# Authentication System For Off-line Fingerprint Image

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**Abstract**— The use of fingerprint authentication has become very important of many security applications. There is a need for such systems in military and civilian applications: computers, networks, systems, entry and exit, and others. In this paper, a fingerprint recognition system for authentication the off-line fingerprint( inked-printed paper) is developed.That method including two Systems, first Fingerprint Feature Extraction(FFE) based on Hu's invariants moment, after the image rotated by angle, the ranges of angles rotation between: (0-45),(45-90) and (90-180), second is a Recognition of Fingerprint system (FRS) by comparing between an input test Fingerprint features using moments for the input image (without rotate) within the Fingerprint images features which store in Database (DB)System, Database system have three local databases types depended on the three cases of rotation angles.

**Index Terms**— fingerprint, authentication, FFE, FRS
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## 1 INTRODUCTION

Fingerprint recognition is one of the oldest and most important research areas in the field of pattern recognition, one of the basic problems in the design of an imagery pattern recognition system relates to the selection of a set of appropriate numerical attributes of features to be extracted from the object of interest for the purpose of classification [1, 2]. Simple properties of the image which are found via image moments include area the higher order moments give even more detailed shape properties of the polygons such as symmetry, etc. Geometric moments present a low computational cost, but are highly sensitive to noise. Furthermore reconstruction is extremely difficult. Although not invariant under rotation, Hu's invariants [3, 4] derived a transformation of the normalized central moments to make the resulting moments invariant, and central moments. These moments continue to be published in books on image processing. Hu [5] has used the moments for character recognition, The mathematical concept of Moments and the related invariants have been analyzed extensively to characterize the patterns in images in a variety of applications such as fingerprint identification and recognition, and has been used in many application from mechanics and statistics to image understanding, describing images with moments instead of other more commonly used image features means that global properties of the image are used rather than local properties[1].

Fingerprints have been used in identification of individuals for many years because of the famous fact that each finger has a unique pattern [6]. Fingerprint recognition has a very good balance of all the desirable properties like, authentication, universality, Distinctiveness, Permanence, Collectability, Performance, Acceptability and Circumvention. Every human being possesses fingerprints with the exception of any hand related disabilities. Fingerprints are very distinctive; fingerprint details are permanent, even if they may temporarily change slightly due to cuts and bruises on the skin or weather conditions [7]. It is typically used in security systems and can be compared to other biometrics such as Face recognition systems [8].

Many works dealing with fingerprint verification task is present in recent years. Rajeswari eta l[9], the salient features of their proposal make it a suitable candidate for number of practical applications like Biometric ATMs and in future, Biometric online web applications etc. Compared with previous solutions, S.W. Lee and S.Z. Liin [10] have demonstrated a working proof of concept of a secure minutia-based authentication system perform a full security analysis on this system and study methods (finer quantization and codes with larger error correcting capability) to improve its security.

In this proposed system, for authentication of inked fingerprint (off-line), based on moments to extract the features ( the properties) of a inked image fingerprint entered, so we will take a number of cases of fingerprint one-person job rotation of the fingerprint by: (0 – 45),(45 – 90), and (90 – 180) angles and then extract the image properties (shape features) based on the values of moments, these features are used in the recognition step for authentication system

## 2 FINGERPRINT

Extensive research has been done on fingerprints in humans. Two of the fundamentally important conclusions that have risen from research are: (1) a person's fingerprint will not naturally change structure after about one year after birth and (2) the fingerprints of individuals are unique. Even the fingerprints in twins are not the same. In practice two humans with the same fingerprint have never been found [11].

A fingerprint is comprised of ridges and valleys. In Figure 1, we can see more dateless of a fingerprint shape. The ridges are the dark area of the fingerprint and the valleys are the white area that exists between the ridges, that ridges are represent the shape of fingerprint image [11].


Figure 1: the Shape of a Fingerprint Ridges and Valleys

## 3 FEATURES EXTRACTION

In the Fingerprint Feature Extraction, the approach is followed using binary image (black and white pixels) and shape information extracted by central moments. Image threshold, and preprocessing techniques like enhancement, thinning for binary image, is required for this application in order to remove noise effect and to simplify the test image processing. Preprocessing steps include several traditional image processing methods which are applied together to obtain a better-input data for features extraction step [5].

There are lots of different features available that are used in image classification and retrieval, the degree of similarity between query images and images in databases can be measured by color distribution, texture distribution, shape similarity, or object presence between the two images. Searching for images using shape features has attracted much attention. Shape representation and description is a difficult task [12].

### 3.1 Pre-processing Image

In this work, before extract the features can be done, fingerprint image must be preprocessed. The preprocessing of the image is done in five stages:

1. Gray scale Image: the color inked of fingerprint image was converting to gray image
2. Binary Image: convert gray fingerprint image to binary image.
3. Enhancement: edge enhancement is used to fill in gaps in ridge detail. The gaps can be result of the quality of the input fingerprint image. The ridges get some gaps; parallel ridges connected due to noise and natural effect to the finger like cuts, wrinkles and injuries. The Fingerprint enhancement is anticipated to improve the contrast between ridges and valleys and reduce noises in the fingerprint images, we have used median filter, to reduce the noise from gray scale image.
4. Thinning: the ridges must be thinned to a width of one-pixel. In this step two consecutive fast parallel thinning algorithms are applied, in order to reduce to a single pixel the width of the ridges in the binary image. These operations are necessary to simplify the subsequent structural analysis of the image for the extraction of the fingerprint shape.
5. Image Rotation: this step doing for only Author user in one time. That using equations rotation[16].

$X2 = \cos(Ø) * (x1 - x0) - \sin(Ø) * (y1 - y0) + x0$

$y2 = \sin(Ø) * (x1 - x0) + \cos(Ø) * (y1 - y0) + y0$

### 3.2 Moments

In many applications such as shape recognition, it is useful to generate shape features which are independent of parameters which cannot be controlled in an image. Such features are called invariant features. There are several types of invariance.

Moment invariants have been frequently used as features for image processing, remote sensing, shape recognition and classification. Moments can provide characteristics of an object that uniquely represent its shape. Invariant shape recognition is performed by classification in the multidimensional moment invariant feature space [13]

Moments are the statistical expectation of certain power functions of a random variable. There are two ways of viewing moments, one based on statistics and one based on arbitrary functions such as f(x) in 1-D or f(x, y) 2-D. As a result moments can be defined in more than one ways, for binary connected components, this can be achieved simply by using the central moments, (μpq) [14].

of order up to 3: [5, 14]

$∂1 = η20 + η02$

$∂2 = ( η20 + η02 )2 + 4 η2 11$

$∂3 =( η30 + 3η12 )2 + (3η21 + η03 )2$

$∂4 =( η30 + η12 )2 + ( η12 + η03 )2$

$∂5 =( η30 + 3η12 )( η30 + η12 ) [( η30 + η12 )2 - 3( η21 + η03 )2] + ( 3η21 - η03 )( η21+ η03)$

$∂6 =( η20 + η02 ) [( η30 + η12 )2 - 3( η21 + η03 )2] + 4 η11 ( η30 + η12 ) ( η21 + η03 )$

$∂7 =( 3η21 - 3η03 ) ( η30 + η12 ) [( η30 + η12 )2 - 3( η21 + η03 )2] + ( 3η12 - η03 ) ( η21 + η03 ) [3( η30 + η12 )2 - ( η21 + η03 )2]$

## 4 AUTHENTICATION SYSTEM

The proposed system comprises two main components:

1. Fingerprint Features Database System
2. Fingerprint Recognition System

The fingerprint images may be acquired either by an off-line or an on-line process. The fingerprint images acquired by the off-line process are known as the "inked", fingerprints while the images acquired by the on-line process are known as "live-scan" fingerprints. A live-scan fingerprint is obtained directly from the finger without the intermediate use of paper. Typically, live-scan sensors capture a series of bad fingerprints when a finger is pressed on the sensor surface [15].

In this research, inked fingerprint off-line is used, therefore, have not used any live-scan sensors device, in fingerprint acquisition, ink is applied to the finger and then pressed onto a paper without rolling. The paper is then scanned in a digital image.

### 4.1 FINGERPRINT FEATURES DATABASE SYSTEM

The type of fingerprint ink used in this research and set by the user on paper, so it is possible that the fingerprint irregular in terms of developing the finger on paper, it has placed randomly and trends variable time and again unlike a fingerprint taken from the devices sensitive to the fingerprint, which finger is placed in a specific place is not possible change of direction,

for this reason we rotate the image fingerprint several angles before they enter to extracted it's features based on central moment, figure2 and algorithm(1), are show the database system for features extraction from input fingerprint images.

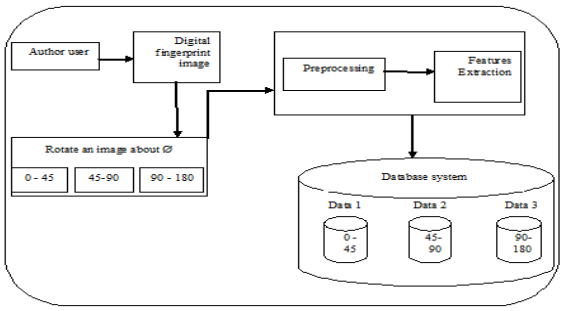



Figure2 : fingerprint Features Databases System

**Algorithm (1): Fingerprint Features system**
Input: scanned ink-on-paper Fingerprint image.
Output: Moment features saved in Database system, three values for each image.
Step1: Input ink color Fingerprint image.
Step2: The Image rotate about each of the following case using equations of Rotations [16]:
(0 – 45) and (45 – 90) and (90 – 180)

where (x0, y0) are the coordinates of the center of rotation (in the input image) and Ø is the angle of rotation with clockwise rotations having positive angles.

Step 3: Preprocessing of image that result from Step2. By:
1. Convert Image in to Gray Scale Image
2. Convert Gray Image to Binary Image
3. Segment Binary image using thresholding technique.
4. Thinning its boundary and limitation for ridges which result from the thinning.
5. Smoothing the result thinning image.

Step 4: A set of seven invariant moments can be derived from central moments
That is the features for fingerprint image input for each angles case in Step 2.

Step5: Saved all moment values (features) for all fingerprint images testing in Database system to use it in Recognition system for this research.
Step6: for any Fingerprint Image do:
If FI rotate about ( 0 – 45 ) degree then saved it in D1
If FI rotate about ( 45 – 90 ) degree then saved it in D2
If FI rotate about ( 90 – 180 ) degree then saved it in D3
Where : FI is Fingerprint image input, D1 ,D2, and D3 are Local database.

The database System includes three local database was divided according to the degree of rotation to the image of a fingerprint, and include the following

1. Rotate the image specific angle between 0-45 degrees, store in local database (D1).

2. Rotate the image angle is restricted between 45 to 90 degrees, store in local database (D2).

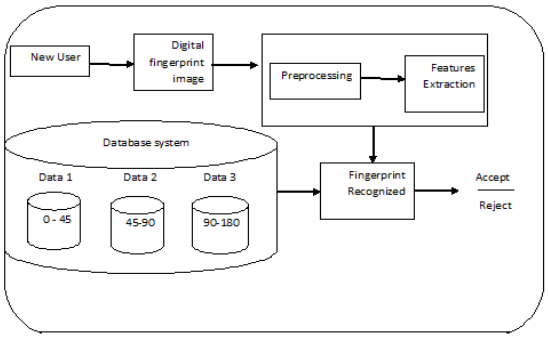
3. Rotate the image for a certain angle between 90 to 180 degrees, store in local database (D3).

In all three cases showing above, the applier of the system have a freedom to choose the degree of rotation in the range specified for each case, this matter as we mentioned earlier will help in the development of several possibilities for the image fingerprint that will enter through a system of discrimination, which comes from the introduction of image a fingerprint through the paper content that fingerprint may not be subject by the person concerned to accept his mark in moderate any direction angle.

### 4.2 Fingerprint Recognition System(FRS

After applied fingerprint features extraction (FFE) steps from algorithm(1) ,on the input inked fingerprint image, we define Maximum one object, for this object (ridges connected) define seven Features and there threshold value.

In the Fingerprint Recognition system FRS was show in Figure3, each new inked fingerprint image including for the system to recognition it, will be applied first in the FFE system without any change (without rotate) to get their 7 features moment and there threshold to compare its features with features for different images of fingerprint stored in our database system for each Local Databases of Database System (D1, D2, and D3) to accept a new user or reject it, the idea of our proposed Authentication Fingerprint System (AFS) are explain in algorithm (2).




Figure(3): fingerprint Recognition system

**Algorithm(2): Fingerprint Recognition and Authentication System**
Input : New inked fingerprint image.
Output: Accept or Reject a new inked fingerprint image.
Step 1: Input a new inked fingerprint image.
Step2: Applied Step3 to step5 in Algorithm (1), to get 7 Features for new Fingerprint image input.
Step 3: For each D1, D2, and D3:
Compare the 7 Features from step2 within each 7 Features from each local database in our database system by:

$$F = \sum_{i=1}^{7} (Fi\ p / Fi\ db) * 14.28$$

Where: F is the summation of ((Fi p / Fi db) * 14.28) , it will between (14.28 *7 %) and (100%), 14.28 is the average of (100/7) for 7 features.
(Fi p) is the feature gets it from new person fingerprint image, (Fi db) is any feature gets it from our database.
Step 4: If the rate of F ≥ 80% then Fi p is same of one feature in DB.
Step 5: for step3 , if the result is more than one Fingerprint image features have same rate value ( F ≥ 80% ) then: the Maximum value is the nearest features back in to test person Fingerprint image.
Step 6: Authentication: from Step4 and Step5, the new Fingerprint is Accept or Reject.

## 5 Experimental and Results

Fingerprint Features Database system is the first step in this work and the task to extract the shape features from inked fingerprint image after rotate it then stored in the database system in one of local database (D1,D2, and D3). In the recognition step, the data will be compare with the specification of the inked fingerprint image and what had been extracted based on the methods that was represented and described of the part of the moments, considering the features that was stored in images database.
The experiment is calculated under the following conditions:

1. Inked fingerprint on the paper is used only (Off – line type).
2. All fingerprints for any user have same ink color.
3. All of the test images have same size (100 × 200) and resolution from ink paper scanning.

Our image system contain 50 testing images and saving their features after rotate step into local database (D1,D2, and D3) that mean we have finally 150 image stored in Database System,

Figure (4) show the result of preprocessing steps from algorithm(1) for F25 fingerprint test image, such as Gray scale image, Smoothing, Threshold Segment, and Thinning.

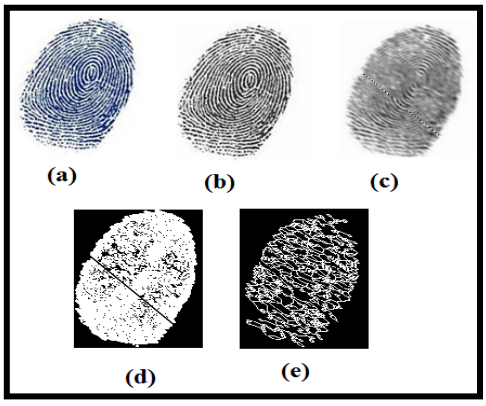



Figure4: Preprocessing steps (a) Inked fingerprint (b) Gray scale image, (c)Smoothing, (d) threshold segment, (e) thinning.

Table (1) including all the information of features for the test F25 fingerprint image, from Fingerprint Features system using algorithm(1), this image rotate about 10 degree, 50 degree and 110 degree, saved in D1,D2, and D3. Each Image test has 21 features 7 for each case explains in algorithm(1), and it will be saved in the database system to recognition level, where User Name is the name of fingerprint image saved in database system.
Table1: Information of features for F25 Fingerprint image

| User Name In Database | F 25 | | |
|---|---|---|---|
| Moment Features | D1(0-45) | D2(45-90) | D3(90-180) |
| ∂ - 1 | 0.272 | 0.222 | 0.516 |
| ∂ - 2 | 0.794 | 0.719 | 1.103 |
| ∂ - 3 | 1.793 | 1.675 | 2.251 |
| ∂ - 4 | 1.541 | 1.413 | 2.180 |
| ∂ - 5 | 3.209 | 2.957 | 4.397 |
| ∂ - 6 | 1.938 | 1.773 | 2.732 |
| ∂ - 7 | 0.292 | 1.313 | 1.800 |

A new input image test named F53 for recognition it within database images. After we find the features moment for F53 Fingerprint image test input, we compared between 7 features with 150 fingerprint image features saved in our database ( each local database have 50 image), see Figure5.

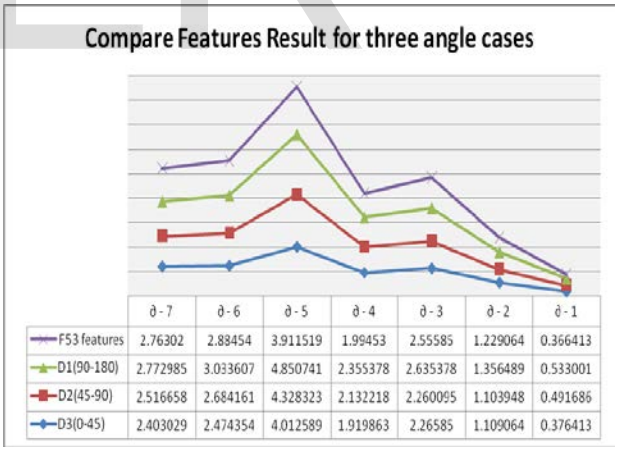
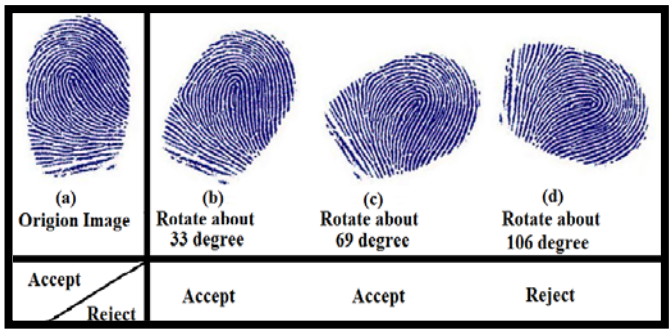



Figure5: Recognition Step for Fingerprint image F53 features Within images features from three local databases
Figure (5) include compare chart and Table content the features for new input image F53 and 7 features for each rotate case for F50,F51,and F52 fingerprint image will be saved in three local databases.
In the case of image F53 in figure6: a is noticed that the features of this input image is approaching the features of a single image stored in the database D1 named F50 more than others by 88.1179 ratio, which was rotated at an angle of 33 degrees on the original image in Figure6:b, while the ratio of the next it goes back to the forms F51 and stored in the database D2 which been

rotated 69 degrees angle for original image in Figure6:c was approaching rate features of the input image is equal to 81.3392, while the F52 and the image that resulted from the original image rotation angle of 108 ° , in Figure6:d has been Reject, like images of the fact that the comparison rate was less than 80% the requirement proposed in the discrimination step4 from Algorithm(2).




Figure(6) : The Recognition result for F53 fingerprint and its Rotation cases

## 6 CONCLUSIONS

In this research was to rely on the features of the shape of the Ridge of a Fingerprint being a deferent between humans and the last, In FFS, we relied on moments to extract the features of the shape of the fingerprint, and because the fingerprint approved is ink on paper, so we take into account that the printed fingerprint vary in terms of the site fingerprint on paper the direction no it is not necessary to find all fingerprint-derived vertical and on a regular basis, so we proposed fingerprint by rotate processed in the order of several cases and the extent of each case. FRS is the system of Recognition fingerprint by comparing input test person inked fingerprint features from within 150 fingerprint images features, each 50 are saved in one local database, we adopted on the rate of recognize step of the fingerprint entered with the fingerprints stored in the system and test the 50 files its entrance with 10 images recognized against and we found that the more the value of the angle in the stage of rotation to the image of fingerprint, the less the rate of the image to be recognizable, and the images fingerprint ink on paper more difficult to decouple the fingerprint image quality from the intrinsic finger quality.

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