for test. It been notices that features of hand were very effect on recognition accuracy, therefor the experiment was being repeated many times to define and select best feature. In the end, it was 24 feature been select to create a final classifier model.

2. BIOMETRICS SYSTEM

A biometric system refers to a system that uses a set pattern to identify an individual after extracting saved information from the database. A biometric system operates in two distinct contexts, it can either identify an individual or it can be used as a verification tool for checking if the person is indeed the real person they claim to be.

- The verification stage of a biometric system is responsible for verifying user credentials matching them with the information stored in the database and comparing the two before granting access or authenticating a user.

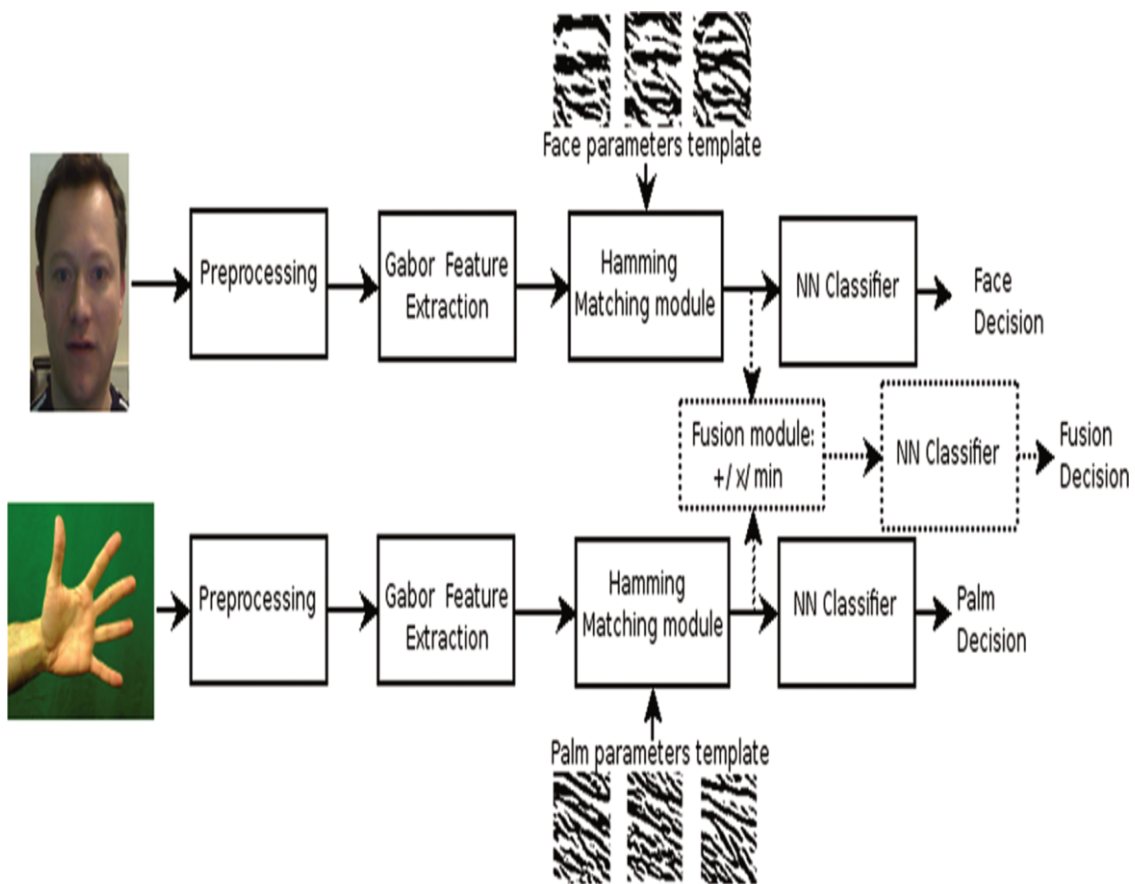


Figure 2.1: Block Diagrams of Enrollment

The main purpose for the verification process is to prevent impersonation, a scenario whereby an individual use someone else identity and pretends to be who they are not. Normally in this verification process the user is prompted by the system to verify themselves by either entering a PIN code or a one-time pin sent to a device believed to be with the owner of an account.

- In an identification biometric system, the system checks the database in-order to identify the user. The system checks the entire database to retrieve the match and if no matching record is found, the system notifies the user that no record has been found.
- For identification purposes, an identity must be established as to who owns this information. Recognizing confirmation is crucial especially for unfavorable affirmation applications where the structure sets up whether the individual is who she (undeniably or unequivocally) refuses to be associated with. The inspiration driving adversarial affirmation is to keep a single individual from using various characters. Recognizing confirmation might similarly be used as a piece of positive affirmation for solace (the customer is not required to ensure a character). While customary schedules for individual affirmation, for instance, passwords, tokens, one-time PINs, as well as keys are best used for positive affirmation, whereas negative affirmation must be set up using a biometry

It is crucial to note that in this thesis the researcher uses the word acknowledgment in cases where the researcher does not wish to make an overall conclusion in the middle of confirmation and ID. The piece graphs of a confirmation framework and an ID framework are delineated in Fig. 1; client enlistment, which is normal to both of the undertakings, is likewise graphically outlined [3].

2.1. History and Development

Biometrics have been defined as systems put in place to identify or verify humans by using physical and behavioral characteristics programmed in databases. The origin of biometrics began from identifying people using body characteristics such as scars, height, eye color as well as complexion. The first uses of biometric systems were in China where babies were distinguished from each other using their palm prints and foot prints taken at birth. In the 19th century researchers began to propose the use of biometrics in the criminal sector to identify criminals. This approach included a method whereby skulls of people were measured in order to identify criminals. Although this method was not very effective, it led to the identification of unique human being features such as fingerprints.

Biometrics used in the movies include fake identities which are portrayed through the use of contact lenses and security measures are put in place to protect those who break

the law. Many places have adopted the usage of biometric features as part of their systems in places such as border control points, mines, in prisons and at state embassies. Security is a main concern at such places hence companies invest in biometric security features. There has been an increase in the interests of researchers to examine how these systems function. It is proposed that biometric systems will be used for internet transactions, telephone transactions, travel as well as tourism.

Technological advancements are being done to upgrade and integrate old biometric systems making them into new systems. Among the most popular biometric systems are finger prints facial recognition systems, signature verification systems voice recognition, hand geometry and retinal scanning. The systems are explained in detail below:

- **Fingerprint:** This is a widely used biometric system in which individuals are identified using their finger prints. However, the cons of this system is that it requires training for one to be able to take recognizable fingerprints.
- **Hand geometry:** The easiest method to use which measures physical and visible aspects of the hand.
- **Voice verification:** This method is still in its infancy and is being developed to remedy the current flows that it comes with regards to local acoustics.
- **Signature verification:** This is the widely accepted verification process which has been used over the past years
- **Retinal scanning:** This technology features requires an individual to look into an object and focus and the retina is scanned
- **Iris scanning:** This is the easiest method that is not so intrusive compared to retinal scanning.
- **Facial recognition:** This technology possess strong detection and verification features which are discussed in the section below



Figure 2.2: History of Biometric

2.2. Various Types of Biometrics

Various applications in the industry make use of different biometric features as illustrated in the diagram below.

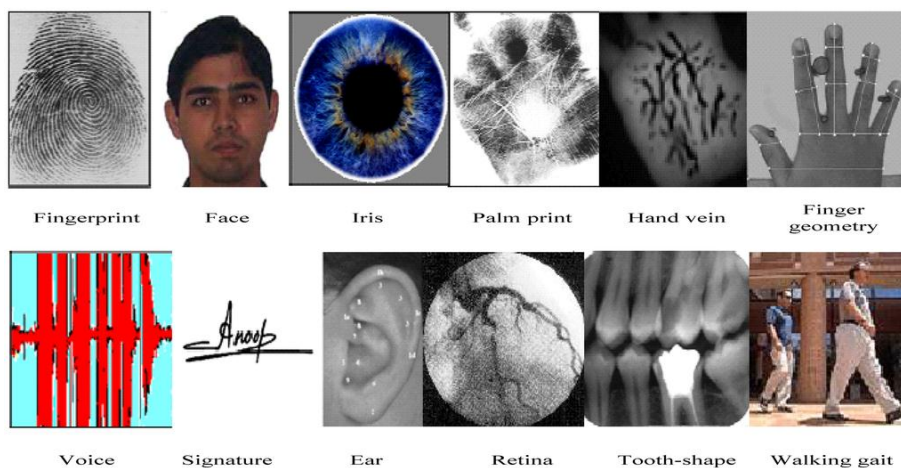


Figure 2.3: Characteristics of biometric systems: (a) Fingerprint, (b) Face, (c) Iris, (d) palm print (e) Hand vein, (f) Finger Geometry, (g) Voice, (h) Signature, (i) Ear, (j) Retina, (k) Tooth-Shape, and (l) Walking Gait, (m)

Biometric features pose distinct features and qualities and shortcomings, however, decisions rely upon the biometric system to be configured. No biometric system has been identified yet which best meets the utilization requirements. There is no biometric application that best meets all specifications and requirements, however, remedies are done based on system properties. The researcher explains the biometrics which are frequently used in more detail below:

2.2.1. Fingerprint

Fingerprints have been used over the past decades as a means of matching people and identifying individuals. Fingerprints are patterns which appear on the surface of the hand and forms ridges which develop the first few months after a baby's birth. The interesting facts lie in the fingerprints of identical twins which are also unique from each other despite similar physical characteristics.

Unique mark scanners in the United States cost an average of \$20 a unit. In cases where the requested scanners are more, the amount increase together with the negligible expense of inserting a unique mark in a biometric framework (e.g., tablet phone) [5]. The precision of the as of now accessible unique mark acknowledgment frameworks is satisfactory for confirmation frameworks and little to medium-scale recognizable proof frameworks including a couple of hundred clients. Different fingerprints of a man give extra data to permit to vast scale acknowledgment including a great many personalities. One issue with the present unique mark acknowledgment frameworks is their demand for excessive computational assets, particularly in cases where one is working in proof mode. At long last, fingerprints of a little division of the populace may be unacceptable for programmed recognizable proof as a result of hereditary variables, maturing, ecological, or word related reasons (e.g., manual laborers might have countless and wounds on their fingerprints that continue evolving).

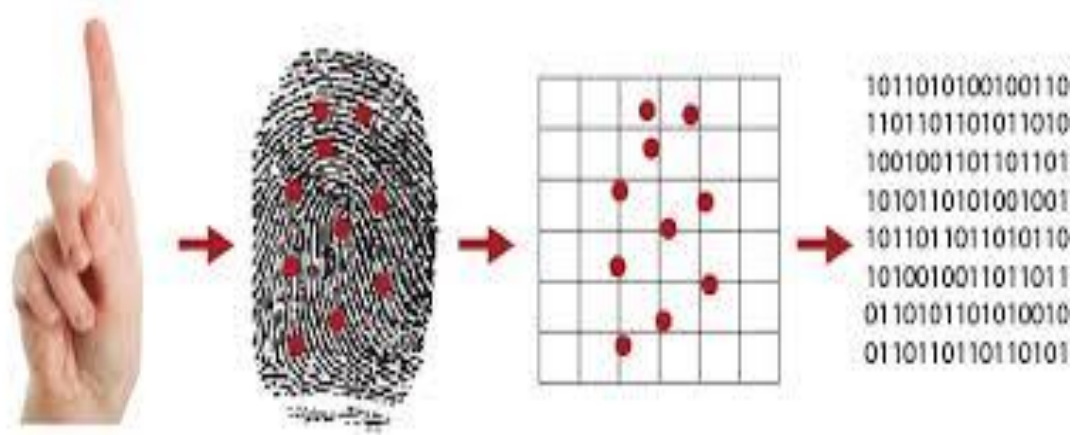


Figure 2.4: Finger Scan

Pros:

- Accuracy levels are extremely high.
- It can be used on a Pc making it more economical verification feature.
- It is a widely manufactured biometric system
- Simple to use
- Minimal storage space is required and it also uses less data making it more convenient to use.
- A standard framework is used globally for the manufacturing of finger scan biometric systems.

Cons:

- The system is unpleasant to some people since it is widely associated with crime identification.
- Prone to make mistakes in cases were hands are dry or dirty and it is not suitable for young children as their fingers grow with age.

- As the number of dots captured per inch increase it results in higher resolution but it then demands an increase in storage space.

2.2.2. Face

This is the widely used recognition method used by humans to identify other fellow humans. Face recognition is done in several ways which include static, dynamic as well as controlled. Face recognition captured image is determined by several factors such as: 1) location of facial features such as lips, eyes, nose etc.; 2) The shape of the face and how well it clearly identifies an individual. Although facial recognition systems in place can identify individuals, they still pose a lot of restrictions as to the type of background required and other things to note. Facial recognition frameworks likewise experience issues in perceiving a face from pictures caught from two radically diverse perspectives and under distinctive brightening conditions. It is flawed whether the face itself, with no logical data, is an adequate premise for perceiving a man from countless with a to a great degree abnormal state of certainty. All together for a facial acknowledgment framework to function admirably practically speaking, it ought to consequently: 1) distinguish the availability of a facial image in the capture; 2) Trace the screen to locate a face and 3) perceive facial features from a distant [4].



Figure 2.5: Face Scan

2.2.3. Iris

The center part of the eye surrounded by sclera which is the white part of the eye is called the iris. The texture of the visual aspect of the iris is formed the first 2 years after birth. In the literature, researchers have noted that the surface of the iris conveys exceptionally particular data helpful for individual acknowledgment. The precision and rate of as of now conveyed iris-based acknowledgment frameworks is promising and indicate the achievability of extensive scale recognizable proof frameworks in view of iris data. Every iris is unmistakable and, similar to fingerprints; including the iris of indistinguishable twins have also been said to be distinctive. It is hard to alter the composition of the iris even by surgery. Furthermore, it has been said to be fairly simple to distinguish counterfeit irises which are referred to as contact lenses and the original iris. Despite the fact that, the first iris-based acknowledgment frameworks needed significant client support and they costed a lot of money. Fresher framework are easier to understand and savvy.

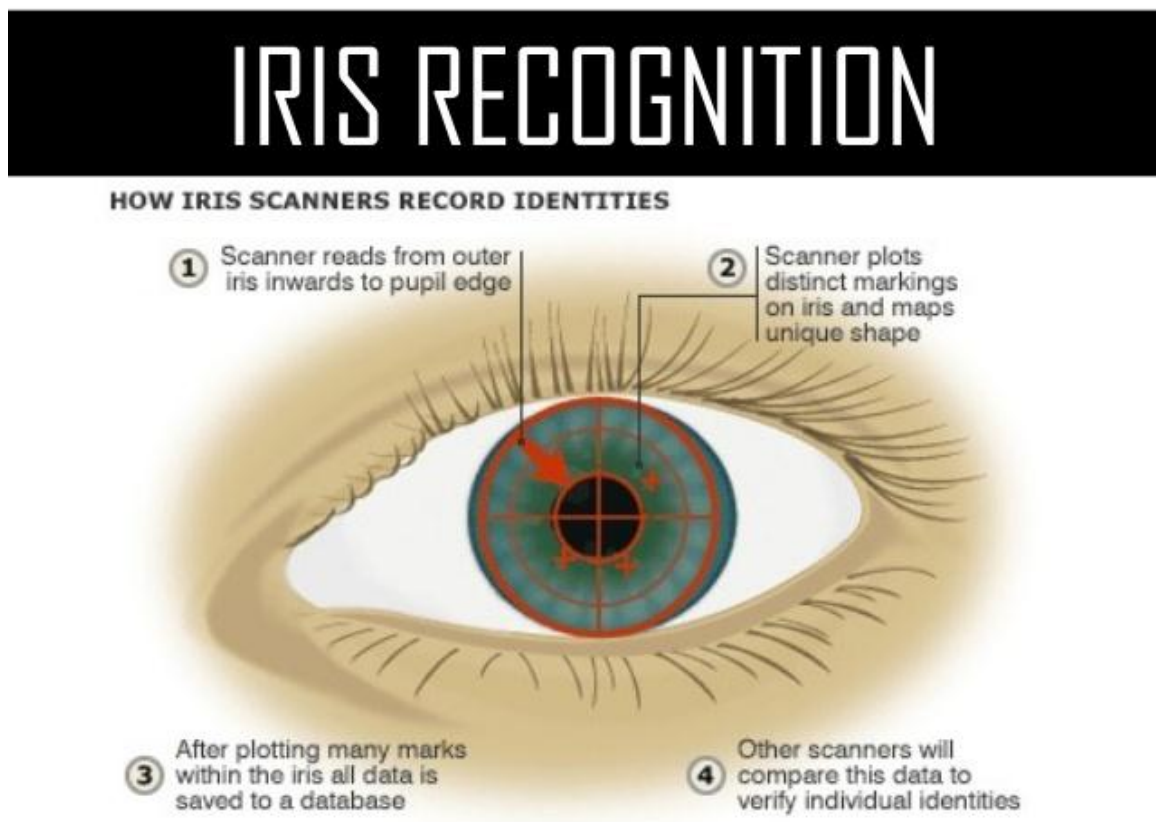


Figure 2.6: Iris Scan

Pros:

- Accuracy levels are extremely high.
- The time taken to verify an individual is relatively low e.g. 5 seconds.
- No further actions are required to confirm the death of people as retinal scans are quick to confirm loss of life as eyes of dead people quickly deteriorate.

Cons:

- Very disturbing to the eye.
- Requires a large amount of data for the information to be stored.
- Costly.

2.2.4. Palm print

The inside of the hand known as the palm has patterns which form ridges and are unique to every person similar to fingerprints. Palm prints are larger compared to fingerprints and for this reason they tend to be more distinctive.

Scanners used for palm prints are expected to capture a substantial territory, the scanners are big in size and more expensive compared to finger impression sensors. Palm prints have extra particular components, for example, essential patterns that are often caught even with a low resolution scanner that is less expensive. At long last, while utilizing a high-determination palm print scanner, every one of the components of the entire palm facet, for example, hand geometry, edge and depression highlights (e.g., particulars and solitary focuses, for example, deltas), key lines, and other patterns such as wrinkles are normally consolidated to manufacture a profoundly precise biometric framework [6].

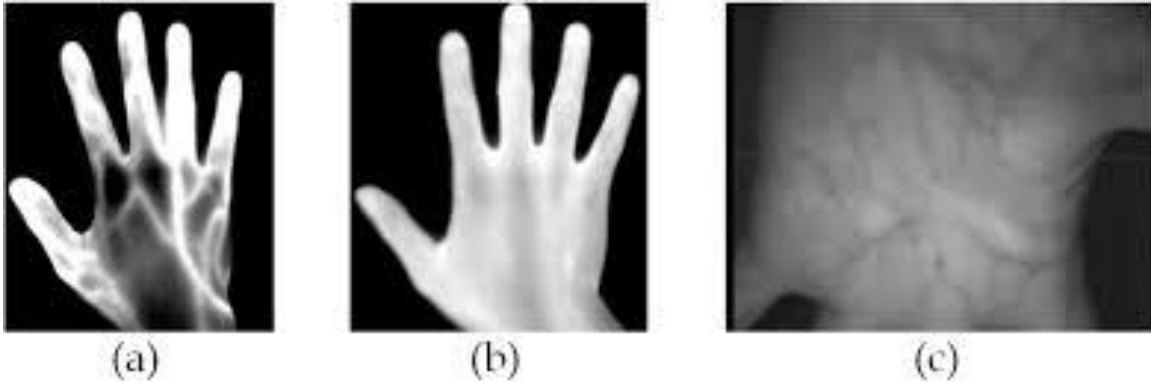


Figure 2.7: Facial, Hand, And Hand Vein Infrared Thermos Gram

2.2.5. Facial, hand, and hand vein infrared thermos gram

Humans radiate heat in their bodies and the pattern that the heat is radiated can be apprehended just like in a photograph. Covert recognition is normally used for this technology. A thermos-gram system captures the pattern of blood flow without human contact using lenses, however other factors such as heat in the body which is a result of a room heater can affect the output pattern. Infrared technology is also used to scan the pattern of a hand were an individual forms a fist and the vein structure is captured. The reason behind the widespread usage of thermo-grams is that it is cheaper compared to infrared technology.

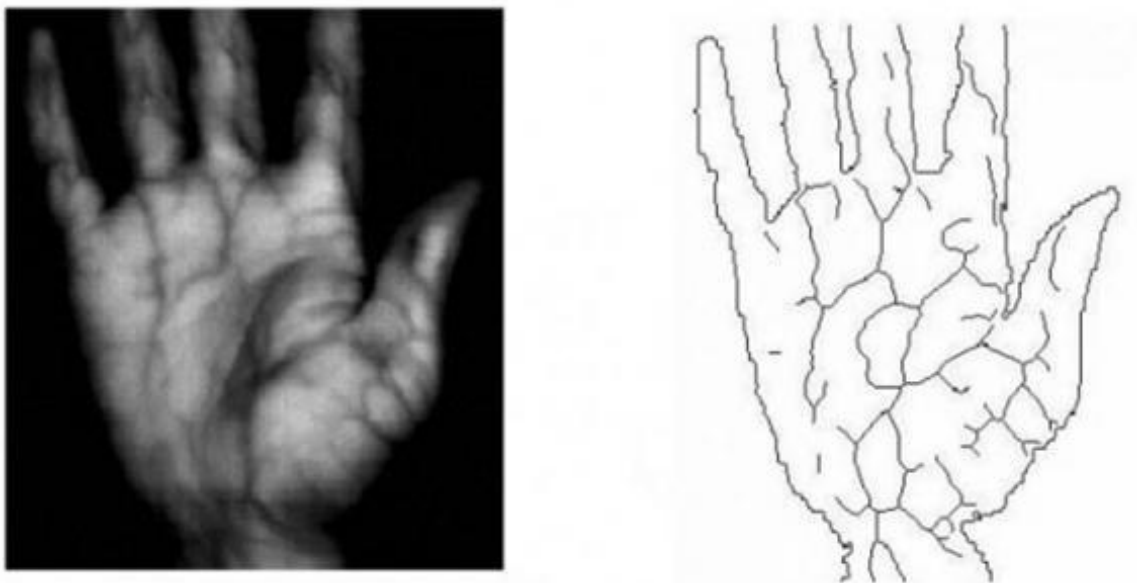


Figure 2.8: Hand Vein Infrared Thermos Gram Scan

2.2.6. Hand Geometry

Hand geometry involves taking measurements of the human hand, palm size, shape, length as well as the width of the fingers. Verification systems that use hand-geometry are being used at different places worldwide.

This strategy is exceptionally basic, easy to use and reasonably priced. Ecological components, for example, dry climate or individual irregularities, for example, dry skin doesn't seem to have any negative consequences for the confirmation exactness of the hand features to be scanned. Extremely particular and hand geometry-based acknowledgment frameworks can't be scaled up for frameworks requiring recognizable proof of a person from an expansive populace. Furthermore, data obtained from hand geometry will not vary for a child as they grow from infancy to adulthood. Also, a person's adornments such as rings and impediments might posture further difficulties in separating the right-hand geometry data. The basic sizes for hand geometry frameworks are large, and they can't be installed on specific gadgets such as tablets. Confirmation frameworks accessible depend upon estimations for a couple of fingers rather than the whole hand. The gadget is littler compared to those utilized specifically for hand geometry, yet at the same time much bigger than those utilized as a part of some different biometrics (e.g., unique mark, face, voice).

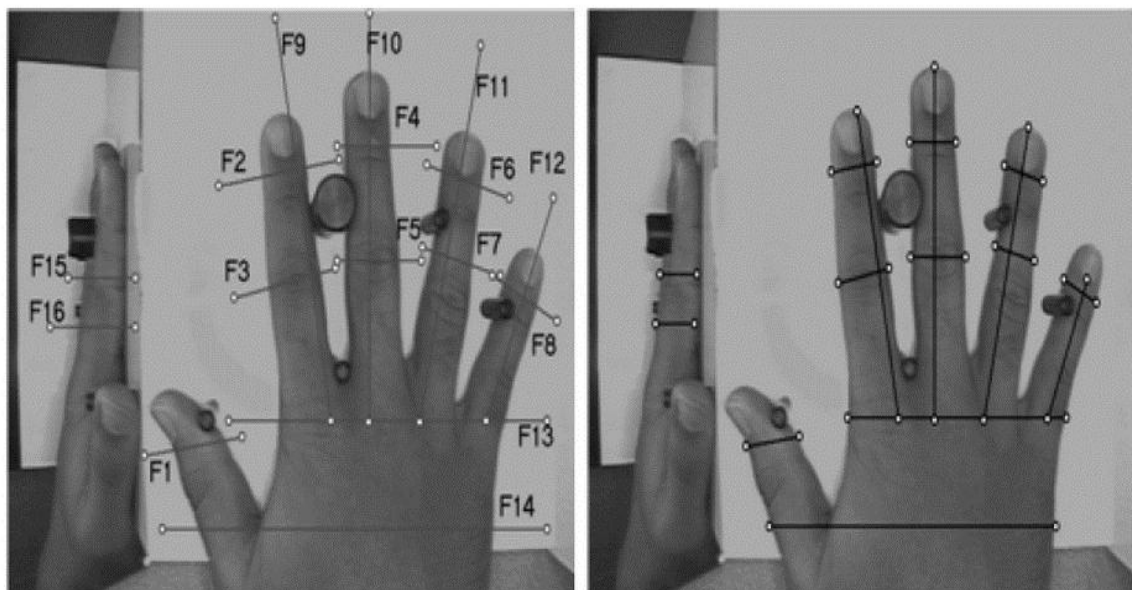


Figure 2.9: Hand Geometry Scan

Pros:

- Hand geometry scan can still be easily integrated in other systems despite its need for other devices for proper functioning.
- Not much problems with this biometric system as it mainly used for identification purposes.
- It makes use of low data to identify an individual.

Cons:

- This biometric system is very costly.
- Sizes are normally small
- Not suitable for disabled people e.g. people suffering from arthritic

2.3. Measurement and analysis methods

Rehashed estimations emerged during a period succession of estimations s taken from each of various test units dispensed to one of the few medicines. As a particular case, Box (1950) presents the information from an examination in which 27 rats were dispensed to one of three test medicines in a totally randomized plan, and the body weight of every rodent was recorded on occasion 0, 1, 2, 3, and 4 weeks after the begin of the try. This illustration serves as a model for the class of issues which we address in this paper. Specifically:

- The reaction for each exploratory unit is a succession of estimations on a persistent scale.
- The mean reaction relies on upon both the trial treatment and the time at which the reaction is measured.
- The essential target is to make deductions about the impacts of the test medications on the mean reaction profile.

We view the accompanying as alluring components for a general strategy for examination for rehashed estimations ate.

2.4. Aim and Objectives

Biometric authentication and their template security are increasing day by day posing challenging requirements for Automated Secured Personal Authentication Systems. The reason behind on this demand for the replacement of old-fashioned automatic personal identification tools by new one. The old-fashioned automatic personal identification tools use traditional approaches like PIN codes, Login Id, ID card, password and other features which may be used to authenticate a person. Biometric scheme delivers automatic recognition of a person depending on some particular trait.

But, there are various unfolded challenges in the existing researches in biometric personal authentication. Among these, major challenges of iris recognition systems are associated with differences in iris performance as well as the overall security of the iris template.

Biometric features have always been an important part of every human being mainly for security purposes and identity purposes. A critical concern is on securing the iris template for authentication usage. Following are the four types of biometric systems:

- Traditional Biometric Systems
- Biometric Key Release Systems
- Cancelable Biometrics Systems
- Biometric Key Generation Systems

Three last mentioned biometric systems are effective for security issues, however, the following must be noted.

- Recognition performance is affected for most systems.
- The systems have slow performance contrary to the iris recognition systems.

- Since Iris image datasets are noisy, it means that a lot of the systems will not function to the best of their ability.

Basing on the above points, it is therefore crucial to have a reliable remedy to solve the issues of template security [8].



3. BIOMETRIC IDENTIFICATION SYSTEM DESIGN

The design of Biometric system is consisted of many steps, the Image Acquisition is the first step, the Data preprocessing is essential for any data collection to be filtered and prepared for classification. There are many steps as a data processing must be done before making and experiments, the diagram as depicted in figure 3.1 shows a process for experiments of data from raw data to pre-processing to results.

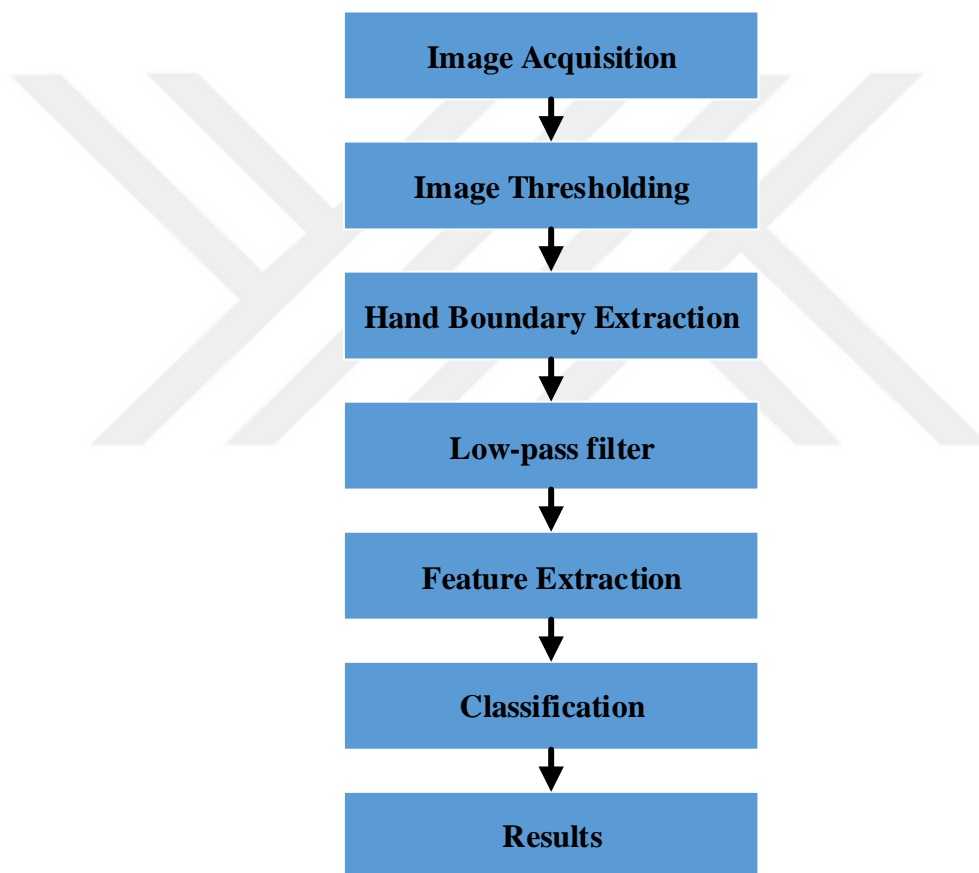


Figure 3.1: Structured Diagram of Biometric Identification System

3.1. Data Preprocessing

Data collecting is a first step for many researches after define a problem, the process of collecting Data was done from 35 person hands, each person with 10 samples. The data been collected by scanning hands. This samples are stored as an image package. The Total number being 350 samples, to prepare images for extracting feature it must be filtered

from noise, MATLAB Software Package been used in this experiment. Many steps are essential to prepare images to define and select feature, the basic idea it to normalize all samples of image to be measurable by any algorithms. The following step are process to be prepared.

3.1.1. Image Acquisition

At first, we must obtain our data, image acquisition is first stage, the images data collection stored as a PNG Data format, and Figure 1 shows one hand sample. Dataset contain 350 sample from 35 people's hand, each person with 10 samples.

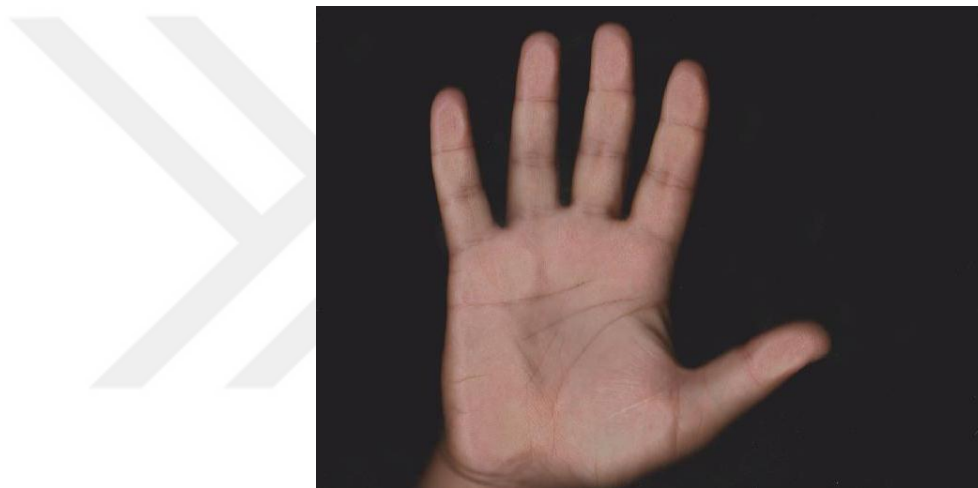


Figure 3.2: Image of Hand

3.1.2. Image Thresholding

Threshold process been applied to obtain Binary image, the first step is convert color image to Grayscale image, then to Binary image, its essentials to do this step to define and select hand shape. Pixels in binary image either 0 or 1, therefor it will be easy to recognize hand object in image using algorithm to detect it, figure 2 show all steps how image are converted to binary image. Cropping and Resizing are last step of converting images to be normalize of specific size. The last image product size 1459 by 1650. It's high resolution image and its fit the requirement and ready for extract all features from it.

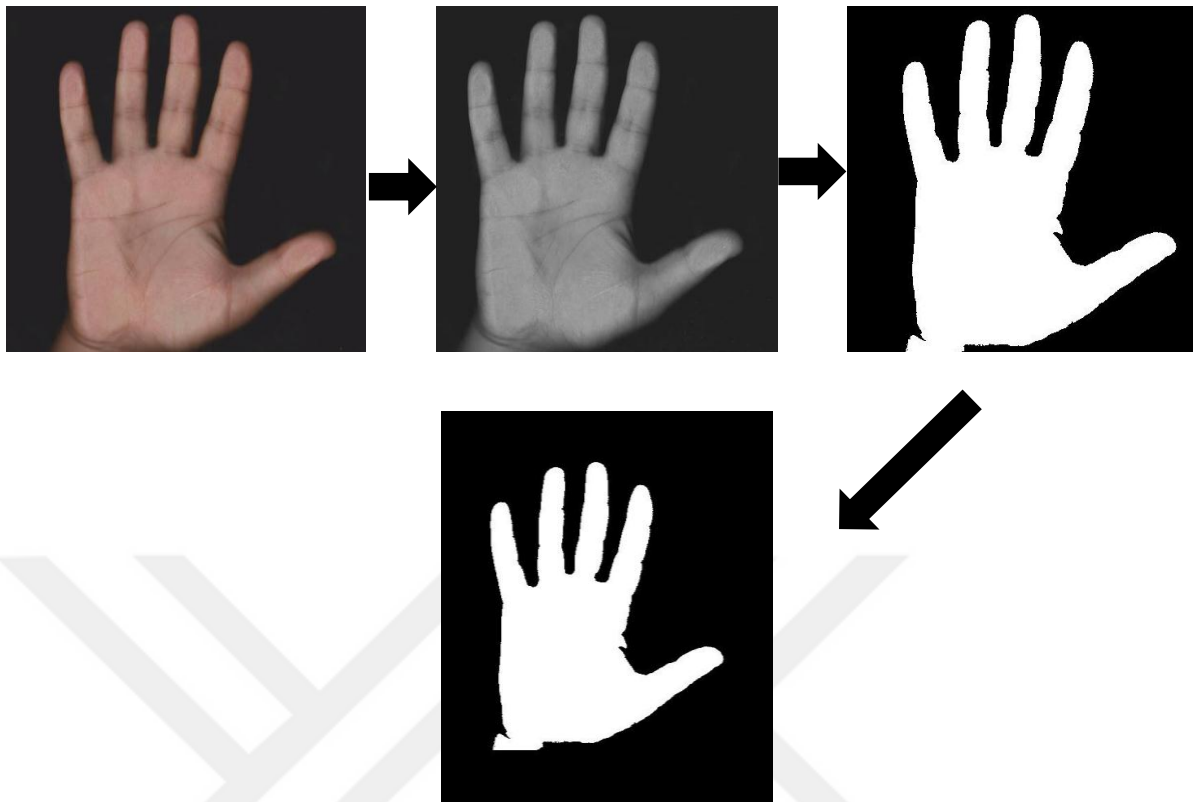


Figure 3.3: Image Thresholding, Crop and Resize Steps

3.1.3. Hand Boundary

Hand Trace object in binary image is a search process, it applied to traces the outline of an object, because binary image contains only 0 or 1, it easy to specify the object by search a connected component, nonzero pixels are belonging to object and zero pixels are non, an efficient way to define an object boundary that the maximum number of boundary pixels to be object outline. Because of images normalization size, it's easy to trace to all images boundary. The boundary been find as a sequence of points (x, y) that represent an outline around the boundary of the shape in order.

3.1.4. Low-pass filter

Images required smoothing, therefore we need low pass filter, at first the boundary of sequence set (x, y) been converted to frequencies domain. The fast Fourier transform can be used to turn this sequence into a trigonometric polynomial in frequency domain, we must deal with pixel effects that will show up as high frequency components in the FFT. Looking closely at the boundary that's been traced, it is jagged due to the discrete pixels. To the FFT, this high frequency component of the shape boundary need to be removed. Oscillations all over the boundary been removed by equal to zero. After that image been converting from frequencies domain to time domain. Figure 3 shows image boundary and how low-pass filter effect in pixel level of image.

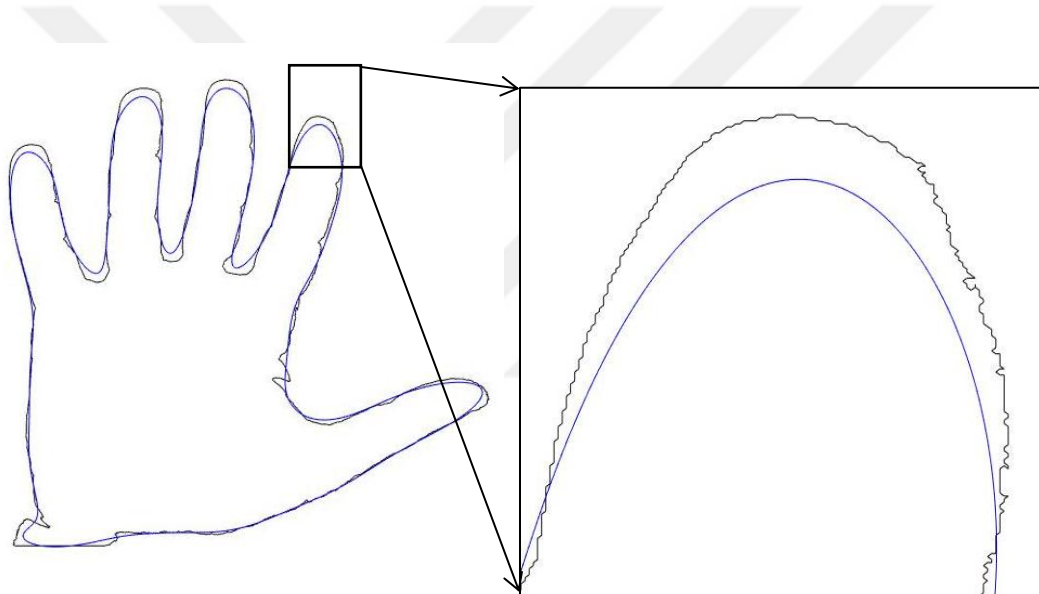


Figure 3.4: Image boundary and how low pass filter effect in pixel level

3.1.5. Feature Extraction

Dataset are represented in sequence of (x, y) form, the dataset is easy to compute because it's in matrix form in MATLAB Package, after low-pass filter that shown above, the features been extracted, the suggested technique seeks to calculate the curvature of shape, as show as below: -

$$\kappa = \frac{x'y'' - y'x''}{(x'^2 + y'^2)^{\frac{3}{2}}}$$

We need a parametric function in form $x=x(t)$ and $y=y(t)$ to compute curvature at any point along the boundary of the shape. The variable x', y'', y' and x'' are required as shown in formula above. Useful property of Fourier transform relationship to derivatives of functions given in a function $x(t)$ form as follow: -

$$\mathcal{F} \left[\frac{d^n}{dt^n} x(t) \right] = (iw)^n \mathcal{X}(iw)$$

Where:

$$\mathcal{X}(iw) = \mathcal{F}[x(t)]$$

That convenient relationship of Fourier transform in the parametric function appear. First the Fourier transform is selected from the parametric function, then derivatives [2] [3] [4] [5]. The derivative can be produced by performing multiplications using the frequency domain, then use calculated inverse Fourier transform as shown in formula below: -

$$x^n(t) = \mathcal{F}^{-1}[(iw)^n \mathcal{X}(iw)]$$

The curvature can be computed with all (x, y) points of boundary, then the threshold of curve values been filter, all values less than 0.001 has been deleted, the remain points

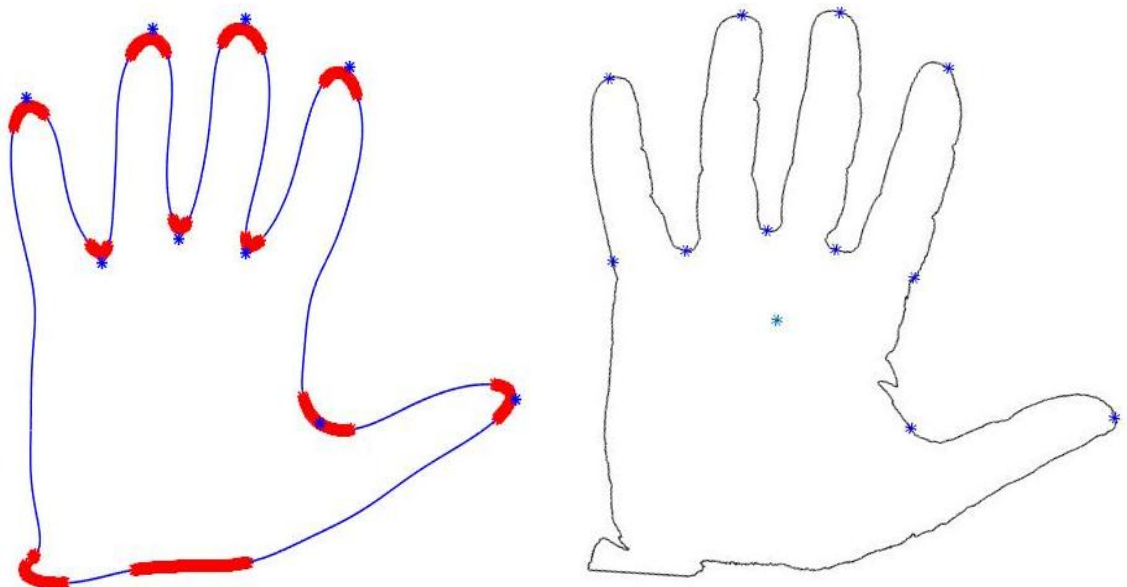


Figure 3.5: Points in Hand Boundary

will appear as a cluster points of figure tips and hand valleys, to specify and select each figure, dents and blobby in the shape, the midpoint of cluster been calculated. Figure 4 show how the points are appearing and distributed in red stars and blue stars. The nine points of fingers tips and valleys are not enough, therefore three additional points been calculated and defined using Euclidian distance and midpoint of hand boundary as shown in figure 5.the features been extracted after specify these twelve points. All figures length and area been extracted and the distance among many points are calculated using Euclidian distance, the total number of features was 24, all features been appearing to be very effective in testing phase, therefore it been noticed these features were being enough to create a classifier [6].

3.2. Classification

the problem of identification is the key point of biometric system, the features being label for each hand.in this paper we proposer two classifiers, Artificial neural network and k-nearest neighbors algorithm, a neural network consists of units called artificial neurons or nodes, the NN nodes arranged in specific way called layers, typically backpropagation NN comprises of three strata's of input, unknown as well as the final output [7], The input entry level represent the number of features, in this experiment it been 24 nodes in input layer, the output Layer been representing number of labels (persons) witch was 35 people, there are many parameters of NN for example in hidden layer the number of nodes, learning rate, epoch...etc.in our experiment there been many test of different parameter to create better classifier as possible. to classifiers its need two level, training and test, the data been split as 70% for training and 30% for test, which convert an input vector into some output.

3.2.1. K-Nearest Neighbor

Introduction to supervised classier includes learning about K-nearest neighbor which is an essential topic for learners in the science field. In the literature, some researchers proposed the K-nearest classifier algorithm which is used to perform patterns of classification tasks.

For this method, the term given to the classifier is Knn. In the literature, most researchers shorten k-nearest neighbor to Knn which merely addresses problems associated with pattern recognition as well as to address some tasks associated with classification tasks. A simpler version of Knn seeks to identify target labels by trying to find the closest neighbor class. Distance measures such as Euclidean distance are used to identify the closest class.

3.2.1.1. KNN for Classification

This section describes the usage of Knn classification when given training data points as well as data which is unlabelled to be used for testing. The main purpose is to find a new point for the class label. However, it is important to note that different behaviours come from algorithms based on k.

3.2.1.2. Nearest Neighbour Rule

A simple illustration will be done here using the value $K=1$ and X being the unknown index. The closest point to X is Y , the rule states that you assign the value of y to x based on the nearest neighbor rule. These calculations may produce errors if not correctly done and in cases where smaller data points are used.

In cases where large data points are used, it is most likely that the labelled axis for x and y have the same figures. To explain this, let's assume there is a biased coin that is tossed a million times and the output of the toss is 900k revealing the head of the coin. You then assume that the next time you toss, the output is going to be a head. The same argument can be used when applying this method.

A similar assumption can be raised from points which are in a D dimensional plane which have large points implying that density levels of the plane are reasonably high. This means that in any subspace you will find a number of points. In addition to this, let's assume point x has a lot of neighbors with y being the closest. In cases where x and y are really close, we assume that x and y are from the same class based on their probabilities.

The nearest neighbor rule is explained in detail by researchers Hart and Duda in their book titled, "Pattern Classification" in which they explain about obtaining a tight

error bound which is closest to the Nearest Neighbor rule. Basing on this, the bound will be:

$$P^* \leq P \leq P^* \left(2 - \frac{c}{c-1} P^* \right)$$

Based on the equation above, c represent the number of classes available, P represent the error rate of the closest neighbor and P^* represent the Bayes error rate. The findings are interesting since the assumption is that the larger the number of points, the lesser the error rate of the closest neighbor which in fact is lesser than the Bayes error rate multiplied by 2. Further reading is recommended for a clearer and more detailed of Knn.

3.2.2. Artificial Neural Network

A massively connected system based on the parallel architecture of biological human nervous systems specially brain. ANN learns by example like human by processing a huge information for specific task like pattern recognition or data classification and adjustments the synaptic weights connections that exist among the neurons [8]. The neuron basically consists of an input with synapses weight and transfer function (axon), inside the neuron determining output. Perceptron is a smallest unit to make neural network.

In general, most Neural network consists of a huge number of neurons arranged in layers and there are two types of neurons, not processing neurons which haven't transfer function and processing neurons which have transfer function; the first one exists in data entry strata, second strata contain hidden and output strata, a synapses weight represent a memory of network and connect a neuron from the specific layer to other layer neurons and axon represent activation or transfer function. Number of available neurons for the data entry strata determine the size of input as well as the number of neurons in the output layer determine output sample [9].

ANN can recognize a pattern with Backpropagation algorithm, it's a supervised learning method using gradient descent (delta rule) to minimize error in every layer for specific target. The network must consist of one hidden layer or more, and must be fully connected from input to the hidden layer also from hidden to output layer. Because it's supervised learning the network learn by example and that mean processing input information update weight according to the target [10].

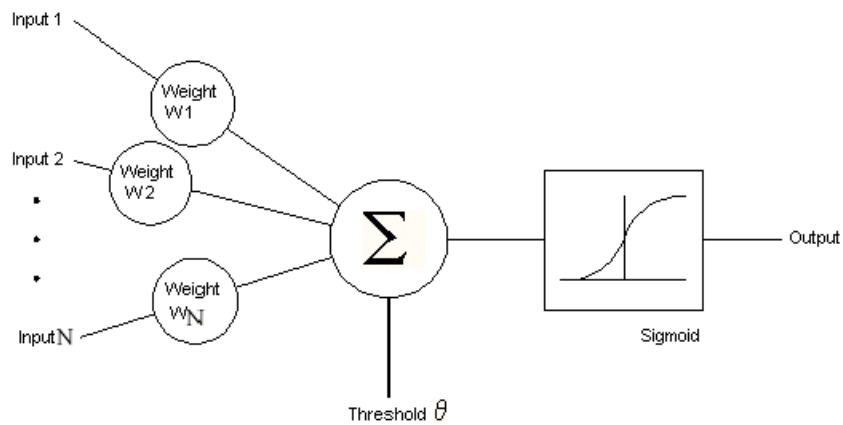


Figure 3.6: Shown Artificial Neurons

3.2.2.1. Transfer function

Hidden as well as the output strata contains neurons which use sigmoid transfer function, it cannot be used hard threshold function because it's discrete function (not differentiable) (1 or 0), it will be used logistic sigmoid function because it's differentiable and continues function and the output will be between (1 and 0) for every out neuron output equation will be

$$y = \sigma \sum \omega_i \varepsilon_i$$

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$

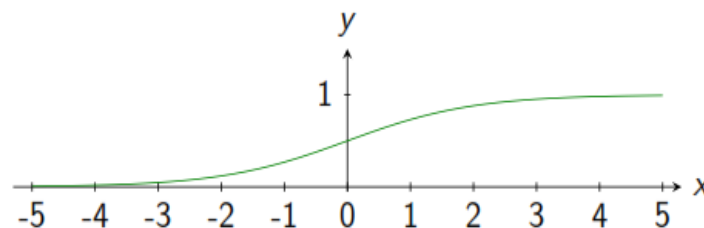


Figure 3.7: Shown Sigmoid Function

There are many neural network models in artificial intelligence, each model has its own specification. The type of model depends on many characters like transfer function, weight updating technique, connectivity among layers and nodes.

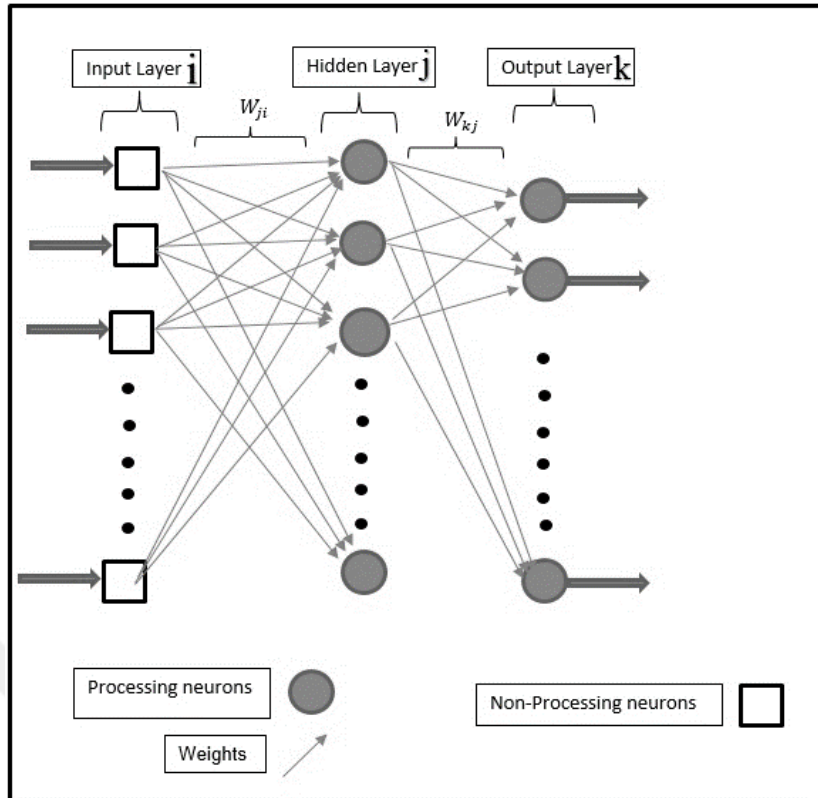


Figure 3.8: Neural Network Connection

3.2.2.2. Backpropagation algorithm

A common type supervised learning method and it's used as an overview for delta rule apply multiple strata perception to update the weight by calculating error and correcting the weight and repeated that until the error be minimize [11] [12].

Backpropagation algorithm steps:

- 1) First the weights must be initialised with small random number.
- 2) Feedforward (forward propagation) input data to input layer.
- 3) Feedforward process through the neural network.
- 4) Get the output data from output layer.
- 5) Calculate the error among actual output and desired output (target)

- 6) Back propagate error to the previous layer to update weight to new value and back propagate again another previous layer update weight until finished and update all weights.
- 7) Repeating from step 2 to 6 until the error be minimized to the very small value.

3.2.2.3. Error calculation

Because back Backpropagation algorithm are using gradient decent method it checks the weights and calculates derivative of the error function whilst it's squared for the entire network.

Let consider they have 3 layers (i, j, k) i represent data entry strata whilst j represents the hidden strata and finally, k represents the output layer as well as weight between i and j will be (W_{ji}) , and the weight between j and k will be (W_{kj}) and the X will input to the neuron from previous layer and y be output and d will be target as shown in figure above.

The common function for calculation error is:

$$E = d - y;$$

d is desired output and y is actual output

For gradient: -

$$E_j = \frac{1}{2} \sum (d - y)^2 \dots \dots (1)$$

The derivative of neurons outputs function will be as:

$$\frac{\partial y}{\partial x} = \frac{\partial}{\partial x} \sigma \dots \dots (1)$$

For (n) number of neurons the error be as:

$$E(n) = \frac{1}{2} \sum (d - y)^2 \dots \dots (1)$$

And

$$\frac{\partial E}{\partial y} = y - d \quad \dots \dots (1)$$

Now let derivative the function with respect to weight

$$\frac{\partial E}{\partial W_{kj}} = \frac{\partial}{\partial W_{kj}} \frac{1}{2} \sum_{k \in K} (y_k - d_k)^2 \quad \dots \dots (2)$$

Let derivative sigmoid function: -

$$\frac{\partial}{\partial x} \sigma = \frac{\partial}{\partial x} \left(\frac{1}{1+e^{-x}} \right) \quad \dots \dots (3)$$

$$= \frac{e^{-x}}{(1+e^{-x})^2} = \frac{(1+e^{-x})-1}{(1+e^{-x})^2} = \frac{1+e^{-x}-1}{(1+e^{-x})^2} = \left(\frac{1}{1+e^{-x}} \right)^2 \dots \dots (3)$$

$$\frac{\partial}{\partial x} \sigma = \sigma(x) - \sigma(x)^2 \quad \dots \dots (3)$$

$$\frac{\partial}{\partial x} \sigma = \sigma(x) (1 - \sigma(x)) \quad \dots \dots (3)$$

From (1), (2) And (3) using partial derivative and chain rule:

$$\frac{\partial E}{\partial W_{kj}} = \frac{\partial E}{\partial W_{kj}} \frac{\partial y}{\partial x} \frac{\partial x}{\partial W_{kj}} \quad \dots (1) \dots (2) \dots (3)$$

$$\frac{\partial x}{\partial W_{kj}} = \xi_k$$

And

$$\frac{\partial y}{\partial x} = \frac{\partial}{\partial x} \sigma$$

We get

$$\frac{\partial E}{\partial W_{kj}} = (y_k - d_k) y_k (1 - y_k) y_j$$

For determinate equation, the Notation it been used δ_k to represent expression

$$(y_k - d_k) y_k (1 - y_k)$$

So, it will be

$$\delta_k = (y_k - d_k)y_k(1 - y_k)$$

$$\frac{\partial E}{\partial W_k} = y_j \delta_k$$

To update weights, we must use learning rate η eta as follow:

$$\Delta W_{kj} = -\eta \frac{\partial E}{\partial W_{kj}}$$

So, the error correction for output weight layer for gradient descent will be:

$$\Delta W_{kj} = \eta y_j \delta_k$$

For the hidden layer the error calculation will be calculate as follow: -

$$\frac{\partial E}{\partial W_{ji}} = \frac{\partial}{\partial W_{ji}} \frac{1}{2} \sum_{k \in K} (y_k - d_k)^2$$

$$\frac{\partial E}{\partial W_{ji}} = \sum_{k \in K} (y_k - d_k) \frac{\partial}{\partial W_{ji}} y_k$$

$$\frac{\partial E}{\partial W_{ji}} = \sum_{k \in K} (y_k - d_k) \frac{\partial}{\partial W_{ji}} \sigma_k$$

$$\frac{\partial E}{\partial W_{ji}} = \sum_{k \in K} (y_k - d_k) y_k (1 - y_k) \frac{\partial x}{\partial y_j} * \frac{\partial y_j}{\partial W_{ji}}$$

Because

$$\frac{\partial x}{\partial y_j} = W_{kj}$$

$$\frac{\partial E}{\partial W_{ji}} = \sum_{k \in K} (y_k - d_k) y_k (1 - y_k) W_{kj} \frac{\partial y_j}{\partial W_{ji}}$$

$$\frac{\partial E}{\partial W_{ji}} = \frac{\partial y_j}{\partial W_{ji}} \sum_{k \in K} (y_k - d_k) y_k (1 - y_k) W_{kj}$$

$$\frac{\partial E}{\partial W_{ji}} = y_j (1 - y_j) y_i \sum_{k \in K} (y_k - d_k) y_k (1 - y_k) W_{kj}$$

$$\frac{\partial E}{\partial W_{ji}} = y_i y_j (1 - y_j) \sum_{k \in K} \delta_k W_{kj}$$

It will define term $(y_j (1 - y_j) \sum_{k \in K} \delta_k W_{kj})$ as δ_j notation

So, the equation as:

$$\frac{\partial E}{\partial W_{ji}} = y_i \delta_j$$

And delta change of weight as: -

$$\Delta W_{ji} = -\eta \frac{\partial E}{\partial W_{ji}}$$

So, the error correction for hidden weight layer for gradient descent be:

$$\Delta W_{ji} = \eta y_i \delta_j$$

3.2.2.4. Updating network weights

To make ANN efficient they will add another term to learn faster it will be α momentum to pass local minimum in gradient decent to help learning rate η eta [7] [13].

In output layer: $\Delta W_{kj}^{new} = \eta y_j \delta_k + \alpha \Delta W_{kj}^{old}$

In hidden layer: $\Delta W_{ji}^{new} = \eta y_i \delta_j + \alpha \Delta W_{ji}^{old}$

4. ANALYSIS OF EXPERIMENTAL RESULTS

4.1. Overview

It has been achieved different classification accuracy between k-nearest neighbors and NN classifier, in general NN is more accurate than k-nearest neighbors, and we obtained better classification accuracy when use just selected feature from filtered hand images. Filtering and other images preprocessing are essential to make data prepared for creating a model using NN and K-NN classifiers.

4.2. Image Database

The dataset was 350 samples from 35 persons, each person with 10 hand images. Dataset been collected from Student of Zakho Technical Institute, DPU, IT Department, second year class.

4.3. Evaluating Classification Accuracy

There are many techniques for evaluating or estimating the outcome of a classifier and this will in overall conclude the outcome of a dataset. The sole purpose for the usage is to find accurate prediction for future data, and predict the performance of an established model. In a general overview, the data divided in two set, train set and test set. The there are many technique. We will use two techniques, the holdout method and K-fold cross-validation with both K-nn and ANN.

4.3.1. Holdout method

The easiest approach involves taking the first database and partitioning it into bi-groups which are selected at random and choose an instance to make use of as a training set which can be $2/3$ of the first set and a third of the entire set. Firstly, create a classifier by making use of set of training and further analyze the set. The main advantage for this method is traced back to simplicity although it lacks representativeness for future data prediction, because training dataset not been represented in testing process.

4.3.2. K-fold cross-validation

When using k-fold cross-validation, first data samples are distributed randomly into k group of equal sizes. One selected sample (group) is kept and use for validation purposes of testing models whereas the other sample which is left ($k - 1$) is used as a training dataset. Cross-validation processes are done over and over again (iteration) k times (number of folds) whilst every k sample group is only used once to validate the data and all remaining is used for train. The mean is taken for the k number of results achieved after the folds are made to come up with one estimation (final classification accuracy). Figure 4.1 shows 4-fold cross-validation.

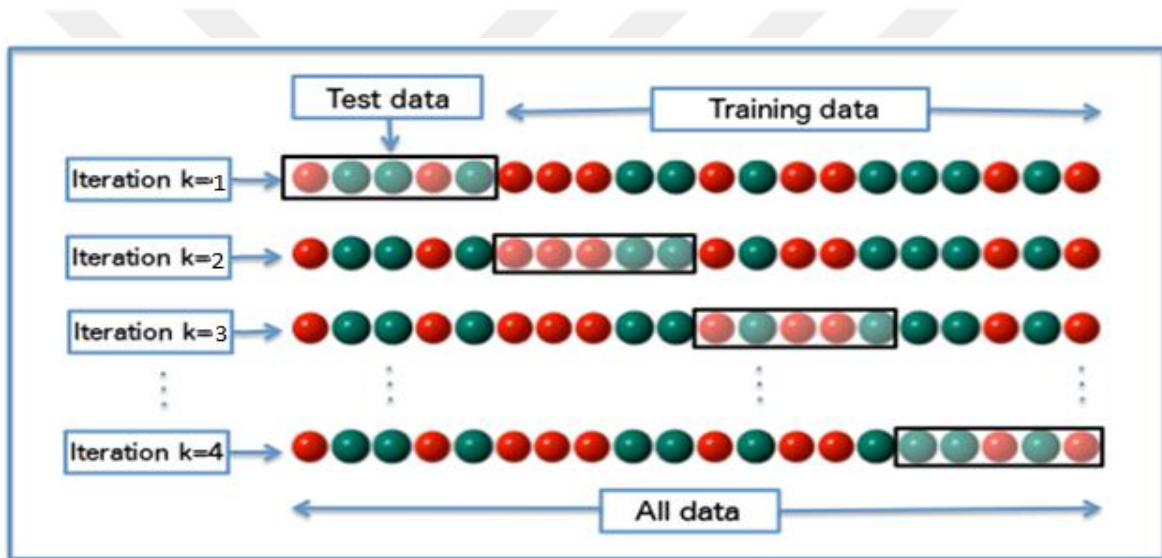


Figure 4.1: 4-fold cross-validation

4.4. Classification Accuracy

Classifier Accuracy been Evaluated using above methods of and Testing Dataset. In general, the NN been more accurate than K-NN. The holdout method and K-fold cross-validation are used with different training and test data size. The K-fold cross-validation are more computational expensive than the holdout evaluation. Both evaluations are good techniques to calculate model confidence and reliability, especially for future data test.

4.4.1. ANN Classification

Neural Network been evaluated with different parameters. The general structure of network been constructed as follow, the input layers' neurons been 24 as an extracted feature and the output layers' neurons been 35 as a number of persons. There was been different performance accuracy of classifier, each model been achieved and finished with maximum epoch. In the ANN, Sum squared error (SSE) used as performance function and Scaled conjugate gradient backpropagation method use for train neural network. Table 4.1 shows many test and evaluation of ANN classification.

Table 4.1: Neural Network Classification Accuracy

Experiments	Evaluating method	Hidden Layer neurons	Classification Accuracy
1	Holdout 70% train- 30% test	183	85.71%
2	Holdout 70% train- 30% test	65	91.42%
3	Holdout 60% train- 40% test	65	80.71%
4	Holdout 50% train- 50% test	65	77.14%
5	Holdout 50% train- 50% test	25	81.14%
6	Holdout 60% train- 40% test	25	88.57%
7	Holdout 70% train- 30% test	25	91.42%
8	3-fold cross-validation	183	92.28%
9	5-fold cross-validation	183	91.42%
10	10-fold cross-validation	183	86.57%
11	10-fold cross-validation	25	94.28 %
12	5-fold cross-validation	25	94.28%
13	3-fold cross-validation	25	93.43%
14	3-fold cross-validation	61	93.70%
15	5-fold cross-validation	61	94.28%
16	10-fold cross-validation	61	94.28%
17	Holdout 70% train- 30% test	61	96.19%
18	Holdout 70% train- 30% test	61	94.28%

The Table of NN classification Accuracy shows different results and it appear that the k-fold cross-validation has better estimates when used to calculate classification accuracy than holdout method, we can notice in the last two experiments how holdout evaluation failed to be accurate and precise, k-fold cross-validation is more reliable and dependable evaluation. The accuracy of Neural Network appears 94.28% using 10-fold cross-validation. It's been many more test has been Experimented as mentioned above, the best NN design was 25 neurons and 61 neurons in hidden layers been tested. Figure 4.2 shows NN design and Figure 4.3 shows SSE of training and test Curve and Figure 4.4 shows training all in MATLAB software Package with 25 neurons in hidden layers.

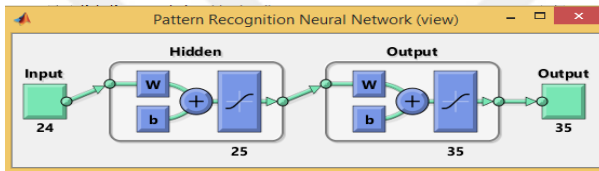


Figure 4.4: Neural Network

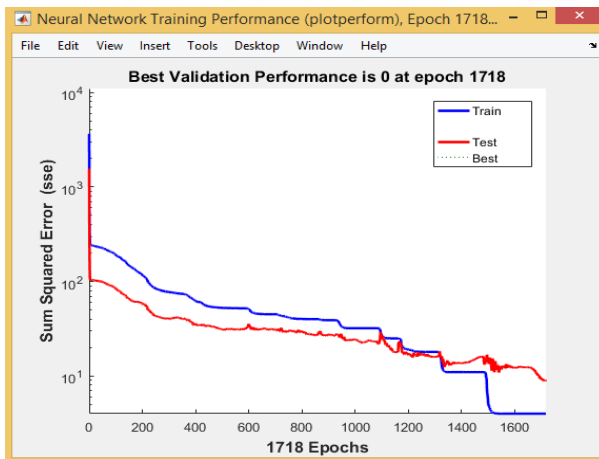


Figure 4.3: SSE Curve

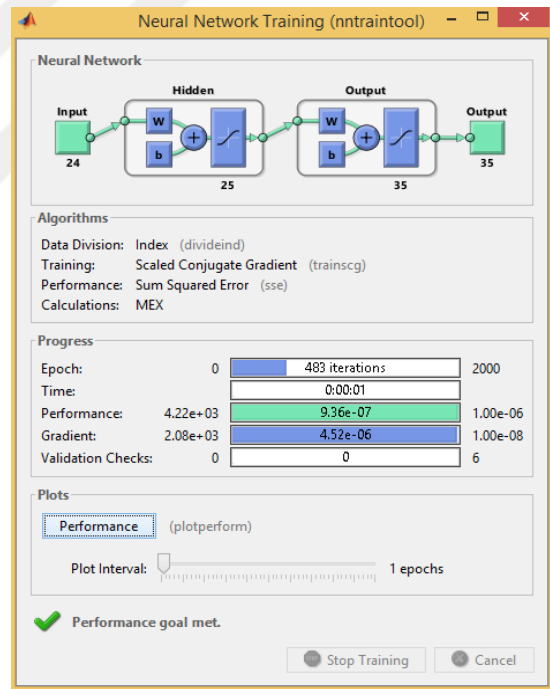


Figure 4.2: Neural Network Training Process

4.4.2. K-NN Classification

K nearest neighbors is a simple algorithm and cheap for computation, it based on distance functions (Euclidean Distance) and calculate a similarity measure (e.g., distance) to predict and classify new Data. The classification is based on its vote of neighbors, the Number of neighbors must be specified for classification. In the Table 4.2 we experiment 1,2,3,5 and 10 neighbors and evaluated classification accuracy using both Holdout and K-fold Cross-Validation methods.

Table 4.2: K nearest neighbors Classification accuracy

Experiments	Evaluating method	Number of Neighbours	Classification Accuracy
1	Holdout 70% train- 30% test	1	89.5%
2	Holdout 70% train- 30% test	2	85.7%
3	Holdout 70% train- 30% test	3	81.9%
4	Holdout 70% train- 30% test	5	80.0%
5	Holdout 70% train- 30% test	10	72.4%
6	Holdout 60% train- 40% test	1	87.1%
7	Holdout 50% train- 50% test	1	86.3%
8	3 -fold cross-validation	1	90.3%
9	5 -fold cross-validation	1	92.1%
10	10 -fold cross-validation	1	94.0%
11	10 -fold cross-validation	3	92.9%
12	10 -fold cross-validation	5	90.9%
13	10 -fold cross-validation	10	90.9%
14	Holdout 70% train- 30% test	1	87.6%
15	Holdout 70% train- 30% test	2	86.7%
16	10 -fold cross-validation	1	93.7%
17	Holdout 60% train- 40% test	1	89.3%
18	Holdout 50% train- 50% test	1	89.1%

The Table of K nearest neighbors Classification accuracy shows different results. The results above prove that better estimates are found when using the k-fold cross-validation when calculating classification accuracy compared to the holdout method, we can notice in the two experiments (1, 14) and (6, 17) how holdout evaluation failed to be accurate and precise, k-fold cross-validation is more reliable and dependable evaluation we can notice it in the two experiments (10, 16). The accuracy of K-nn appears between 93.7% -94% using 10-fold cross-validation. The best Number of Neighbors for K-nn is (1).

There are many Biometric Method System Based on Hand Geometry. A Comparisons with Other Experiment Work been shown in below table. The advantage of this study are Classification Rate and feature space, the Table shows how features space are affect classification rate using curvature of shape. The demonstrated how features been extracted through curvature of shape been mentioned in the previous chapter.

Table 4.3: Comparisons with Other Experiment work

Paper	Classification Methods	Dataset Size	Feature Space	Classification Rate
The study investigates hand geometry as an identification tool together with a neural net classifier [14]	radial basis function neural network	220	9	90%
The usage of Biometric Palm print and hand geometry for personal verification integrated in recognition systems.	False Rejection Rate(FRR) and False Acceptance Rate (FAR)	250	26	92%
The usage of Time Series Representation embedded with RK Band to enhance the performance of hand geometry biometric systems. [16]	False Acceptance Rate (FAR), False Rejection Rate (FRR), and Total Success Rate (TSR) at Equal Error Rate (EER)	118	50	76.33%
A New Features Extracted for Recognizing a Hand Geometry Using BPNN [17]	Propagation Neural Network (BPNN)	100	66	93%
Proposed Method	ANN with SSE	350	24	94.28%
	K-NN			93.7%

5. CONCLUSION

This study made an analysis of biometric techniques with a focus on hand geometry used for identification purposes and verification purposes was recommended by the researcher. The study has shown features been extracted through curvature of shape, the curvature calculation is simple and easy way for an effective and simple defining hand fingers points and valleys, then features like figure length, width, area, and distances are extracted. This approach produces a quite well and accurate features for identification each individual. There been many test of neural network and k-nearest neighbors algorithm, the dataset was 350 samples from 35 persons, each person with 10 hand images. Dataset been divided into 70% for training and 30% for test The NN been more accurate than K-NN. The NN with 29 neurons in hidden layers was been **95.3%** accuracy. The K-NN test with K=1 been as a **91.2%** accuracy a Comparisons with Other Experiment Work, shows how features space are affect classification rate, in the ANN, Sum squared error(SSE)use as performance function and Scaled conjugate gradient backpropagation method use for train neural network. Neural network and k-nn been designed in MATLAB software.

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