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DEVELOPMENT AND EVALUATION OF THE AUTHENTICATION SYSTEMS BY USING DIFFERENT PALM PRINT IDENTIFICATON METHODS

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DEVELOPMENT AND EVALUATION OF THE AUTHENTICATION SYSTEMS BY USING DIFFERENT PALM PRINT IDENTIFICATON METHODS

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that,as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to tish work.

Emel ÇOŞKUN

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Contents

FARKLI AVUÇ İÇİ TANIMA YÖNTEMLERİ KULLANILARAK KİMLİK DOĞRULAMA SİSTEMLERİNİN GELİŞTİRİLMESİ VE DEĞERLENDİRİLMESİ X

DEVELOPMENT AND EVALUATION OF THE AUTHENTICATION SYSTEMS BY USING DIFFERENT PALM PRINT IDENTIFICATON METHODS XI

1. INTRODUCTION AND AIM 1

1.1. INTRODUCTION 1

1.1.1. General Overview to the Biometric Systems 1

1.2. THE AIM 5

1.3. GENERAL INFORMATION ABOUT THESIS 6

2. IMAGE RECOGNITION SYSTEMS 6

2.1. OVERVIEW TO PATTERN RECOGNITION 6

2.2. IMAGE PROCESSING TECHNICS 7

2.2.1. Removing Noise on the Image 7

2.2.2. Winnowing the Undesirable Parts out of the Image and Filling the Small Gaps 8

2.2.3. Histogram Equality 8

2.3 FEATURE EXTRACTION 9

2.3.1. Feature Extraction via Gabor Filter 9

2.3.2. Use of Hu’s Moment Algorithm 10

2.3.3. GLCM Texture Feature Extraction 11

2.4. CLASSIFICATION TECHNICS 13

2.4.1. Linear Discriminant Analysis 13

3. PALMPRINT AUTHENTICATION SYSTEMS 14

3.1. DATABASES USED FOR THE PALM AUTHENTICATION 14

3.2. EXTRACTING THE RELEVANT AREA FROM THE PALM PRINT 15

3.3. LITERATURE SURVEY ABSTRACTS 17

4. PALM PRINT RECOGNITION APPLICATION 20

4.1. APPLICATION DESIGNED WITH GABOR FILTER 20

4.1.1. Feature Extraction with Gabor Filter 20

4.1.2. Classification with Linear Discriminant Analysis 21

4.2. SYSTEM DEVELOPED WITH HU’S MOMENT FEATURE AND GLCM TEXTURAL FEATURE 22

4.2.1 Feature Extraction with Hu’s Moment 22

4.2.2 Extraction of GLCM Textural Features 22

4.2.3. Classification with Linear Discriminant Analysis 23

5. CONCLUSION AND SUGGESTIONS 23

6. REFERENCES 25

Figure List

Figure 1.1 : DNA Structure 2
Figure 1.2 : Fingerprint Example 3
Figure 1.3 : Ataturk’s signature 4
Figure 1.4 : PalmPrint 5
Figure 1.5 : Overwiev Pattern Recognition 7
Figure 2.1 : Histogram Change 9
Figure 2.2: Two-dimensional LDA work 13
Figure 3.1: Six typical palm print images in the database 15
Figure 3.2: Original hand image 16
Figure 3.3: Double image 16
Figure 3.4: Relevant area on the palm image 17
Figure 3.5: Extracted Area 17
Figure 4.1: Gabor System Flow Diagram 20
Figure 4.2: Virtual part of the Gabor filter 21
Figure 4.3: Real part of the Gabor filter 21
Figure 4.4: Flow Diagram for GLCM 22

Table List

Table 1.1 : Information of Biometric System 2
Table 4.1: Accuracy Rates for Gabor..................... 21
Table 4.2: Accuracy Rates for GLCM and Hus..................... 23
Table 5.1: Accuracy Rates for single algorithm..................... 24
Table 5.2: Accuracy Rates for double algorithm 24
Table 5.3: Accuracy Rates for triple algorithm..................... 25

FARKLI AVUÇ İÇİ TANIMA YÖNTEMLERİ KULLANILARAK KİMLİK DOĞRULAMA SİSTEMLERİNİN GELİŞTİRİLMESİ VE DEĞERLENDİRİLMESİ

ÖZET

Bilgi güvenliği, teknolojinin ilerlemesi ve siber ortamlarda işlenen suçların artmasıyla daha önemli bir hale gelmiştir. Günümüzde tüm kurum ve kuruluşlar bu sebeple, kişi tanıma sistemleri kullanmaktadır. Bir çok farklı yöntem ve algoritma ile kişinin bilgilerinin bir diğer kişi ile karışmaması ve ele geçirilmemesi için yazılımlar geliştirilmiştir. Bu yazılımlar tekil ve kişiye özgü olan dna, iris, parmak izi, avuç içi gibi özellikleri kullanmaktadırlar. Kurumun bilgi güvenliğine ne kadar ihtiyaç duyduğu ve bunun için ne kadar yatırım yapacağı ile ilgili olarak doğruluk oranları değişmektedir. Kişiden alınan özelliğin dikkatli ve temiz olması bu konuda çok önemlidir.

Günümüzde avuç içi tanıma sistemleri yaygın olarak kullanlımaya başlanmıştır. Bu çalışmanın amacıda textural özelliklerden yararlanarak avuç içi tanıma sistemi tasarlamak ve maximum doğruluğu hedeflemektir. Bu konuda iki farklı sistem tasarlanmıştır.

İlk sistemde referans bölgesi Gabor filtresinden geçirilerek öznitelikleri çıkartılmıştır. Bu özellikler ile basit bir linear discriminant analiz algortiması kullanılarak sınıflandırma gerçekleştirilmiştir.

İkinci sistem de ise referans bölgesi üzerinden GLCM ve Hu's yntemeleri kullanılarak text öznitelikleri bulunmuştur. Ayrı ayrı ve tek olarak bu öznitelikler basit bir linear discriminant analiz algortiması kullanılarak sınıflandırılmıştır.

Çalışma kapsamında CASIA veri tabanından alınan datalar kullanlımıştır.

DEVELOPMENT AND EVALUATION OF THE AUTHENTICATION SYSTEMS BY USING DIFFERENT PALM PRINT IDENTIFICATON METHODS

SUMMARY

Information security has become more important after the increase in cyber-crimes. Thus, all corporations today are using person- recognition systems. Plenty of software products have been developed in order not to allow personal information to be confused with another one by means of different ways and algorithms. These software products use unique specialties such as DNA, iris, fingerprint and palm print. They differ in direct proportion to how much the corporation needs information security and how much it invests. The most important part is to have a clear characteristic from the person.

Today, palm print recognition systems are started to be used commonly. The aim of this paper is to design a palm print recognition system by using textural features and it aims maximum correctness. Two different systems were designed with this aim.

In the first system, features were extracted by passing it through Gabor filter. Classification was made by using a simple linear discriminant analysis algorithm with these features.

In the second system, text features were found by using GLCM and Hu's methods. These features were classified separately by using a simple linear discriminant analysis algorithm.

Data was taken from CASIA database in this study.

1. INTRODUCTION AND AIM

1.1. INTRODUCTION

Identification and verification systems have a great importance in terms of information security and confidentiality. It is an undesirable situation that information is possessed by another person. Accession to an area by a person who is not authorized actually causes both material and intangible losses.

There are different ways in identity recognition systems. Information-based systems, ownership-based systems and biometric identity recognition systems are the most frequently used ones today.

Information-based systems mostly require a user name and password. These are the systems controlled by inquiring and matching the information made by the person or given to the person.

Ownership-based systems work via a magnetic card given to a person and an infrastructure of the corporation to read this card.

Biometric-based systems stem from the unique features of a person that cannot be changed. For example, DNA, iris, fingerprint, palm print are among this methods. The most preferred and the most successful systems today are biometric-based systems.

1.1.1. General Overview to the Biometric Systems

Biometric systems have more advantages compared to the other systems. While passwords can be stolen in the information-based systems and magnetic card can be lost or magnetic area can be copied in the ownership-based systems, there are not such undesirable situations in the biometric systems. Biometric systems do not change in any point of the world. Characteristic features cannot be reproduced. They are integrated to the recognition systems easily by compatible devices. Nobody can argue about the owner of the feature. [17]

Biometric System	Universality	Singularity	Continuity	Accessibility	Performance	Acceptability	Penetration
DNA	High	High	High	Low	High	Low	Low
Retina	High	High	Medium	Low	High	Low	Low
Fingerprint	Medium	High	High	Medium	High	Medium	Medium
Face	High	Low	Medium	High	Low	High	High
Vein	High	Medium	Medium	Medium	High	Medium	Low
Signature	Low	Low	Low	High	Low	High	High
Palm	Medium	Medium	Medium	High	Medium	Medium	Medium

Table 1.1 : Information of Biometric System

These are the examples from the most frequently used biometric systems: [14] [6] [17]

DNA Recognition

Samples taken by the person such as blood or hair are used in this expensive method whose analysis is also difficult. Its correctness rate is extremely high and it is generally used in the judicial cases. It is not a real-time recognition system. It uses the positions of the chemical units in DNA (Adenine, Guanine, Cytosine, and Thymine) and the sugar molecules and their relationship with each other.

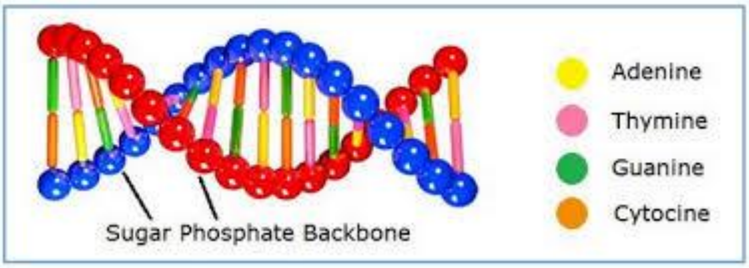

Figure 1.1 : DNA Structure

Retina Recognition

Though it is hard for a person to focus on a certain point and the method scans with a light source, its accuracy is proven. It is a method that uses scanning of unique patterns of the retina with a low-density light source by means of an optical receiver.

Fingerprint Recognition

It is one of the most commonly-used recognition methods thanks to its easy application and its compatibility with the technology. This method uses the position of the points on the finger and their relationship with each other. The cleanliness of the fingerprint has a great importance. Many algorithms were developed for the separation of the data and transforming the fingerprint into numerical area. Even though it seems to be an inimitable method, it is not impossible for today's technology to copy it. Also, it has the potential of the identity losses because of the probable damages on the fingers.

Figure 1.2 : Fingerprint Example

Face Recognition

It is the fastest biometric technology and it has the minimum problem rates. It works with the most clear personal identity: face.

Face recognition technology has broken through in recent years thanks to the successful studies carried out in the field. Problems such as losing cards or forgetting passwords have been eliminated and it has been a great ease of use.

Instead of putting the person's hand on a scanner or looking at a scanner with their eyes, face recognition system takes the person's image in the certain areas silently. They even do not notice it and there is no delay or obstructions. They do not feel that they are being observed and their privacy is being violated.

Face recognition system analyses the face images via a digital video camera and it measures the whole face pattern including the eyes, nose, mouth and chin. These measurements are hidden in a database and used for comparisons when that person comes in front of the camera.

Each faces have different characteristics. Each human face has 80 knot points. The distance between the eyes, nose width, orbital depth, shape of the cheekbone, length of the chin lines are measured with this technology.

Vein Recognition

Vein recognition systems are widely used in the areas such as ATM machines, hospitals, employee continuity control, passing controls, web-based identity applications, and system login operations.
The system works by mapping the vein structure of the hand. Vein recognition system is a fast, accurate, hygienic, contact-free, and practical.

Signature Recognition

Signature of a person shows that person accepts and approves a certain thing. So, signature forgery causes both moral and material damages for a person. It resulted in the need for a strict identity recognition system. Certain algorithms were developed based on the time, speed, momentum, and pressure of the pen while signing. Personal mood or health situation of the person during signing can affect this method negatively.

Figure 1.3 : Ataturk's signature

Palm Recognition

This method that is going to be studied in this thesis includes in the comparisons of the positions, bents and numbers of the palm lines in the images taken. It can be evaluated in the same category with fingerprint matching. Heart line, head line and the life line are three main lines on the palm. Also, there are less distinctive lines that support these lines.

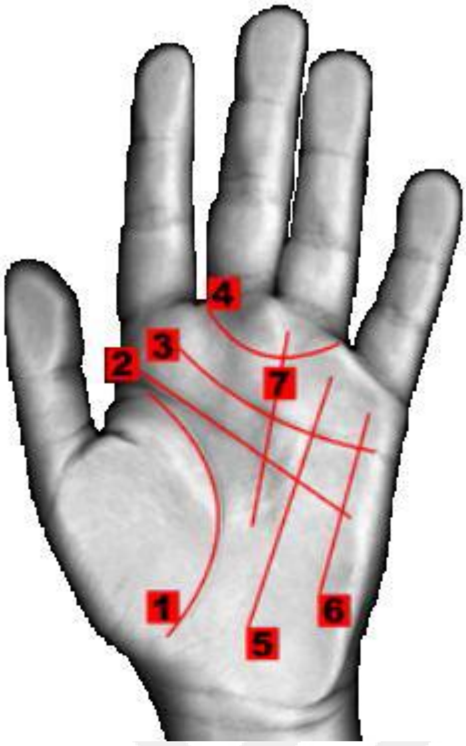

Figure 1.4 : PalmPrint

There are main steps while processing palm print images. Accuracy of the image recognition increases according to the cleanliness and resolution of the palm image taken by the user. Perspective of the image and the position between the fingers also has great importance. After taking the image, data will be ready to be processed with certain cleaning methods. Then, the middle point of the hand is found and a section is taken. This section is transformed into numerical value after passing through different filters. Numerical values enter certain classification algorithms and constitute identity recognition system.

1.2. THE AIM

Identity recognition systems have great importance for protecting the information and preventing it from possession of the wrong hands. Different textural features were extracted from the palm within the scope of this study. User recognition system was designed both separately and together with the help of these features by using a simple classifier.

In this application CASIA database palm print data was used. Two different systems were constituted with Matlab with two different algorithms. Accuracy rates were calculated for these systems and compared to each other.

1.3. GENERAL INFORMATION ABOUT THESIS

Chapter 2 examines what is pattern recognition and which methods does it use. The technics that are used after palm image is taken and their functions were expressed.
Chapter 3 shares the information about the points that should be taken into account in choosing the reference areas to be used and how they are extracted from the palm image. Also, it contains information about databases that are used for these works.
Chapter 4 discusses the application written in this study. Inputs and outputs were examined in detail. Their accuracy rates were stated.
Chapter 5 comments on the results obtained within the thesis scope. It argues about how to reach the next level.

2. IMAGE RECOGNITION SYSTEMS

2.1. OVERVIEW TO PATTERN RECOGNITION

Pattern is a sample group which can be observed and has similarities. Relationship between these similarities is the subject of pattern recognition. The aim of pattern recognition is to classify an unknown object and to verify a known object. [21]
Pattern recognition has three phases. First phase is to mark the physical situation to be perceived and to clean the physical situation by using certain filters and technics. In the second phase, features unique for the pattern are extracted from this pattern group. In the last phase, these features are grouped and classified according to their similarities.

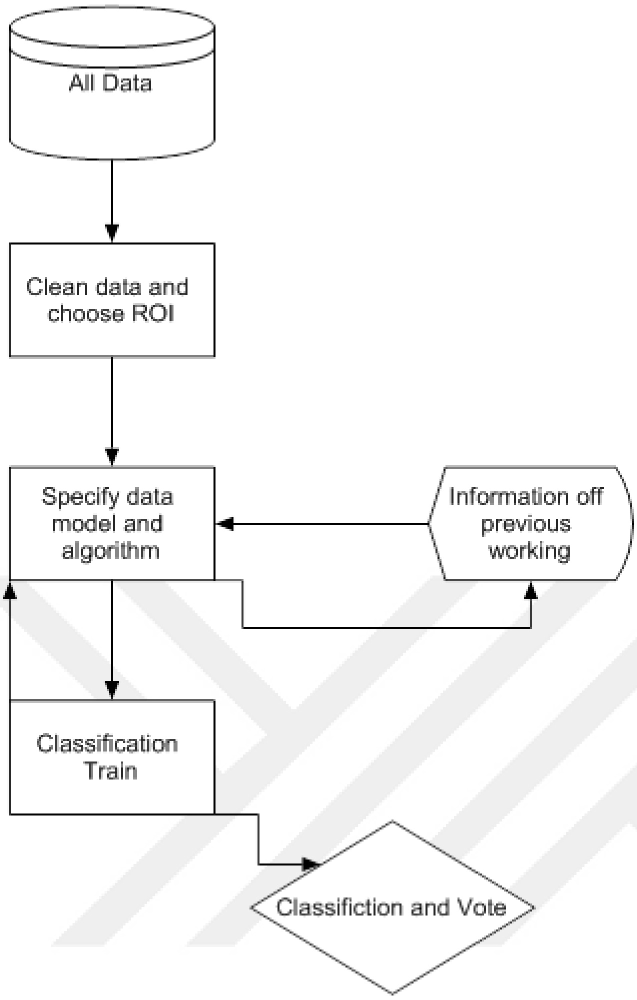

Figure 1.5 : Overwiev Pattern Recognition

2.2. IMAGE PROCESSING TECHNICS

These are the systems perceiving the image and extracting the features. The techniques and methods to be used in this study are examined in this part.

2.2.1. Removing Noise on the Image

Noise can be defined as irregularities, stains and deficits on the image. It is a kind of visual pollution, in general. The main reason of the noise is about the light. To have a clean image, the light should be suitable for the image to be taken and the environment should be suitable for the image. Certain filters are applied for such noisy images. Filters clean the noises and it enhances the quality of the image. In this study, one of the most commonly-used filters, Gaussian filter was used to soften the image. Average brightness value in the original image taking part in the neighborhood of the filter core was used. [22]

Formula for the Gaussian filter is shown below.

$$G(r) = \frac{1}{(2\pi\sigma^2)} e^{-r^2/(2\sigma^2)} \tag{2.1}$$

Simplified version of this formula for two-dimensional images (for N=2) is shown below.

$$G(u,v) = \frac{1}{(2\pi\sigma^2)} e^{-(u^2+v^2)/(2\sigma^2)} \tag{2.2}$$

2.2.2. Winnowing the Undesirable Parts out of the Image and Filling the Small Gaps

It enables us for eliminating the small gaps on the images with denudation and expansion methods. Because of the inadequate light or reflection, some little deficiencies or redundancies can occur while taking the image. Objects are separated from each other by using denudation method. Also, little undesirable shadows are cleaned in the image. Expansion method is used to fill little gaps. The image to be processed becomes cleaner thanks to these extension and reduction processes.

2.2.3. Histogram Equality

Histogram is the graphic that shows the color values in the image with numbers. Histogram equalization or balance is the method that is used for eliminating color distribution faults resulting from the color clusters in a certain area of the image. Color clusters are distributed through the histogram curve tones (0-255), so the color dispersion is ensured to be homogeneously structured. This method does not work in all images. It is only effective in the images where all pixels have color values in a certain range.

There would be no problem if the image comprises of grey and its tones; but if this method is going to be applied on a colored image and RGB values are used, then a separate histogram balance should be done for each blue, green and red colors.

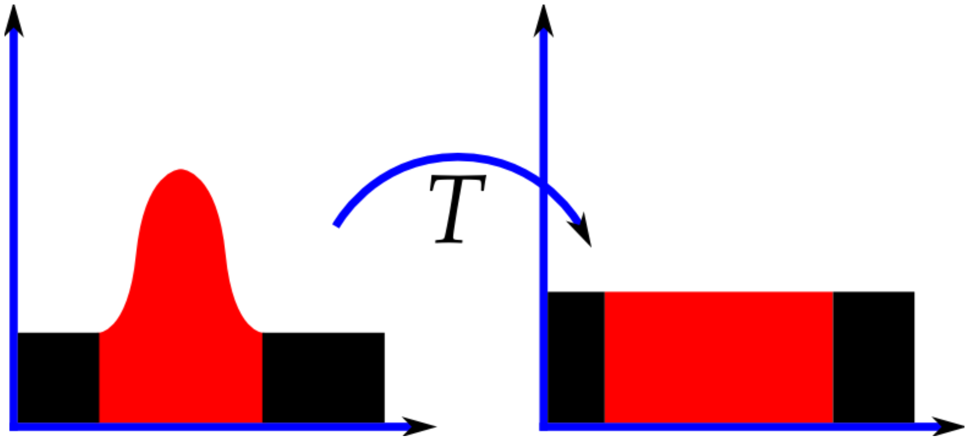

Figure 2.1 : Histogram Change

2.3 FEATURE EXTRACTION

Feature extraction is the process of finding mathematical expressions that enable us for describing the image thoroughly and distinguishing it from the other images. Methods to be used in the scope of the thesis are explained in this part.

2.3.1. Feature Extraction via Gabor Filter

Edges going over a certain way can be determined by Gabor filter that is used in the image analysis. The process is the result of the convolution a matrix named core matrix with the image to be filtered. It is calculated with the function below and converts a complex number. [5]

$$g(x,y;\lambda,\theta,\varphi,\sigma,\gamma) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right) * \exp\left(i\left(2\pi\frac{x'}{\lambda}+\varphi\right)\right) \quad \textbf{(2.3)}$$

In this function, formulation of the real and imaginary parts is shown below.

$$g(x,y;\lambda,\theta,\varphi,\sigma,\gamma) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right) * \cos\left(2\pi\frac{x'}{\lambda}+\varphi\right) \quad \textbf{(2.4)}$$

$$g(x,y;\lambda,\theta,\varphi,\sigma,\gamma) = \exp\left(-\frac{x'^2+\gamma^2 y'^2}{2\sigma^2}\right) * \sin\left(2\pi\frac{x'}{\lambda}+\varphi\right) \quad \textbf{(2.5)}$$

Besides designing systems using just real values are more common, square root of the sum of the squares of real and imaginary parts can also be used. Values shown in the formula is explained below.

Lambda: It is the wavelength of the cosine multiplier. This value should be selected equal to 2 or as a bigger value.

Theta: It is one of the most important variables of Gabor filter. It is used in the calculation of x' and y' variables among x and y variables. It states the orientation angle.

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos(\theta) & \sin(\theta) \\ -\sin(\theta) & \cos(\theta) \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \quad \textbf{(2.6)}$$

Phi: It is the phase angle of the core matrix that is going to constitute a Phi angle to use for shifting the filter in x axis.

Sigma: Sigma value is the coefficient that determines the standard deviation of Gaussian function. This value determines the clearance of Gaussian function and selecting it as a big value is going to increase the distance between Gabor waves.

Gamma: This value enables given standard deviation value to be determined for y'. Matrix to be made on the condition that the value is selected 1, has the equal standard deviation for x and y, they will have the same length.

x, y: These two values represent the coordinates two dimensional core matrix to be made up.

2.3.2. Use of Hu's Moment Algorithm

The concept of moment has long been present in mechanics and statistics. While average, variance and kurtosis is used in statistics, in mechanics it is used in the calculations of inertia and center of gravity. Hu's moment is a mathematical moment and it is based on seven invariable functions. One of the reasons it has been used in the image recognition systems is that these seven moments do not change despite scaling, spinning and transformation processes.

Two-dimensional distribution of moment formula is shown below. [3]

$$m_{pq} = \iint x^p y^q f(x,y)\, dx\, dy \quad \textbf{(2.7)}$$

p,q=0,1,2,… are the values and they can vary according to the outer environment.

$$m_{pq} = \iint (x - x')^{p'} (y - y')^{q'} f(x,y)\, d(x - x')\, d(y - y') \quad \textbf{(2.8)}$$

Central moments are described above. Here, it is defined as:

$$x' = \frac{m_{10}}{m_{00}} \tag{2.9}$$

$$y' = \frac{m_{01}}{m_{00}} \tag{2.10}$$

Formula for the central moment made with the normalization of the moments which do not change on the transformation condition, is shown below:

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00}^{r}} \tag{2.11}$$

In the formula:

$$r = 1 + \frac{(p+q)}{2} \tag{2.12}$$

Here are 7 formulas for Hu's moment. [3]

$$\varphi_1 = \eta_{20} + \eta_{02} \tag{2.13}$$

$$\varphi_2 = (\eta_{20} + \eta_{02})^2 + 4\eta_{11} \tag{2.14}$$

$$\varphi_3 = (\eta_{30} + 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2 \tag{2.15}$$

$$\varphi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{03} + \eta_{21})^2 \tag{2.16}$$

$$\varphi_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] +$$

$$(3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \tag{2.17}$$

$$\varphi_6 = (\eta_{20} + \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03}) \tag{2.18}$$

$$\varphi_7 = (3\eta_{21} + \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] -$$

$$(\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \tag{2.19}$$

2.3.3. GLCM Texture Feature Extraction

Gray-level co-occurrence matrix shows the relation between two neighbor pixels in two different positions. With the contemplation that the image is made of N_x and N_y amount of pixels in horizontal and vertical directions, {0, 1, 2, 3,.. G-1} represents G amount of grey level. For $L_x = \{1,2,3, N_x\}$ and $L_y = \{1,2,3, N_y\}$, $L_y * L_x$ set is the pixel set that belongs to the sub-window in line as rows and columns in the image. The matrix that has the angle and frequency data is named as co-occurrence matrix. [2] [4]

$$P_{d,\theta}(i,j) = \frac{P(i,j,d,\theta)}{\sum_{i=1}^{N_g}\sum_{j=1}^{N_g} P(i,j,d,\theta)} \quad \textbf{(2.20)}$$

For each d and θ value, a different G*G matrix is made. By reducing the gray amount, design load is also reduced; however it results in data loss.

Haralick developed some tissues that give information about the image, by using these features. Some of the most frequently used features are:

- Energy: It is the standard that gives homogeneity value of the image and it is as big as the homogeneity of the image.

$$\sum_{i=1}^{N_g}\sum_{j=1}^{N_g} P_{d,\theta}(i,j)^2 \quad \textbf{(2.21)}$$

- Entropy: It is related to the contrast value and it gives the compressibility value of the image. If the contrast value is low, entropy value is also low and it cannot be compressed.

$$-\sum_{i=1}^{N_g}\sum_{j=1}^{N_g} P_{d,\theta}(i,j)\log P_{d,\theta}(i,j) \quad \textbf{(2.22)}$$

- Contrast: It shows the density difference between reference pixel and neighbor pixels.

$$\sum_{m=0}^{N_g-1} m^2\{\sum_{i=1}^{N_g}\sum_{j=1}^{N_g} P_{d,\theta}(i,j)^1\}, |i-j| = m \quad \textbf{(2.23)}$$

- Correlation: It calculates how the reference pixel is related with its neighbors. It is a variable that is related to the standard deviation and average. It keeps the linear dependency of gray level values.

$$\frac{\sum_{i=1}^{N_g}\sum_{j=1}^{N_g} P_{d,\theta}(i,j)\log P_{d,\theta}(i,j) - \mu_x\mu_y}{\sigma_x\sigma_y} \quad \textbf{(2.24)}$$

- Homogeneity: It is the similarity rate in different areas of the image.

$$\sum_{i=1}^{N_g}\sum_{j=1}^{N_g} \frac{1}{1+(i-j)^2} P_{d,\theta}(i,j) \quad \textbf{(2.25)}$$

2.4. CLASSIFICATION TECHNICS

2.4.1. Linear Discriminant Analysis

Linear Discriminant analysis method examines the statistic distributions of the series using covariance matrix. It is used in the separation process of the two classes with the best divider. The algorithm calculates the class probabilities, covariance matrixes and mean vectors, at first step. With the help of these values, covariance matrixes and coefficient model is created. As seen in the figure below, with the application of Fisher equation, two classes are best separated with split line linearly. Test set that is going to come to the group is estimated according to its position to the line. [15]

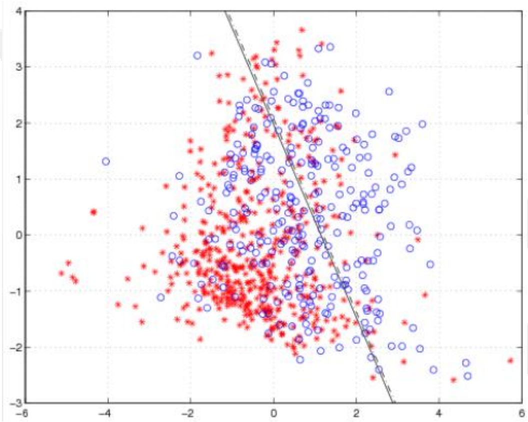

Figure 2.2: Two-dimensional LDA work

LDA process is shown in this formula:

$$C = \frac{1}{(n_1+n_2)}(n_1C_1 + n_2C_2) \tag{2.26}$$

$$B = C^{-1}(M_1 - M_2) \tag{2.27}$$

$$Z = B_1x_1 + B_2x_2 + \cdots + B_dx_d \tag{2.28}$$

In the formulas above, C stands for covariance matrixes, M stands for mean vectors and B stands for coefficient model.

3. PALMPRINT AUTHENTICATION SYSTEMS

First point to be taken into consideration in palm print recognition systems is the absence of the noise while taking the image and all the images taken should be in a certain format. The more samples are taken, the better system is trained. Accuracy rate increases and the relation between the features becomes more obvious. The images gathered together are put through a series of processes, separated into training and test groups and their features are extracted with determined algorithms. It is based on the principle of comparing the features with each other. After this process, the system is designed according to the desired situation.

These systems can be evaluated in two categories: description-based and verification-based systems. In the description-based systems, users upload the image containing their own data into the system. System scans the whole feature pool created before for all of the classes and recognizes the user's identity information. In the verification-based systems, users send their own feature and identity information. These systems decide by comparing with the features extracted only for its class.

3.1. DATABASES USED FOR THE PALM AUTHENTICATION

PolyU Database

Palm print recognition systems are highly practical and reliable biometric identification method. Because of the demand for a more accurate palm print authentication system, multispectral imaging is started to be used for acquiring more unique information and increasing anti-spoofing for palm print recognition systems.

Multispectral palm print capture device that is developed by the Biometric Research Center at Hong Kong Polytechnic University is able to take palm print images under red, green, blue and near infrared light, that enables a large-scale multispectral palm print database. This multispectral palm print database is intended to be presented for academic and noncommercial uses for providing researchers with a platform to compare the effectiveness of different palm print recognition algorithms.

Database is constituted with the information taken from 250 volunteers, including 195 males and 55 females whose ages are varying between 20 and 60. Samples are collected in two different sessions. 6 images of each palm are provided in each session. The database contains 6000 images from 500 palms totally.

CASIA Database

CASIA palm print image database includes 5502 palm print images taken from 312 subjects. All of the images are 8 bit gray level JPEG files. There are also real time palm print recognition systems that works on PDA and common computers.
The light of the device is homogeneously distributed and it uses a CMOS camera taking place on the top of the device. These are six typical palm images from the database.

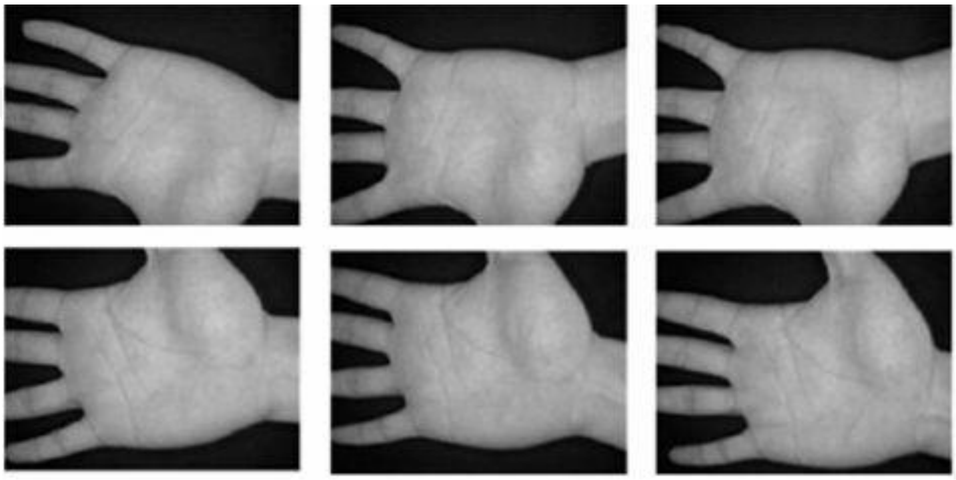

Figure 3.1: Six typical palm print images in the database

In the database, “m/f” abbreviation stands for male and female, “l/r” stands for left and right hands.
The database presents an area for research and educational purposes. All rights of CASIA database is reserved and it cannot be published, copied, or distributed by any person or corporation. In all studies that use the results from this database, a reference to CASIA database should be included.

3.2. EXTRACTING THE RELEVANT AREA FROM THE PALM PRINT

All the images in the database have to go through a pretreatment and the central area on the each palm should be determined before the feature extraction. Palm area is extracted as 128*128 as determined in the coordinate system. [6] [10]

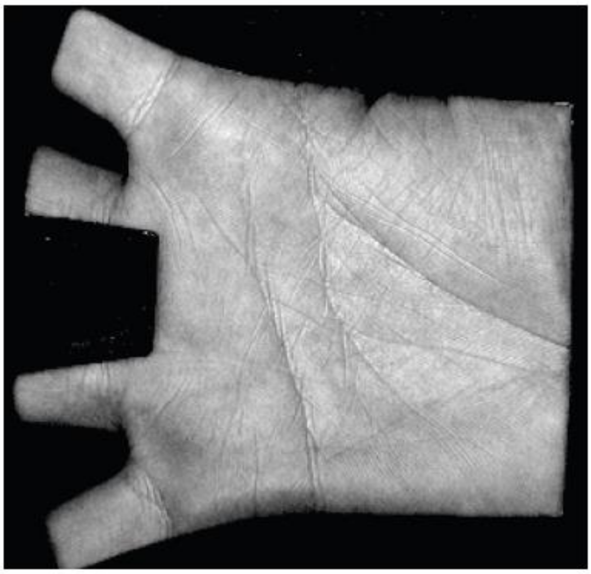

Figure 3.2: Original hand image

Five main steps in the image process is explained below:

1st step: Gaussian low-pass filter is applied on the original image. Then, it is transformed into double image.

Figure 3.3: Double image

2nd step: Middle points of the finger gaps are determined.

3rd step: Tangent between two finger gaps is calculated.

4th step: Horizontal and vertical lines on the middle of the finger gaps are determined and marked areas are united.

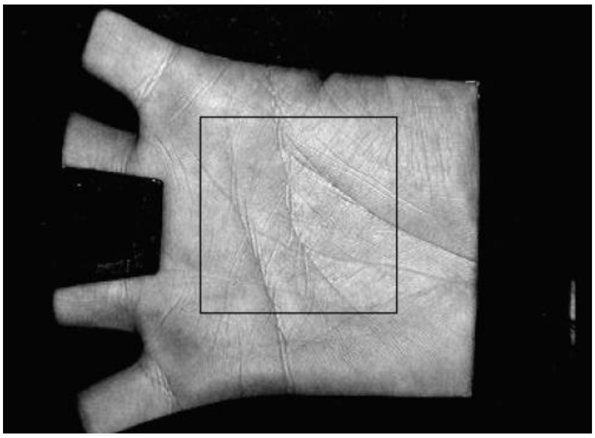

Figure 3.4: Relevant area on the palm image

5th step: Palm area is extracted as 128*128 as determined on the coordinate system.

Figure 3.5: Extracted Area

3.3. LITERATURE SURVEY ABSTRACTS

The algorithms used for the extraction of the palm reference points are generally used in the same or similar way in the works of the literature.

Developments in the palm print recognition area enabled the societies with accurate data, especially to be used in the criminal cases and commercial applications. This paper proposes a new authentication technique, using 3D discrete multi-wavelet Transform for feature extraction and probabilistic artificial neural network (PNN) for the classification. In this technique, the image is considered as a piece of texture and 3D multi-wavelet filters are used for extracting texture information, then texture information is compared according to the distance between the vectors. 240 samples having different contrast quality, size and rotation are used in the system. The results of this system proved to have a fast and higher representation rates for the palm print authentication. [1]

Palm print recognition systems are generally based upon extracting feature vectors and distance metrics. However, there could be many parameters that can influence feature extraction processes such as the environmental factors. This paper studies on the phase-based image matching. With the aim of achieving a highly robust palm print recognition system; phase components are used in 2D (two-dimensional) discrete Fourier transforms of the images. This experimental change shows and efficient matching performance of the proposed algorithm. [11]

In this paper, biometric system of the palm print recognition is based on the texture of palm print principle lines. Principle lines are detected with two novel methods using graph search algorithms, one of which having a high performance on detecting the connected lines. The lines detected are used for extracting textural information using Haralick's features. Finding representative textures in principal lines is succeeded with the concept of texton dictionary whose histogram represents for the palm print. This innovative method achieved 85% accuracy, showing the importance of the texture in palm print recognition systems. Also, it constituted a framework for future approaches in the field. [13]

This study proposes a new algorithm based upon 2D Gabor filters. The accuracy, speed and template size of this algorithm was tested on The Hong Kong Polytechnic University Palm Print Database. Palm images were taken by a scanner integrated into this algorithm in order to enable an online palm print recognition system. A novel palm print database was also developed in the Middle East Technical University whose results proved the success of the algorithm developed. [12]

This paper is based on a real-time biometric system for palm print recognition using Scale Invariant Feature Transform (SIFT). Each SIFT features are classified with KNN. Using CASIA and PolyU databases, this method proved high authentication accuracy with regard to the other new algorithms. [8]

In this paper, a novel palm print recognition method is introduced using Gabor magnitude features. In the first step, illumination is normalized in order not to allow the light variations caused by changing sensors and light conditions. Then, Gabor magnitude features are used for palm print representation. Lastly, most effective features are extracted by using AdaBoost learning and Local Discriminant Analysis (LDA) is applied to decrease the dimension further for palm print recognition. According to the experimental results, this method succeeded effectively high accuracy. [19]

Palm print feature extraction is carried out by combining 2D Gabor transforms, invariant moments, and neural network. Taken images are firstly pretreated and get region of interest (ROI), and make up a set of Gabor filters to get ROI eigenvectors. Experimental results showed the effectiveness of this method. [16]

Eliminating the distortion caused by the movements of the hands or fingers is aimed in this paper. This Palm print recognition algorithm uses phase-based correspondence matching. By using this method, firstly corresponding points between two images are found and then, a similarity between local image blocks around the corresponding points is evaluated. [10]

In this study, images taken through the palm print scanner are translated into numerical values by using image processing technics. Two dimensional discrete wavelet transform is applied in this method. Excessive coefficient that is obtained in this process is classified in feedforward backpropagation artificial neural network without losing features. Palm print images used in this study are taken from PolyU database system. [7]

This study uses the palm print database images of Hong Kong Polytechnic University. The classification is carried out to analyze texture features and after the preprocessing, the region of interest (sub-image) is extracted from the whole image. The texture features are extracted by using the Grey Level Co-occurrence Matrix (GLCM). Then, GLCM based texture features vectors are applied to k-Nearest Neighbor (KNN) method as the input of the classification. The problem of classification in the palm print recognition systems are aimed to be eliminated by using K-nearest Neighbor algorithm. [4]

Distortions such as variable sizes and noises are aimed to be eliminated in the preprocessing step of the palm print recognition system. The proposed algorithm in this study focuses on Region of Interest extraction from the images. In order to use more distinctive features of the image, a larger area of the palm is used, contrary to the mainstream works using a fixed size of ROI. The samples are experimented on PolyU database. [18]

4. PALM PRINT RECOGNITION APPLICATION

4.1. APPLICATION DESIGNED WITH GABOR FILTER

In this chapter, the application designed with Gabor filter will be examined. Images which were separated as 128*128 pixel and reference areas where histogram equality algorithm is not applied will be used.

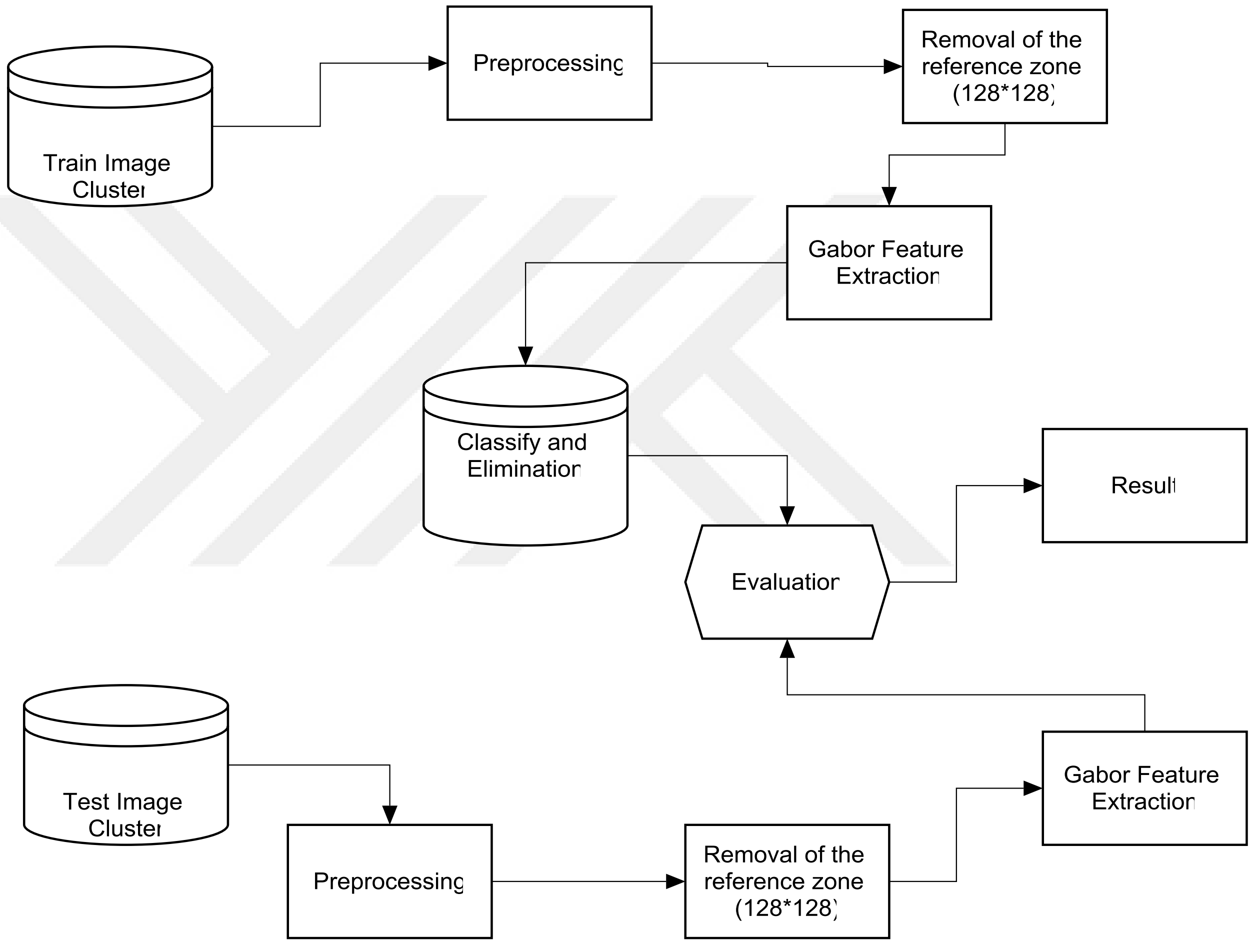

Figure 4.1: Gabor System Flow Diagram

4.1.1. Feature Extraction with Gabor Filter

The usage of Gabor filter was mentioned in the chapter 2.3.1. Gabor filter which will be used for this work includes in 5 scales and 8 angles. The applied filter is shown below.

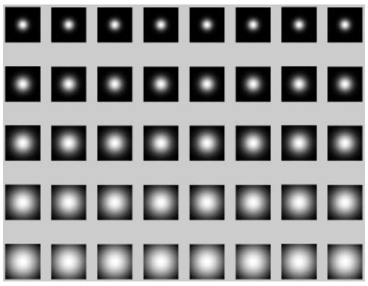

Figure 4.2: Virtual part of the Gabor filter

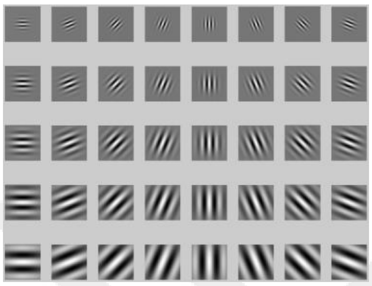

Figure 4.3: Real part of the Gabor filter

For each test and learning class image underwent filtering process, 5*8 (40) matrixes are obtained. The average value and standard deviation of these matrixes are found. 5*8*2 (80) features for each image are made.

4.1.2. Classification with Linear Discriminant Analysis

80 features extracted in the last part and label class was tested by using linear discriminant classification prepared code block of MATLAB program. For the application, left palm print images of the first 30 people. The first image in the database comprises test set and the other images comprise train set for the determined person and hand type.

When the Gabor feature rate is found, the output of the images in the training set is compared to the test set. If the result of this comparison is the same as the result of the label of the view, the correct match is made, otherwise the match is incorrect. The ratio of correct matches to all matches gives the correctness ratio.

Accuracy Rates	Gabor feature
Normal Image	0.900
Histogram Image	0.933

Table 4.1: Accuracy Rates for Gabor

4.2. SYSTEM DEVELOPED WITH HU'S MOMENT FEATURE AND GLCM TEXTURAL FEATURE

In this chapter, the application designed with Hu's Moment and GLCM feature will be examined. Reference areas where histogram equality algorithm was used and images which was separated as 128*128 pixels will be used.

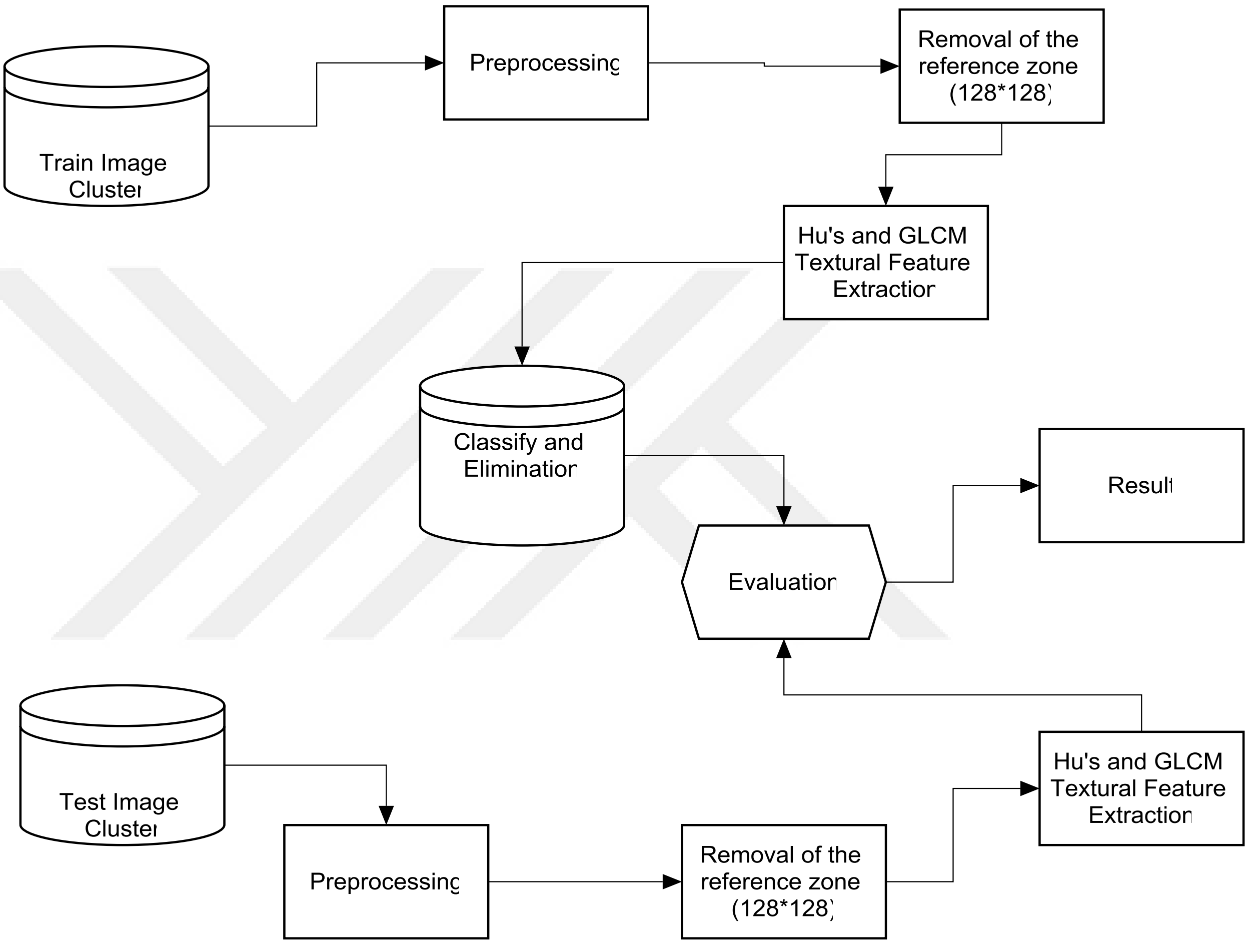

Figure 4.4: Flow Diagram for GLCM

4.2.1 Feature Extraction with Hu's Moment

Usage of Hu's Moment is mentioned in the chapter 2.3.2. 7 features are extracted from each test and learning data images by using this method. Because these features are too small, their logarithm is taken first and then their absolute value is calculated.

4.2.2 Extraction of GLCM Textural Features

Usage of GLCM textural feature is mentioned in the chapter 2.3.3.
22 GLCM features shown below were extracted for each image.

Energy, Entropy, Dissimilarity, Contrast, Inverse, Correlation, Autocorrelation, Cluster Shade, Cluster Prominence, Maximum probability, Sum of Squares, Sum Average, Sum Variance, Sum Entropy, Difference variance, Difference entropy, Information measures of correlation, Maximal correlation coefficient, Inverse difference normalized, Inverse difference moment normalized.

4.2.3. Classification with Linear Discriminant Analysis

Label class was tested using its own linear discriminant classification prepared code block of MATLAB program with 7 Hu's features extracted in the last part and 22 GLCM textural features. For the application, left palm print images of the first 30 people. The first image in the database comprises test set and the other images comprise train set for the determined person and hand type.

When the GLCM and Hu's feature rate is found, the output of the images in the training set is compared to the test set. If the result of this comparison is the same as the result of the label of the view, the correct match is made, otherwise the match is incorrect. The ratio of correct matches to all matches gives the correctness ratio.

Accuracy Rates	GLCM feature	Hu's Moment Feature	Both of Them
Normal Image	0.566	0.466	0.666
Histogram Image	0.533	0.466	0.633

Table 4.2: Accuracy Rates for GLCM and Hus

5. CONCLUSION AND SUGGESTIONS

In this thesis work, three palm print recognition systems were designed by using CASIA database. In the first work, image whose Gabor features were extracted was classified with LDA method. In the third work, images whose Hu's Moment and GLCM textural features were extracted was tested by applying LDA method classification with the set comprised together with these features.

In the first system, Gabor filter was applied on the image and the accuracy rate was determined by using a simple LDA classifier with features.

In the second system, the accuracy rate was determined by using a simple LDA classifier with features, by applying Hu’s Moment and GLCM textural methods on the image.

In fact, the attributes extracted from the histogram image and the normal image are grouped according to the algorithms that used for the extraction of the attributes. These attributes were run separately in classification algorithm as binary groups and a single triple group and compared. Only the version which has the highest accuracy rate is presented in the context of the thesis.

Accuracy Rates	GLCM feature	Hu's Moment Feature	Gabor feature
Normal Image	0.566	0.466	0.900
Histogram Image	0.533	0.466	0.933

Table 5.1: Accuracy Rates for single algorithm

The highest accuracy is obtained from the algorithm which uses only Gabor attributes for the histogram.

However, the difference in the comparison results may not show the effectiveness of the feature extraction algorithms. Because classification algorithms affect the efficiency of feature extraction algorithms in biometric systems. Only the LDA was used for the classification method within the thesis. These accuracy ratings apply only to this classification.

Accuracy Rates	GLCM feature – Hu's Moment Feature	Gabor feature – GLCM feature	Gabor feature – Hu's Moment Feature
Normal Image	0.666	0.900	0.900
Histogram Image	0.633	0.800	0.933

Table 5.2: Accuracy Rates for double algorithm

The highest accuracy rate is obtained from the histogram which Gabor and Hu's moment attributes are taken together. However, only the Gabor attributes also give the same results. When GLCM attributes and Hu's attributes are evaluated together, the validity is slightly increased.

Accuracy Rates	Gabor feature – Hu's Moment Feature – GLCM feature
Normal Image	0.900
Histogram Image	0.866

Table 5.3: Accuracy Rates for triple algorithm

The highest accuracy rate is obtained from the histogram image. However, only the attributes of it gives the same results.

As the algorithms are used in combination, there has not been any improvement in the uprightness of the system, and even it has become worse.

To Increase Accuracy:

- We need to get more clear images.
- More resoluble images can be used.
- Systems that evaluate both hands together can be designed.
- A simple classifier LDA was used for the classification algorithm. More extensive artificial neural networks or SVM can be used.

6. REFERENCES

[1] A. H. M. Al-Helali, W. A. Mahmmoud, H. A. Ali. (2012, October). A Fast Personal Palm Print Authentication based on 3D-Multi Wavelet Transformation. *International Journal of Scientific Knowledge, 1*(2).

[2] A.Gebejes, R.Huertas. (2013). Texture Characterization based on Grey-Level Co-occurence Matrix. *ICTIC,* (s. 375-378).

[3] Abdulkadir ŞENGÜR, İbrahim TÜRKOĞLU. (2004). *DEĞİŞMEZ MOMENTLERLE TÜRKÇE KARAKTER TANIMA.* Fırat University, Depatment of Computer Engineering.

[4] Abidin Çalışkan, Emrullah Acar, Yılmaz Kaya. (2012, April 18-20). GLCM Tabanlı K-NN Sınıflandırıcı Modeli ile Avuç içi Tanıma Sistemi. *Journal of Life Sciences, 1*(2).

[5] Atasoy, H. (2011, February 8). Retrieved from atasoyweb: http://www.atasoyweb.net/Gabor-Filtresi

[6] B. Ergen, A. Çalışkan. (2011). Biyometrik Sistemler ve El Tabanlı Biyometrik Tanıma Karakteristikleri. *6th International Advanced Technologies Symposium.* Elazığ.

[7] ÇELİK, E. (2011). *GÖRÜNTÜ İŞLEMEYE DAYALI AVUÇ İÇİ İZİNİN YAPAY SİNİR AĞI İLE TANINMASI.* Thesis, MARMARA University, Department of Computer Science and Engineering, İstanbul.

[8] H.Pasindu Abeysundera, M. Taner Eskil. (2011). *Palm Verification Using SIFT Majority Voting.* ISIK University, Department of Computer Science and Engineering.

[9] Kenji TAKITA, Mohammed Abdul MUQUIT, Takafomi AOKI, Tatsuo HIGUCHI. (2004, August). A Sub-Pixel Correspondence Search Technique for Computer Vision Applications. *Special Section on Digital Signal Processing*, 1913-1923.

[10] Koichi Ito, Satoshi Iitsuka and Takafumi Aoki. (2009). A PALMPRINT RECOGNITION ALGORITHM USING PHASE-BASED CORRESPONDENCE MATCHING. *ICIP*, 1977-1980.

[11] Koichi Ito, Takafumi Aoki, Hiroshi Nakajima, Koji Kobayashi, Tatsuo Higuchi. (2006). A PALMPRINT RECOGNITION ALGORITHM USING PHASE-BASED IMAGE MATCHING. *ICIP*, 2669-2672.

[12] KONUK, B. (2007). *PALMPRINT RECOGNITION BASED ON 2-D GABOR FILTERS.* Thesis, MIDDLE EAST TECHNICAL UNIVERSITY, Department of Electrical and Electronics Engineering.

[13] Martins, D. S. (2011). *Biometric recognition based on the texture along palmprint principal lines.* Thesis, Faculty at Universidade do Porto, Porto.

[14] ÖZEYRANLI, E. B. (tarih yok). *Biyometrik Tanıma Sistemleri.* Poster, Pamukkale University, Denizli.

[15] Rafael A. Irizarry, Hector Corrada Bravo. (2010). *Linear methods for classification.*

[16] Rina Su, Yongping Zhang, Jianbo Fan, and Shaojing Fan. (2009, December 26-28). Palmprint Recognition Based on Gabor Transforms and Invariant Moments. *Proceedings of the Second Symposium International Computer Science and Computational Technology*, 254-257.

[17] ŞAMLI, R. (2010, December). Retrieved from bilisimdergi: http://www.bilisimdergi.com/Biyometrik-Guvenlik-Sistemleri-21-3.html

[18] Yatam Laxmi Malathi Latha, Munaga V. N.K Prasad. (2013). Extraction of Dynamic Region of Interest (ROI) for Palmprint. In *Proc. of Int. Conf. on Advances in Computer Science* (pp. 264-269). Elsevier.

[19] Zhen Lei, Yufei Han, Stan Z Li. (2007). Learning Gabor Magnitude Fatures for Palmprint Recognition.

[20] Anil K. Jain,Salil Prabhakar. (2004, January). An Introduction to Biometric Recognition. IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY, 14(1).

[21] OZ, E. (2011,). Oruntu Tanıma Ders Notları: http://emrahozkaynak.blogcu.com/oruntu-tanima-ders-notlari-1/10026042

[22] ŞEKER, S. (2011). Düzleştirme Filitresi

http://bilgisayarkavramlari.sadievrenseker.com/2007/11/25/duzlestirme-filitresi-gauss-filtresi-gaussian-filter-smoothing-filter-gaussian-blur/