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Intelligent Fingerprint Recognition System for Comprehensive Student Information Using MATlab

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Abstract*:* In this paper we propose a system that eases the whole process of taking attendance and maintaining its records in an academic institute. Managing people is a difficult task for most of the organizations, and maintaining the attendance record is an important factor in people management. When considering academic institutes, taking the attendance of students on daily basis and maintaining the records is a major task. Manually taking the attendance and maintaining it for a long time adds to the difficulty of this task as well as wastes a lot of time. Designing a better student information system so that, records be maintained with ease and accuracy in organizations. The finger print is cheaper and easy to implement compared to other biometrics technology. The biometric identification methodology that uses digital imaging technology to obtain, store, and analyze fingerprint data is used in this system. The method Used for fingerprint identification technology is minutiae feature extraction using back propagation algorithm. To handle large finger print database Artificial Neural Network (ANN) is used.

Keywords – Artificial Neural Network (ANN), Region of Interest (ROI)

1. INTRODUCTION

Every organization whether it be an educational institution or business organization, it has to maintain a proper record of students or employees for effective functioning of an institute or an organization. Designing a better student information management system for students, so that records can be maintained with ease and accuracy is an important key. Our project **"Intelligent fingerprint recognition system for comprehensive student information using MATlab"** is a dispensable part of any education system. Students have to know much information like their attendance, internal marks and their examination external results frequently. Students have to collect this information, either from respective department in charge of designated office bearer. This regular process can be better managed with sophisticated technologies like student information management system.

Biometric Identification systems are widely used for unique identification of humans mainly for verification and identification. Biometrics is used as a form of identity access management and access control. There are many types of biometric systems like fingerprint recognition, face recognition, voice recognition, iris recognition, palm recognition etc. In our project, we used finger print recognition system. Fingerprint Identification (Sometimes referred to as dactyloscopy) is the process of comparing questioned and known friction skin ridge impression from fingers or palms to determine if the impressions are from the same finger. The flexibility of friction ridge skin means that no two fingerprints are ever exactly alike, even two impressions recorded immediately after each other. Fingerprint identification occurs when an expert determines that two friction ridge impressions originated from the same finger to the exclusion of all others.

Mar Mar Min and Yadana Thein [1] have proposed a method combines both the features extraction by applying a statistical and geometry approach. The core point (CP) of the input fingerprint is detected. Keeping the CP in the centre, the image of size w x w is cropped portion of the image. A fingerprint image is pre-processed for minutiae and core point. The core point is used to align the input image and template image. Based on the align fingerprint image, fingerprint features such as minutiae points determination, their coordinates location, distance between base point and above minutiae points and radius of arcs for each ridge pattern. Lin Hong, Yifei Wan and Anil Jain [2] has presented a fast fingerprint enhancement algorithm ,which can adaptively improve the clarity of ridge and furrow structures of input fingerprint images based on the estimated local ridge orientation and frequency. A critical step in automatic fingerprint matching is to automatically and reliably extract minutiae from the input fingerprint images. However, a performance of a minutiae extraction algorithm relies heavily on the quality of the fingerprint images. In order to ensure that the performance of an automatic fingerprint identification or verification system to be robust with respect to the quality of fingerprint images, it is essential to incorporate fingerprint enhancement algorithm in the minutiae extraction module. Erin Hastings [3] has conducted a general survey of common thinning algorithms. It is written as an introduction to the topic for readers with little or no prior knowledge of thinning processes. Thinning is the process of reducing an object in a digital image to the minimum size necessary for machine recognition of that object. After thinning, analysis on the reduced size image can be performed. Thinning is essentially a “pre-processing” step used in many image analysis techniques. Nalini.K.Ratha, K. Karu, S. Chen, and A.K. Jain [4] has proposed a method of indexing large fingerprint image databases is presented. The approach integrates a number of domain-specific high level features such as pattern class and ridge density at higher level of the search at the lowest level; it incorporates structural feature-based matching for indexing the databases. Hence, successful in achieving reduced search space by a multilevel indexing approach. Rishabh Mishra and Prashant Trivedi [5] Designing a better attendance management system for students so that records be maintained with ease and accuracy This would improve accuracy of attendance records because it will remove all the hassles of roll calling and will save valuable time of the students as well as teachers. Image processing and fingerprint recognition are very advanced today in terms of technology. Still there is a scope to reduce the matching error rates. Robert Hastings [6] developed a method for enhancing ridge pattern by using a process of oriented diffusion adaption of anistropic diffusion to smooth the image in the direction parallel to the ridge flow. The image intensity varies smoothly as one traverse along the ridges or valleys by removing most of the small irregularities and breaks but with the identity of the individual ridges and valleys preserved. Jinwei Gu,et al.,[7] proposed a method for fingerprint verification which includes both minutiae and model based orientation field is used. It gives robust discrimatory information other than minutiae points. Fingerprint matching is done by combining the decisions of the matchers based on the orientation field and minutiae. V.Vijaya Kumari and N.Suriyanarayana [8] proposed a method for performance measure of local operators in fingerprint by detecting the edges of fingerprint images using five local operators namely Sobel, Roberts, Perwitt, Canny and LoG. The edge detected image is further segmented to extract individual segments from the image. Eric P. Kukula, et al., [9] proposed a method to investigate the effect of five different force levels of on fingerprint matching performance, image quality scores and minutiae count between optical and capacitance fingerprint sensors. Luping Ji and Zhang Yi [10] proposed a method for estimating four direction orientation fields by considering four steps, i)pre-processing fingerprint image ii)determining the primary ridge of fingerprint block using neuron pulse coupled neural network iii)estimating block direction by projective distance variance of a ridge, instead of a full block iv)correcting the estimated orientation field.

2. PROPOSED METHOD

Manual attendance taking and report generation has its own limitations. It is well enough for 30-60 students but when it comes to taking attendance of students large in number, it is difficult. For taking attendance for a lecture, a conference, etc. roll calling and manual attendance system is a failure. Time wastes over responses of students, waste of paper etc. are the disadvantages of manual attendance system. Moreover, the attendance report is also not generated on time. To overcome these non-optimal situations, it is necessary that we should use an Intelligent Fingerprint Recognition System for Comprehensive student Information Using MATLAB. So we present an implementable attendance management framework.

This part explains how students and teachers will use this attendance management system.

Following points will make sure that attendance is marked correctly, without any problem:

- All the hardware will be inside classroom. So outside interference will be absent.
- To remove unauthorized access and unwanted attempt to corrupt the hardware by students, all the hardware except fingerprint scanner could be put inside a small cabin. As an alternate solution, we can install CCTV cameras to prevent unprivileged activities.
- Collection of bio-data and fingerprint images of individual student is done during admission process.
- Feature set of fingerprint images are extracted and stored in the database as a template.
- These feature sets are trained using Artificial Neural Network (ANN).
- During regular attendance updation features of student’s fingerprint image are extracted and compared with the trained set of features.
- Subject attendance will be updated if the fingerprint is matched.

- Students can enquire their Marks and Attendance reports.
- Faculty can access the list of students acquiring shortage of attendance.

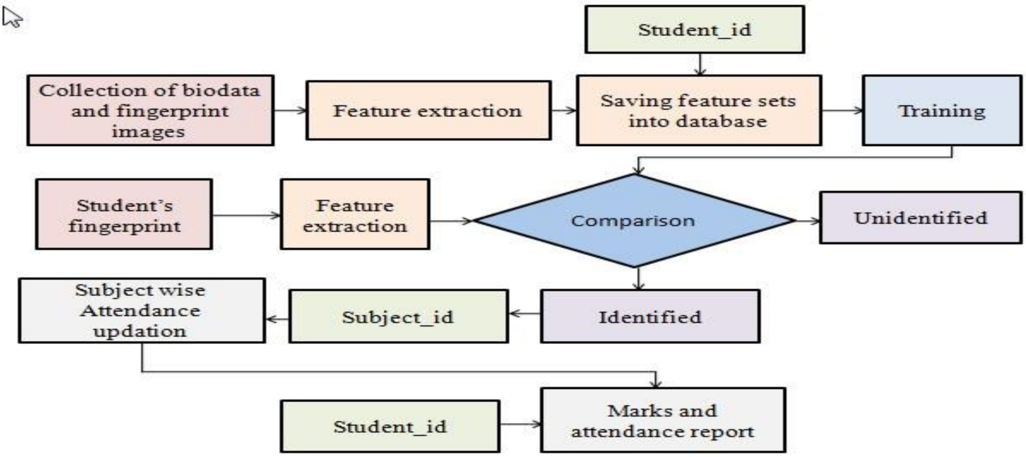
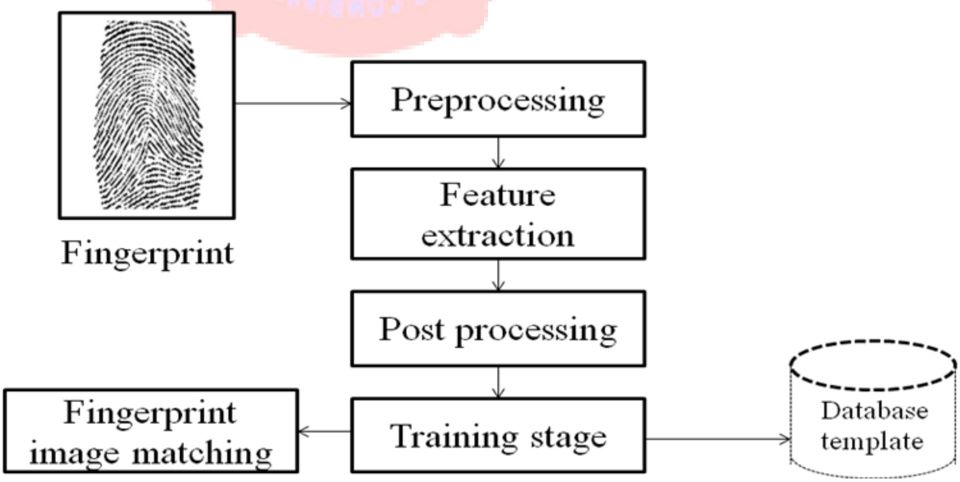


Fig. 1 Block diagram of proposed system



3. METHODOLOGY

Fig. 2 Illustrates the layout of proposed system based on fingerprint

The proposed system as shown in figure consists of following steps: pre-processing, feature extraction, post processing and neural network. The first step is pre-processing, in this step Histogram Equalization and Image Binarization are done to improve the image quality, removes noise from the image may be corrupted during the fingerprint image capture. Later block direction is estimated and region of interest is extracted. The second step is extracting minutiae, that is, feature extraction. In this step the fingerprint ridges are thinned and minutiae are marked. In the last step the extracted feature, fed forward back propagation neural network and training the neural network, the adjusted weight is used to identify fingerprint image. The proposed method reduces almost noise of fingerprint images. It also reduces time complexity of fingerprint image enhancement process. It is capable of handling large fingerprint database by using neural network. We can get the result of the fingerprint matching very fast. The system correctly matches the fingerprint image. It is an efficient method of fingerprint verification system by minutiae extraction using artificial neural network. In Fingerprint Image Enhancement Histogram Equalization is the first step. This is mainly done to improve the image quality and to make it clearer for further operations. Often fingerprint images from various sources lack sufficient contrast and clarity. Hence image enhancement is necessary and a major challenge in all fingerprint techniques to improve the accuracy of matching. It increases the contrast between ridges and furrows and connects some of the false broken points of ridges due to insufficient amount of ink or poor quality of sensor input.

3.1 Pre-Processing

In pre-processing four operations are performed: Histogram Equalization, Image Binarization, Block direction estimation and ROI extraction is performed.

3.1.1 Histogram equalization:

It is a technique of improving the global contrast of an image by adjusting the intensity distribution on a histogram. This allows areas of lower local contrast to gain a higher contrast without affecting the global contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values.

3.1.2 *Image Binarization*:

It is a process which transforms the 8-bit Gray image to a 1-bit image with 0-value for ridges and 1-value for furrows. After the operation, ridges in the fingerprint are highlighted with black color while furrows are white. A locally adaptive binarization method is performed to binarise the fingerprint image. In this method image is divided into blocks of 16 x 16 pixels. A pixel value is then set to 1, if its value is larger than the mean intensity value of the current block to which the pixel belongs.

3.1.3 Block Direction Estimation:

In block direction estimation**,** the fingerprint image is divided into blocks of size 16 x 16 pixels (W x W) after which the block direction of each block is calculated according to the algorithm:

- Calculate the gradient values along x-direction (g_x) and y-direction (g_y) for each pixel of the block. Two Sobel filters are used to fulfill the task.

- For each block, use following formula to get the LEAST SQUARE APPROXIMATION of the block direction

The formula is easy to understand by regarding gradient values along x-direction and y-direction as cosine value and sine value. So the tangent value of the block direction is estimated nearly the same as the way illustrated by the following formula.

$$\tan 2\theta = \frac{2 \sin \theta \cos\theta}{\cos^2\theta - \sin^2\theta}$$

After finished with the estimation of each block direction, those blocks without significant information on ridges and furrows are discarded based on the following formulas:

$$E = \frac{2(g_x * g_y) + (g_x{}^2 - g_y{}^2)}{W * W * (g_x{}^2 + g_y{}^2)}$$

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

3.1.4 ROI Extraction:

It is done using two Morphological operations called OPEN and CLOSE. The original image area is shown in figure. The 'CLOSE' operation can shrink images and eliminate small cavities (Figure 4.7). The 'OPEN' operation can expand images and remove peaks introduced by background noise (Figure 4.8).

3.2 Feature Extraction

$$\tan 2\beta = \frac{2(g_x * g_y)}{(g_x{}^2 - g_y{}^2)}$$

for all the pixels in each block.

In feature extraction two operations are performed: Ridge Thinning and Minutiae Marking.

3.2.1 Ridge Thinning:

In this process we eliminate the redundant pixels of ridges till the ridges are just one pixel wide. The thinned image is then filtered, again using MATlab's three morphological functions to remove some H breaks, isolated points and spikes

3.2.2 Minutiae Marking:

After the fingerprint ridge thinning, marking minutiae points is relatively easy. The concept of Crossing Number (CN) is widely used for extracting the minutiae. In general, for each 3x3 window, if the central pixel is 1 and has exactly 3 one-value neighbors, then the central pixel is a ridge branch or ridge bifurcation (Figure 4.12). If the central pixel is 1 and has only 1 one-value neighbor, then the central pixel is a ridge ending or ridge termination(Figure 4.13) i.e., Cn(P) == 1 it's a ridge end and if Cn(P) == 3 it's a ridge bifurcation point, for a pixel P.

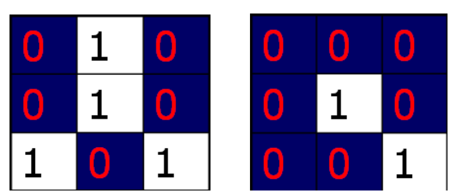


Fig. 3 Ridge Bifurcation and Ridge Termination

3.3 Minutiae Post Processing

3.3.1 False Minutiae Removal:

The preprocessing stage does not totally heal the fingerprint image. For example, At this stage false ridge breaks due to insufficient amount of ink & ridge cross connections due to over inking are not totally eliminated. Also some of the earlier methods introduce some spurious minutia points in the image. So to keep the recognition system consistent these false minutiae need to be removed.

Here we first calculate the inter ridge distance D which is the average distance between two neighbouring ridges.

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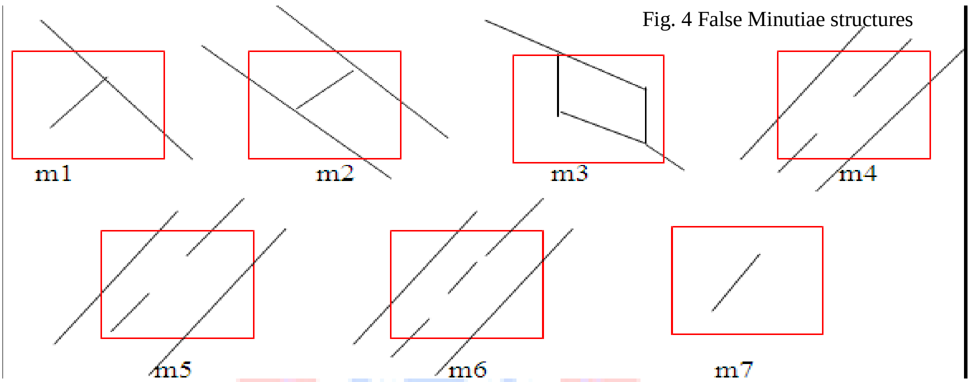

Fig. 4 False Minutiae structures

For this scan each row to calculate the inter ridge distance using the formula:

$$Inter\ ridge\ distance = \frac{sum\ all\ pixels\ with\ value\ 1}{row\ length}$$

Fig. 3 Ridge Bifurcation and Ridge Termination

Finally an averaged value over all rows gives D.

m1 is a spike piercing into a valley. In the m2 case a spike falsely connects two ridges. m3 has two near bifurcations located in the same ridge. The two ridge broken points in the m4 case have nearly the same orientation and a short distance. m5 is alike the m4 case with the exception that one part of the broken ridge is so short that another termination is generated. m6 extends the m4 case but with extra property that a third ridge is found in the middle of the two parts of the broken ridge. m7 has only one short ridge found in the threshold window.

3.3.2 Minutiae Representation:

Finally after extracting valid minutia points from the fingerprint they need to be stored in some form of representation common for both ridge ending and bifurcation.

Actually a bifurcation can be broken down to three terminations each having their own x-y coordinates (pixel adjacent to the bifurcating pixel), orientation and an associated ridge. The orientation of each termination (t_x t_y) is estimated by following method. Track a ridge segment whose starting point is the termination and length D. Sum up all x-co-ordinates of points in the ridge segment.

Divide above summation with D to get s_x, Then get s_y using the same way.

Get the direction from:

$$tan^{-1} \frac{s_y - t_y}{s_x - t_x}$$

3.3.3 Unify Termination and Bifurcations:

Since various data acquisition conditions such as impression pressure can easily change one type of minutiae into the other, most researchers adopt the unification representation for both termination and bifurcation. So each minutia is completely characterized by the following parameters:

- X-coordinate.
- Y- Coordinate.
- Orientation

3.4 Fingerprint Image Matching

From the above process we get feature matrix of each fingerprint image. These feature matrixes are used as input data set of neural network. We fixed target output based on average feature value of fingerprint image. After that we train the network for each fingerprint image. A program should be developed to train the neural network for fingerprint identification system, which takes the input data from the input file and reduce the error between the accepted output and the actual output. When the error will generate the weight file, and we will get the accepted output for our fingerprint identification system then training process will be stop. The training process will generate the weight file, which contains the weights of the neurons of network. After the completion of the training process, we will get the weights of the neurons for the neural network that will be save in the weight file. The weight file will need for testing the fingerprint identification system. Then we simulate the network with the sample of fingerprint image and got a desired output. Error is calculated from the distance between target and desired output value. Then the weights are adjusted to reduce this error. In the multi –layer networks, there are many weights concerning each input to an output, and each of these weights contributes to more than the output. The back- propagation algorithm is sensible approach to dividing the contribution of each weight. As in the network-training algorithm, it tries to minimize the error between each target output and the actual computed by network. The size of the training vector sets was expanded from its initial position. The minutiae positions used to make up the training and testing sets were randomly separated to test the generalization properties of these back propagation networks. Training was performed with a variety of sub-sampling strategies. The generalization properties of these networks were then tested by applying the testing data sets. Finally selected high performance networks were fully tested by convolving them with the entire image.

3.5 Training using ANN

An artificial neural network (ANN), usually called neural network (NN), is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. Modern neural networks are non-linear statistical data modelling tools. They are usually used to model complex relationships between inputs and outputs or to find patterns in data. An artificial neural network (ANN) is an information processing paradigm that is inspired by the way biological nervous system such as brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a larger number of highly interconnected processing elements working in unison to solve the specific problems. ANNs, like people, learn the example. An ANN is configured for a specific application, such as pattern recognition or the data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic

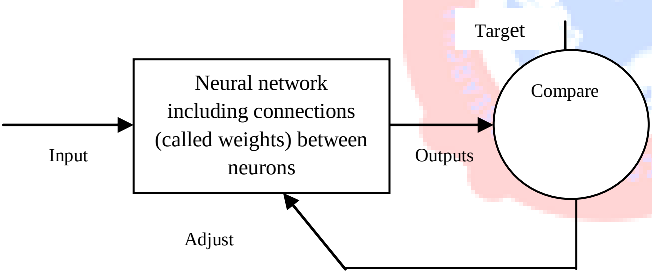

Fig. 5 Typical Neural Network

connections that exist between the neurons. This is the true of ANNs as well.

Typically, neural networks are adjusted, or trained, so that a particular input leads to a specific target output. The next figure 5 illustrates such a situation. There, the network is adjusted, based on a comparison of the output and the target, until the output matches the target

4. ESULTS

Minutiae points from fingerprints have been extracted. Four minutiae features using MORPHOLOGICAL operations are extracted. Then thinning algorithm is applied to eliminate redundant pixels. In post processing step false minutiae are removed and unifying minutiae features. Above process are helpful to recognize a fingerprint image most accurately. The proposed approach is much efficient and can extract the real minutiae features in much better way. The proposed method takes less time and detects very few false minutiae.

Input of back propagation neural network for training is provided from extracted features. This is called feature matrix. During the training period the number of neuron for same image has been increased and got less error. It also reduced time for a successful matching. Then we verify or simulate a fingerprint image in the trained network. Extracted feature of this fingerprint image then verify with stored and trained weight and threshold values. A fingerprint image is recognized based on less difference between the value of target output and desired output.

5. C ONCLUSION

The system successfully took the attendance and updated. The prototype successfully captured new fingerprints to be stored in the database; scanned fingerprints placed on the device sensor and compared them against those stored in the database successfully. The performance of the system was acceptable and would be considered for full implementation especially because of its short execution time and reports generation.

Hence, finger scanning biometrics can provide an ideal solution for college administrators in their effort to identify and track students, provide accurate and auditable student records and provide safer and more secure environment for students, lecturers and staff .This student information management system is very helpful in saving Valuable time of student, lecturers and staff and generating report at required time

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