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Adaptive Genetic Algorithm and KNN for Fingerprint Identification

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Abstract: The fingerprints of any individual are unique and do not change throughout his/her life. In this paper, proposed fingerprint identification algorithm is introduced, it has been used Genetic Algorithm (GA) as a feature selection tool for fingerprint identification. The proposed system contains four main steps: preprocessing, features extraction, feature selection and classification. The preprocessing sub stages consist of some image processing techniques as: Enhancement and Segmentation. A feature has been extracted from ridges that find around core point then DCT has been used to extract features and has been got a few coefficients. Important features have been selected using genetic algorithm filter. Finally, classification step has been done by using k-Nearest Neighbors (k-NN) ,where the database contains samples for 28 person, 7 sample for each person. The recognition rate reached to 98%.

Keywords— Fingerprint Identification, Fourier Transform, Contrast Limited Adaptive Histogram Equalization, Poincare Index ,Morphological Methods, Discrete Cosine Transform , Genetic Algorithm , K-Nearest Neighbors

I. INTRODUCTION

Fingerprint is the representation of the epidermis of a finger; it consists of a pattern of interleaved ridges and valleys. In the early twentieth century, fingerprint recognition was formally accepted as a valid personal identification method and became a standard routine in forensics. Fingerprint identification agencies were set up worldwide and criminal fingerprint databases were established. Various fingerprint recognition techniques, including latent fingerprint acquisition, fingerprint classification, and fingerprint matching were developed. Nowadays, automatic fingerprint recognition is one of the most common applications of machine pattern recognition (it dates back to more than fifty years ago). Because of this, there is a popular misconception that fingerprint recognition is a fully solved problem. On the contrary, fingerprint recognition is still a complex and very challenging pattern recognition task [1].

II. FINGERPRINT IDENTIFICATION AND GENETIC ALGORITHM

The proposed method identifies the fingerprint in Discrete cosine Transform coefficients based on GA and then classified by using k-Nearest Neighbors . This section describes more details.

A. Approaches in Image Enhancement

Image enhancement approaches fall in to two broader categories namely spatial domain methods and frequency domain methods[2].

- Spatial Domain Methods spatial domain are based on direct manipulation of pixels in an image. Gray level transformations, Histogram processing, Enhancement using Arithmetic/Logic operations, Smoothing filters and Sharpening filters are some of the methods used in the spatial domain for image enhancement [2] .
- Frequency Domain Methods approaches in the frequency domain refer to the modification of the Fourier Transform of an image[2].

B. *Fingerprint Image Segmentation*

A fingerprint image is an image that is formed when a fingerprint is impressed against a smooth surface .Image segmentation is the process of separating the image foreground from the image background[3].To extract the ROI must use two-step method. The first step is block direction estimation and direction variety check while in second step used some Morphological methods[4].

The simplest and the most natural approach for computing orientation field is based on the gradient values. Because of the computational effort and the presence of noise, the orientation field is usually computed in a small neighbourhood instead of at each pixel. The gradients of gray intensity of fingerprints are estimated to obtain reliable ridge orientation [5].

The word morphology signifies the study of form or structure. The image processing uses mathematical morphology as a means to identify and extract meaningful image descriptors based on properties of form or shape within the image. Key areas of application are segmentation together with automated counting and inspection[6].

The background has determent area and discard by using steps of [4] as :

1.Those blocks without significant information on ridges and furrows are discarded based on the following formulas:

$$E = \{2\sum\sum (Vx * Vy) + \sum\sum (Vx^2-Vy^2:) \}/ W *W* \sum\sum (Vx^2+Vy^2) \quad \ldots.(1)$$

For each block, if blocks certainty level E is below the threshold, then the block is regarded as a background block.

2. ROI extraction is done by two morphological operations called “OPEN” and “CLOSE”. The “OPEN” operation can expand images and the “CLOSE” operation can shrink images and eliminate small cavities. The bound is the subtraction of the closed area from the opened area.

C. Feature Extraction

When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant then the input data will be transformed into a reduced representation set of features (also named features vector) [7].

A singular point area is generally defined as a region where the ridge curvature is higher than normal and where the direction of the ridge changes rapidly[8].The singular points can be classified into two types: core and delta [9].Core point is the inner point normally in the middle of the fingerprint. Whereas delta point is normally at the lower left and right hand of the fingerprint ,Therefore the absence of delta point is possible. In close around the core point there exists rich minutiae information than others[10].The Poincare Index method (PI) is the most famous approach of singular point detection[8]. Fingerprint representation in DCT is a sum of sinusoids of varying magnitudes and frequencies. The DCT is used in data compression as reconstruction of original image from frequency domain is possible with few DCT coefficients [11].

D. Features Selection

The main issues in developing feature selection techniques are choosing a small feature set in order to reduce the cost and running time of a given system, as well as achieving an acceptably high recognition rate. The GA-based method improved the results by producing a higher accuracy and reducing the number of features required for learning the classification rules , the GA-based method proved quite effective in improving the robustness of feature selection over a range of problems [12].

The basic idea behind the genetic algorithms is to maintain a population of strings or chromosomes ,which are encoding of a potential solution to the problem being investigated. Each chromosome is tested using a fitness function to know the good solution of the problem [13].

E. K-Nearest Neighbor (KNN)

The principle behind nearest neighbor methods is to find a predefined number of training samples closest in distance to the new point, and predict the label from these[14].KNN classifier is best suited for classifying persons based on their images due to its lesser execution time and better accuracy than other commonly used methods which include Hidden Markov Model and Kernel method. Although methods like SVM and Adaboost algorithms are proved to be more accurate than KNN classifier, KNN classifier has a faster execution time and is dominant than SVM [15].

III. THE SYSTEM MODEL

This proposed method uses an automatic direct and fast procedure in both phases, feature extraction and identification. The algorithm of this method consists of the following steps:

Algorithm 1 : Feature Extraction Algorithm in Proposed Method

Step 1: Input number of images (N) ,for each image do the next steps.
Step 2: Pre-process the input image:
Step3: Feature extraction:
- 3.1: Detection reference point.
- 3.2: Determine core block.
- 3.3: Extract features vectors of core block.

Step 4: Features Selection.
- 4.1: Passing filter produced of GA on coefficients vectors.

Step 5: Save the result that represent a final features in features file.
Step 6: Repeat phase 2…5 for all images.

Algorithm 2 : Identification Algorithm in Proposed Method

Step1:Implement feature extraction algorithm for training images.
Step2: Input test image.
Step3: Implement feature extraction algorithm for testing image.
Step4:Traning classifier using features file and test classifier using features test image.
Step5:Identification result.

A. Feature Extraction Phase for the Proposed Method

In this phase all fingerprint image in database has passed in several steps. Input for feature extraction phase has been the image while output has been the vectors which represent features that have been extracted from the input image. following are the more detail description of each step.

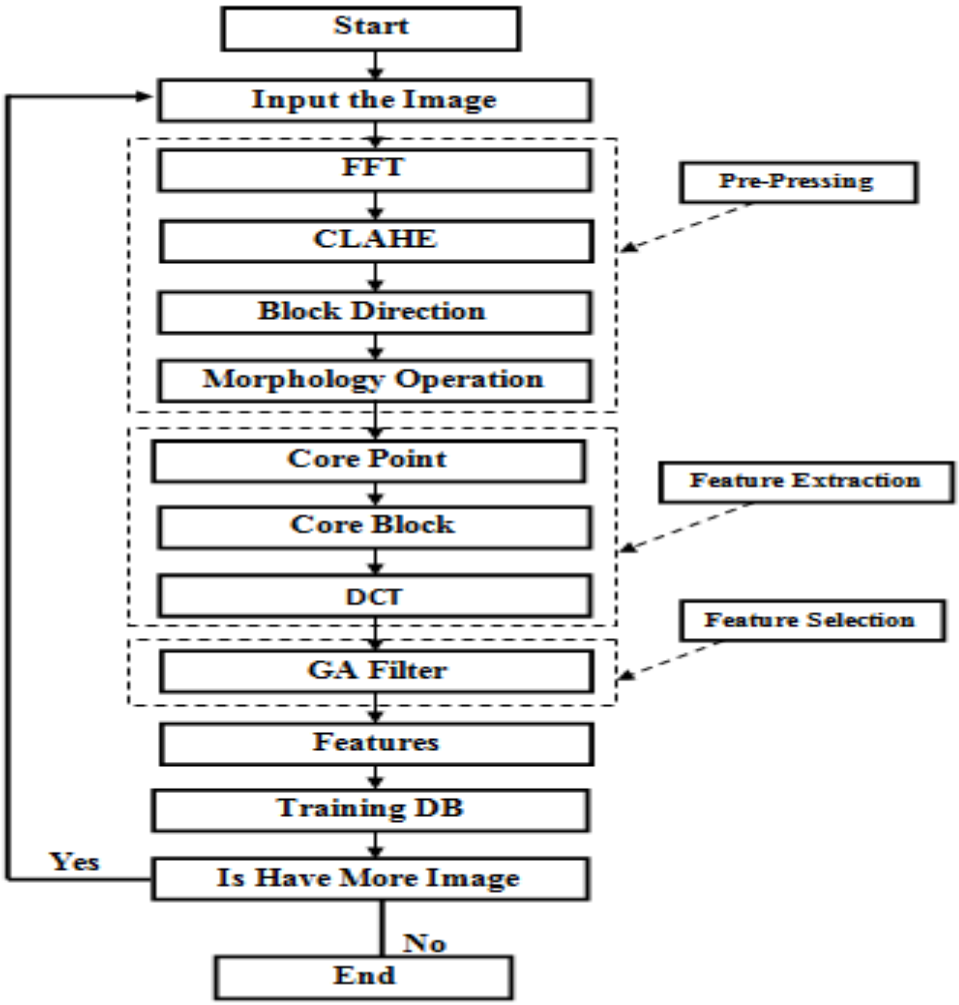


Fig. 1 Block diagram of the feature extraction phase in proposed algorithm.

1)Input the Image

Fingerprint images have been used as input to proposed a method including seven different versions of fingerprint images per person take from FVC(2000,2002,2004). The Fingerprint images have been used back to the twenty-eight individual, five version of images for each person have been used as training images and the other two version of image of the same person has been used as testing images. All samples of fingerprints are of gray scale of tiff image file format.

2)Pre-processing

Fingerprint image quality is a vital issue to measure the performance of fingerprint identification system .So quality assessment of fingerprint data leads to identify the fingerprints in a better way. The main purpose of such procedure is to enhance the image by improving the clarity of ridge structure or increasing the consistence of the ridge orientation.

2.1)Enhancement

The enhancement step contains an enhance ridges and contrast features of fingerprints using the frequency and spatial domain technique from through :

i: Enhance Global Features

This step has used Fast Fourier Transform (FFT) to clarify the shapes of the ridges of fingerprint images.FFT has been work on enhance global features. The Fourier transform of the image to be enhanced is computed, multiply the result by a filter and take the inverse transform to produce the enhanced image.

ii :Enhance Local Features

CLAHE is a special case of the histogram equalization technique that functions has been used to enhance the contrast of the small tiles of an image, where the histogram is calculated for the contextual region of a pixel. The pixel's intensity is thus transformed to a value within the display range proportional to the pixel intensity's rank in the local intensity histogram.

2.2)Segmentation

The goal of segmentation has extracted Region of Interest whereas the image area without effective ridges and furrows has first discarded then the bound of the remaining effective area has sketched out. ROI has determined by :

i: Block Direction Estimation

The block direction estimation operates on the gray level fingerprint image and then obtains an approximate direction for each image block. Estimation of ridge orientation values is based on gradient relationship between neighboring pixels.

ii: Morphological Operation

After finishing the estimation step of each block direction , the background area has been determined and discard by using equation (1) and (close ,open) operation.

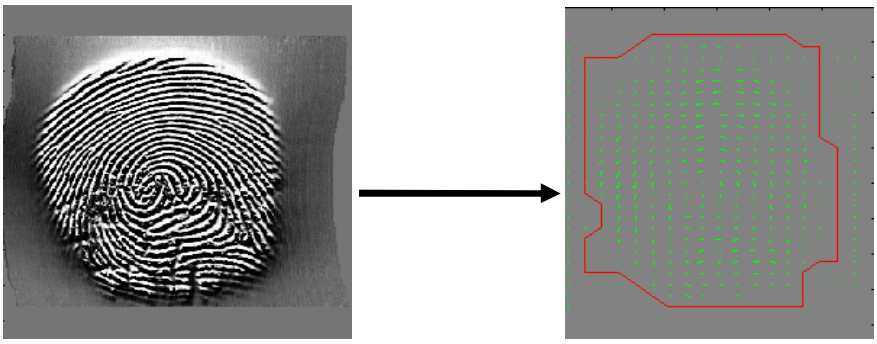


Fig. 2 Show result segmentation step.

3) Implement Feature Extraction

Feature extraction step has been required here detect core point then determine core block which has entered into DCT in order to get on coefficients vectors , more details from through :

i : Detection Core Point

The Poincare index for each pixel of ROI has been calculated by using Poincare Index technique, determination ROI before detection core point has reduced probability of identifying spurious reference point .

ii : Determine Core Block

The core block has extracted from area around core point and after several experimental tests have been found the best size (16×16) and then reconstruct it as vector in size (1×256).

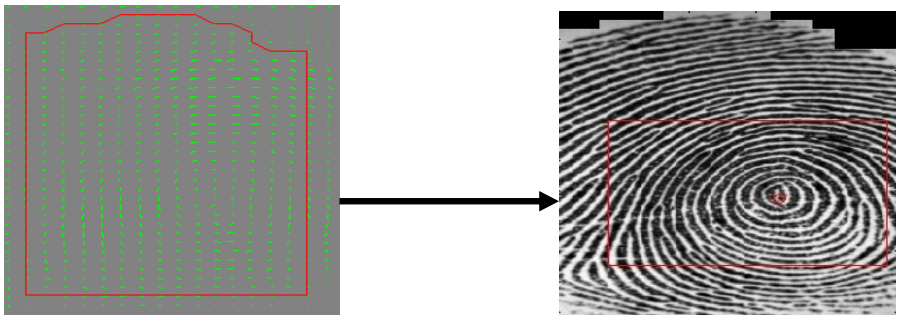
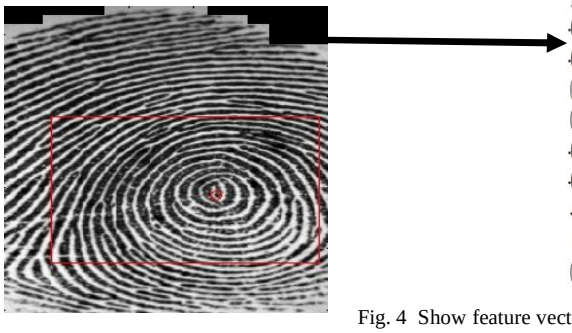


Fig. 3 Show the result detect core point and determine core block.

iii : Extract Feature Vectors

Core block information that take from the previous step as (1×256) vector has entered to 1-DCT in order extract coefficients vectors. The DCT result has got coefficients in size (1×100) vector instead of each image and vectors form for each image that out of DCT as :



1.1502 -1.3348 0.6412 0.0421 -0.3676 0.2775 0.0034 -0.1789 0.1099 0.1156
-0.2994 0.3119 -0.1786 0.0237 0.0525 -0.0441 0.0111 -0.0019 0.0108 -0.0048
-0.0235 0.0412 -0.0122 -0.0565 0.1137 -0.1129 0.0601 -0.0091 0.0079 -0.0490
0.0766 -0.0453 -0.0276 0.0699 -0.0193 -0.1152 0.2528 -0.3045 0.2428 -0.1186
0.0133 0.0265 -0.0139 -0.0070 0.0089 0.0002 0.0016 -0.0168 0.0221 0.0063
-0.0629 0.1128 -0.1221 0.0878 -0.0392 0.0095 -0.0070 0.0142 -0.0123 0.0050
-0.0055 0.0524 -0.0709 0.0920 -0.0773 0.0574 -0.0024 -0.0059 -0.0069 0.0172
-0.0090 -0.0101 0.0188 -0.0067 -0.0127 0.0156 0.0076 -0.0400 0.0555 -0.0356
0.0014 0.0207 -0.0147 -0.0106 0.0341 -0.0450 0.0502 -0.0616 0.0770 -0.0778
0.0480 0.0055 -0.0517 0.0604 -0.0269 -0.0230 0.0556 -0.0560 0.0354 -0.0140

Fig. 4 Show feature vector that out from DCT.

4)Genetic Algorithm Filters

The Genetic Algorithm has been used here to generate a filter. Chromosomes of a certain population size are generated, initialized with random strings, the chromosome length equal length coefficients vectors 1×100 . A chromosome here is a string of bits (0 or 1) whose size corresponds to the number of features that out from DCT.

the crossover rate quite large than the mutation rate. Crossover rate has determined equal 0.9.The crossover method has used the one point crossover. The mutation rate has been determined equal 0.01.The mutation operation has been applied a third order mutation ,in addition the mutation method has been used the inversion mutation.

The Genetic operations have stopped when the value fitness equal number features (number one's (1)) that specific or if the solution does not fit, the solution has stopped after 100 generation.

Algorithm 3: Genetic algorithm that used

Step1: Determine parameter GA .
Step2: Generate randomly the first generation .
Step3: Determine stop condition .
Step4: Crossover structures .
Step5: Mutate structures .
Step6: Evaluate structures .
Step7: Save filter if the result equal number of required features then break else repeat step3…7 until stop condition become true .

This method has been applied and used a different number in order to determin number one's (1) in filter which is the basis of evaluated chromosomes ;during experimentation many results have been found but when 48 used as number of one's (1) in filter ,the results have started improving whenever increased number one's (1) to 65,68 and error in identification rate has reduced contrary with increased number one's (1) in filter until reaching to 75 feature the identification rate still same rate in 68 feature.

For example :

Filter generat by GA : Filter size (1×100)

1	**0**	**0**	**0**	**1**	**1**	**0**	**……**

Distinctive features out of DCT :Features size (1×100)

3.3359	0.2739	-0.0881	-0.2669	-0.2846	-0.2032	-0.2748	**…...**

Features out of GAfilter step:Features size(equal number 1 which found in GAfilter)

Save feature	Not save feature	Not save feature	Not save feature	Save feature	Save feature	Not save feature	**……**

B. Identification Phase for the Proposed Method

When testing any image from 56 test image , the test image has passed in all steps mentioned in section (7.1) and after explaining the that manner gets on filter of GA and how it is used, different GA filters contain different number of one's (1) have used .The number one's (1) in filters are tested (48,65,68 and75) training and testing images have used each filter alone in order to test the ability GA filter on improving identification rate then features out of GA filter enter to K-Nearest Neighbor (see fig.7).

The identification results in KNN as : With 48 feature 82.14% identification rate ,with 65 feature 87.50% , with 68 feature 91.07% and with 75 feature 91.07% in addition all training images (140 image) correct identification.

After explaining the proposed method and display the test results, another idea has attempted going deeply by using more one GA filter with the same number of one's (1) to get better results across improving classification. The result improvement step has been encouraging and the number of one's (1) in filters are tested (53 and 60) .In this improvement two filter are used for all images. The test results for this step disclose improving in the identification rate reach to 98% , wherein use 53 feature the identification rate reach to 96.42% and when use 60 feature the identification rate reach to 98.21% .

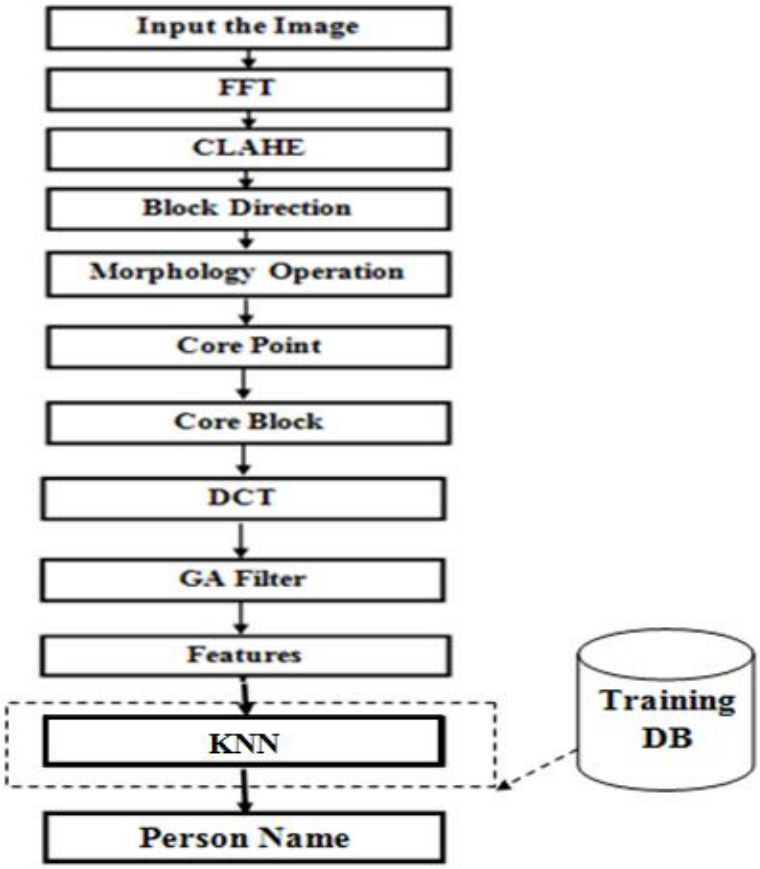


Fig. 5 Block diagram of the identification phase in proposed method.

In addition to the results mentioned, the proposed system has been tested before using genetic algorithm and the test result has reached to 89. 28% , which mean the genetic algorithm has improved results the proposed system.

IV . CONCLUSIONS

This proposed system has attempted development fingerprint identification method depending on strength Evaluations Algorithm in improve capability identification human and able to deal with the fingerprint images regardless of the device used or size of the fingerprint image .The test results has showed of 56 test image which back to the twenty-eight individual not found in training images,the proposed algorithm has gave identification rate reach to 98.21% with use 60 feature . So,genetic algorithm has helped in achieving identification system an acceptably high recognition rate.

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