# Development of a novel biometric authentication & identification of a finger print based attendance system using adaptive digital image processing (DIP) techniques

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**Abstract:** This work presents an finger print based attendance system as a Biometric Identification means, which was tested using a database of gray scale eye images in .bmp format. Firstly, a basic type of LED scanner was used to capture fingerprint images. The images obtained are in gray scale. For a new employee the fingerprint is captured and is converted into integer format and is then encrypted using simple encryption technique and stored in the database. Three fixed points are considered on the image and template of size 15*15 starting from each of these 3 points is stored in the database. Now, when a live fingerprint is scanned, it is converted into integer in similar fashion. The templates stored in the database are scanned on the input fingerprint and the system tries to match. The points, which give the best match, are considered. In this way, we get 3 patches and 3 points. Now, the relative distance and angles between each of the point for both the images are calculated. Their difference is calculated and a decision is made to determine if there is a match or not depending on a threshold error value. Once a match is found, a signal is sent to the micro-controller, which indicates the match by glowing an LED for a short period of time (say 1 sec). At the same time the micro-controller accesses the real time clock to extract the exact date and time of the entry and exit of the employee. This is stored in its EPROM. This work aims to give a new dimension to fingerprint-based attendance systems by incorporating the feature of storing and extracting the exact time of the identification, entry and exit of employees.

**Keywords:** Biometric identification, Image processing.

## 1. Introductory Remarks

Bio-metrics is automatad methodology of recognising a human being based on unique physiological or behavioral characteristics. Physiological characteristics include features such as fingerprint patterns and iris patterns. Behavioral characteristics include handwriting, speech, etc.,. Over the last few years, biometric technologies have emerged as the most reliable and secure authentication technologies the world over. They achieve performance figures hitherto unparalleled by any other approach to security and authentication, making them suitable for use in high security and identifications applications.

As a result, biometrics has gained extensive application in various areas, including:

- Airport security
- Enterprise-wide network security infrastructures
- Secure electronic banking, investing, and other financial transactions
- Law enforcement and similar security-focused applications

Whether used in isolation or in combination with other technologies like smart cards, encryption keys, and digital signatures, biometrics is poised to become a significant part of both the economy and our everyday lives..

## 2. Attendance Systems

Many manual and automated attendance systems are being used in different organization as per their needs and budget. Any attendance system used should have following characteristics :

- The system used should be reliable one, which does not fail to recognize a valid employee and reject a invalid entry. Hence accuracy is major concern.
- It should be speedy in the identification process. Being an attendance system we cannot afford to have an identification system, which take lot of time in identifying. Hence speed is another major concern.
- There should some reliable source, which can give the correct time of entry, and exit of the employee, which can be late, used to calculate the number hour worked.
- Also the information of time and date should be preserved in a secure place so that any unauthorized person cannot tamper it.

### 2.1 Problem formulation

Majority of the Biometric identification systems are plagued by high costs (computational and economic) and expensive hardware. They are very complex to implement and hence do not give the best of speeds which is much required in our attendance system. Hence, there is a need to design a user-friendly, simple, and cost effective, accurate and a fast system. Also there are no such manual attendance systems, which would give us the exact time of entry and exit of the employee. In attendance systems using signatures where in a manual record is maintained the exact time of entry and exit can always be manipulated.

The exact time of entry and exit should be made available so that the number of hours worked could be calculated and it has to be protected so that no one tampers it. Hence the main problem is to obtain a cost effective, reliable, foolproof, simple attendance based system, which can be easily maintained. Also which will make all the calculations simple giving the exact time of entry and exit, thus, giving a very sophisticated and new approach to attendance systems.

### 2.2 Solutions

The work being finger print based attendance system promises to be much simpler than any other biometric identification systems. Also, there are many approaches possible for matching fingerprint. We will be choosing the one that satisfies all the requirements of our attendance system i.e., speed as accuracy. The work also includes interfacing the real time clock with micro-controller 8051. The micro-controller will read the correct time of entry and exit of the employee and which will be used to find the number of working hours of the employee. Also, the time and date will be stored by micro-controller in it's EPROM, hence will safe & protected against any tampering.

How our designed and implemented biometric system works - The various steps involved in working of any biometric system are :

### 2.3 Collection

Every biometric system utilizes a collection mechanism, which may involve a reader or sensor where an individual places their finger or hand, a camera that captures their face or eye, or software that records the rhythm and speed of their typing..

### 2.4 Extraction

Biometric systems selectively extract particular features of the biometric, and the choice of which features depends on the biometric type and the design of the specific system. The extracted data, often referred to as "raw data," is transformed into a mathematical code, which is stored as a "sample" or "template." It is essential for all biometric systems to generate and preserve a template of the biometric for the purpose of recognizing or verifying the individual.

### 2.5 Comparison and matching

The obtained data is transformed into a mathematical code using the identical procedure applied when generating the template. In a one-to-many match scenario, the newly generated code from the live scan is compared to a central database containing various templates. In a one-to-one match scenario, it's compared to a single stored template. The system deems the match valid if the code falls within a specific statistical range of values..

## 3. Different types of identification systems used in our design

Different types of identification systems used in the design are as follows**:**

**Face Detections**

Detecting human faces is a crucial initial step in various applications like video surveillance, human-computer interfaces, face recognition, and image database management. One approach involves identifying skin regions across the entire image and then deriving potential face areas by analyzing the spatial distribution of these skin patches. However, the face of the human being could get distorted or a surgery could change the facial appearance of the human, which could lead to mismatching of the face of the human and the one stored.

**Signature Verifications**

Here, we present an approach for verifying handwritten signatures. We capture these signatures using a digitizing tablet, allowing us to capture both the dynamic and spatial aspects of the writing. Once the signature undergoes preprocessing, we extract various features from it. To determine the authenticity of a writer, we compare the input signature to a reference set (template) that contains three stored signatures..

**Hand Geometry**

This method relies on the geometric characteristics of the hand to verify a user's identity. The authentication of identity based on hand geometry presents an intriguing challenge. Individual hand features alone may not provide sufficient information for accurate identification..

**Iris recognition**

Iris recognition is a sophisticated technology that combines computer vision, pattern recognition, statistics, and human-machine interaction. The iris, being a unique and stable internal organ, can act as a living password that individuals don't need to remember but always have with them. Despite its high accuracy, implementing identification systems based on iris recognition can be quite complex..

**Speech recognition**

The key physiological element in the human speech production process is the shape of the vocal tract. The vocal tract, typically seen as the organ responsible for speech production above the vocal folds, alters the acoustic wave's spectral qualities as it traverses through it, resulting in speech. Consequently, many speaker verification systems focus solely on features originating from the vocal tract. To represent the vocal tract's characteristics, the human speech production process is modeled as a discrete-time system.

**Finger Print Verification**

Fingerprint verification is one of the earliest biometric technologies in use. It relies on the distinctiveness of a person's fingerprints, making it highly reliable. The process involves capturing a fingerprint by placing a finger on a high-resolution CCD (charge-coupled device) camera. These prints are then enlarged and compared to a database of fingerprints. When there's a successful match, it's referred to as a 'hit,' while a non-match is called a 'miss.' Fingerprint classification, based on patterns like whorls, arcs, and loops, helps expedite the matching process. Thus, the basic requirement for any identification system is that should remain unique to every person. Finger print recognition is surely a strong candidate an attendance system as shown in Figure 1.

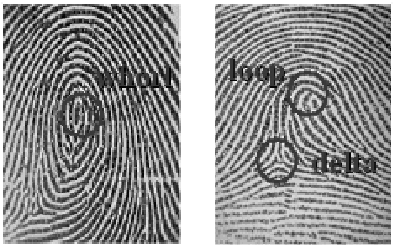



**Fig. 1:** Finger print identification

## 4. Processing and matching of fingerprints

The processing and the matching of fingerprints is done according to the following steps.

### Fingerprint acquisition

One of the oldest and most well-known fingerprint acquisition techniques is the "ink technique," which involves pressing the finger onto a card covered in ink. This method is still widely used by law enforcement agencies in Automated Fingerprint Identification Systems (AFIS). These inked cards are then digitized using scanners similar to those used for regular paper documents, typically at a default resolution of 500 dpi. However, this technique can produce images with missing information due to excessive ink or ink deficiency and is primarily suitable for forensic applications. With several fingerprint scanners now available in the biometric market, it can be challenging for non-experts to understand the technological differences and the factors that determine scanner quality and performance. Some of the technical parameters to consider when selecting a scanner include :

### Resolution

It is the number of pixel per inch (dpi) characterizing the acquired images. Intuitively, the resolution indicates the magnification or zoom factor of the scanner. A 500 dpi resolution is required by FBI-compliant systems. 250-300 dpi is probably the minimum resolution, which allows minutiae to be detected in the fingerprint pattern.

### Size

One of the key technical features to consider is the size of the scanner's sensing area, as this factor dictates the portion of the fingerprint that the scanner can capture. Typically, this parameter varies from approximately 1.0 x 1.0 square inches in professional models to around 0.42" x 0.42" in low-profile models. In addition to resolution and sensing area size, the quality of images produced by a fingerprint scanner is influenced by other factors that impact their clarity, contrast, and geometric accuracy.

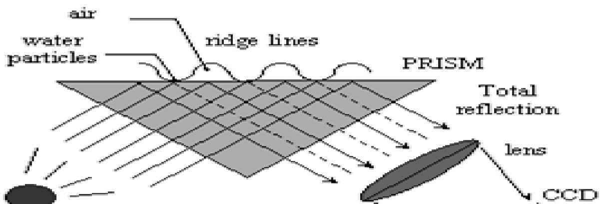



**Fig. 2:** Total reflection

A need to enhance the quality of the fingerprint is obtained by applying procedures like normalization and filtration as shown in Figure 2. These are enhancement technique. Enhancement has to be carried out because the image of the fingerprint obtained could be poor because of dust, water, and moisture.

### Normalization

The objective of this stage is to reduce the gray scale between the ridges and valleys of the image. The input mage is normalized (reduced) to the desired size so as to remove any unnecessary features of the raw image and the normalized image.

### Filtration

Once the fingerprints are normalized they may still be of poor quality because of presence of noise pixels. These noise pixel could be any type of noise (e.g., salt and pepper noise). Before sending the image for matching the effect of noise has to be removed. If not it will effect the results and hence the efficiency of the program. There are many type of filter & filtering algorithm available, for e.g., as in Figure 3.

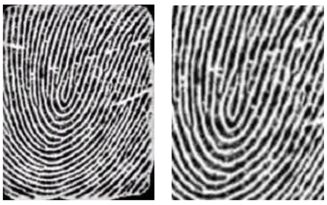


**Fig. 3:** Salt & Pepper Noise

## 5. Adaptive image filtration

This algorithm effectively removes noise, addresses ridge disruptions, and resolves trapped ridges. It reliably extracts minutiae, even from low-quality fingerprints, and accomplishes this within a processing time of approximately 0.2 to 0.4 seconds. Let u see how much filtration helps. We also have weiner filtration which works for noise removal. Gabor filters can also be used.

### 5.1 Encryption and decryption

Encryption is the use of algorithm's or keys to scramble a message or piece of data into an unreadable format. Traditionally, encryption consists of four elements: an algorithm (or method), a key, plaintext, and ciphertext. By applying the encryption method with the key, the sender can transform the plaintext message into ciphertext. The recipient, who is aware of the encryption method and has the key, can then reverse this process. Anyone intercepting the message would be unable to decode it without knowledge of the key. Another similar field is cryptography, which is the science of secret communication. These methods involved manipulating the original message such that it becomes illegible to anyone but the intended recipient.

The recipient, who is familiar with the encryption process, can reverse it and retrieve the original message. Encryption algorithms fall into two categories: symmetric and asymmetric encryption algorithms. In symmetric algorithms, both the encryption and decryption keys are the same. While symmetric encryption is fast, managing the keys can be challenging, such as securely distributing them. In asymmetric algorithms, used in systems like Public Key Infrastructure, the encryption and decryption keys come as a key pair. One key is a private key, which must be kept secret, and the other is a public key. Asymmetric methods simplify key distribution but are slower in encryption. Combining both methods is often referred to as a hybrid approach..

In the work considered, a database of the employee that stores all the information of the fingerprint is created. This information is in the form of integers. It is needed to be encrypted so as to protect its contents from any unauthorized access. Hence, basic encryption technique is used. Integers are converted into their ASCII values. Integer can be encrypted with the integer using some other mathematical formulas. But for simplicity, simple encryption technique is considered. In a similar manner, the data is decrypted when required.

### 5.2 Patch matching

The images obtained are in gray scale. For a new employee, the fingerprint is captured and is converted into integer format. This integer format is then encrypted using simple encryption technique. And hence it this encrypted data is stored in the database. 2 fixed points on the image stored in the database are taken as shown in Figure 4. Templates of 15 * 15 starting from these points are stored in the database.

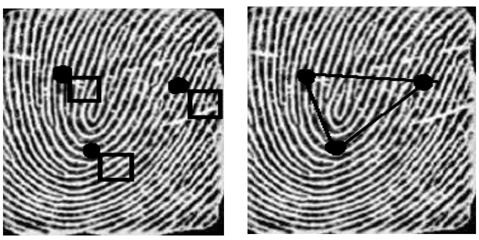
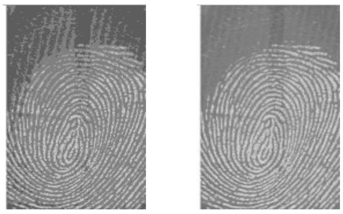


**Fig. 4:** Patch matching diagram

Now, when a live fingerprint is scanned, it is converted into integer in similar fashion. The templates stored in the database are scanned on the input fingerprint and the system tries to match. The points, which give the best match, are considered. In this way, we get 3 points and 3 patches. The three points are joined in both the images. Now the relative distance and angles between each of the point for both the images are calculated. Their difference is calculated and a decision is made to determine if there is a match or not depending on a threshold error value.
The speed of the system can be improved to a very large extent. The entire system has been implemented in C and the micro-controller and RTC have been programmed in assembly language. Instead of implementing the computationally intensive parts in C / C++, the speed of the system can be improved substantially by using MATLAB®, since the speed becomes a crucial factor in case of real-time recognition systems. By extending the system to be interfaced with sophisticated hardware devices, we could make it very user friendly. Like wise a 7-segment display could be used to display the time extracted from the real time clock to the user when he enters. Since our project in its current state of development we could not consider all the above issues.

## 6. Design of fingerprint based attendance system

The system that we intend to design involves the following steps :



Before filtering After filtering

**Fig. 5:** Filtering effect of digital images

**Acquisition of the fingerprint image**

The fingerprint image is acquired using the standard fingerprint scanner, the FIU 500. The image will be a gray image in a .bmp format. Its dimensions are 42 x 42 x 92.5 mm and its weight is 125 g. The scanner used here has a biometric sensor. The biometric sensor detects whether a finger has been placed on the FIU. Only a “live” finger will set off this sensor. This is a precautionary device to keep intruders from using synthetic fingers. The scanner has an average verification time of 0.3 seconds and a registration time of less than 1.0 second. It has a false rejection rate of less than 1.0% after two trials and a false acceptance rate of less than 0.1%. Its 9-pin female, RS-232 connector supports baud rates between 1200 and 57600 bps.

**Preprocessing**

Pre-processing is required to get the image in the form after which computations and transforms or feature extraction from the image are possible. A fixed size has to be acquired; elimination of noise and other unwanted pixels has to be done. Thus pre processing of images is a necessary step to be performed before applying any algorithms on it.

**Noise filtering**

After normalization, the first step after image acquisition is to smoothen out the image to remove the noise pixels, if any. Here, any isolated pixel, which is any pixel having no neighboring pixels will be deleted as shown in Figure 5.

**To convert the image to an integer file**

To perform any operation on an image, it is convenient to convert the image into an integer file. To do the same, we give the .bmp file as an input to the program that converts a picture to integer. In a picture file first few pixels (1078 pixels in our case) contain the HEADER information. This header information is stored in another file as integer (headeri.dat) and character (headerc.dat). After storing the header details the rest of the image is scanned. While scanning every pixel is read as a character and converted into integer. These integers are stored in a file (matrix.dat) in the form a matrix. The integer values can range either from 0 to 255 or from -128 to +127. If the value is negative then 256 is added to it to make it positive.

## 7. Algorithms for patch matching and feature extraction

### 7.1 Storage in database

For the patch-matching algorithm, any 3 random patches from the original image of the employee stored in the database are required. These patches are of the size 15 x 15 in the algorithm. Three patches will be stored in a file temp.dat which contains the x and y co-ordinates of the start point of the patch and the 225 values. The x and y values for the three patches are fixed in the algorithm. The contents of the temp file are copied to the database along with the employee number.

### 7.2 Encryption of the database

The database may not be fully secured. Someone may just change the employee information. In order to protect the database, the information is encrypted. Encryption is done by storing the ASCII value of the integer instead of the integer itself. Thus, the database file db.dat is encrypted to dbe.dat. Now, the database is protected.

### 7.3 Patch matching and feature extraction

The image obtained from the scanner is compared with all the images in the database. This comparison is done using patch matching. For every image in the encrypted database (dbe.dat), three patches are there. For every patch, the x and the y coordinates are stored. This is done by decrypting the information from the encrypted database by converting the ASCII value back to integer. This is also done for the following computations. Then the 15*15 patch is stored in an array (proc_row). Now the image to be tested is scanned vertically and every time a block of 15*128 is stored in another array (proc_row_r). Contents of proc_row are subtracted from 15*15 blocks in proc_row_r. Initially the error is some very high value which is high enough to differentiate two images completely. Every time, the positive difference is compared with the previously stored error and if the new difference is less then the previous error then it is stored as error.

This is done for all the 3 patches. Now, if the error with respect to the first patch is greater than 16000, then the other two patches are not checked for. A direct jump is taken to the next fingerprint in the database. If the error of the first patch is less than 16000, then the error for the second patch is computed. If error of the first patch and the error of the second patch together is greater than 32000, then the current fingerprint is skipped and the next fingerprint is considered for patch matching. The error limits are obtained by testing of different fingerprint images. The output obtained after patch matching is stored in a file (patch.dat). It contains the following information: the x and y co-ordinates of the original three patches of the employee, the corresponding x and y co-ordinates of the scanned image obtained by patch matching. (i.e., the relative poison of the patches in the scanned image and the error term in all the three cases.

The error term, if zero, in all the patches indicate a perfect match. The error occurs mainly because the fingerprints, while scanning, can get tilted slightly. The algorithm is robust to 10 degree tilt on either side of the centre line of the image. The groove for putting the finger on the scanner does not allow more than a 15 degree tilt on either side. Thus the proposed algorithm is quite robust to orientation. The other output of patch matching (log.dat) indicates which fingerprint(s) of the database is considered for final matching. It also gives the stage of rejection, that is, whether the rejection happened in the first patch itself or whether it happened in the second patch or the third one. When the fingerprint is rejected, it displays the error values of all the three patches.

### 7.4 Final matching

The input for the final matching is got from patch.dat which contains the fingerprint number of the employee in the database, the x and y co-ordinates of the three patches of the original image in the database. Also, the x and y co-ordinates of the three patches (of the scanned image), and the error terms for the three cases. Now, the fingerprint(s) considered for evaluation in the final matching get their respective inputs from patch.dat. Here, the three x and y co-ordinates of the patches of the original image in database are got first and stored in an array pat. The pat array contains three values (x1,y1), (x2,y2) and (x3,y3). The three points joined together form a triangle as shown in Figure 4. This is triangle 1. Three distances a, b and c are found which is the distance between the 3 points. This is done using the distance formula.

Similarly, the three x and y co-ordinates of the patches of the scanned image are taken and store it in an array patr. The patr array contains the 3 values (xr1,yr1), (xr2,yr2) and (xr3,yr3). In the same way, the distances

Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 4 (2023)

between the three points of the triangle are found out. This is triangle 2. The distances, that is, the sides are ar, br, cr. Now, the three angles of the triangle are got using the three sides of the triangle. Thus, for triangle 1, we get angles A, B, C and for triangle 2, AR, BR, CR are obtained. The angles are in radians ; hence they are converted them into degrees. Now, the difference between the corresponding angles is taken. If the positive difference of any two corresponding angles is greater than 2.1, then the image is rejected. Also, if the summation of the positive differences of the three angles is greater than 4.3, the image is rejected.

The value 4.3 is taken so that the average angle difference between the two triangles is less than 1.5 degrees. We allow a 2 degree angle difference between the images, but on testing, some images give a difference of 2.0003 which is greater than 2. So, even though there is a match, it gives a no match due to a slightly higher angle variation. Therefore, we take it as 2.1 degrees specifically.

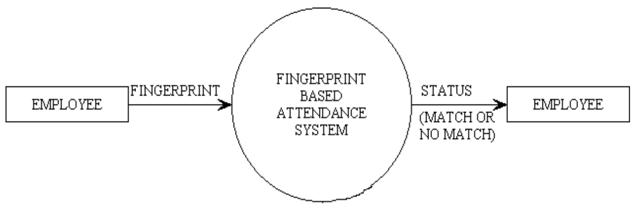
Thus, the output (match.dat) of this algorithm will be the status, which will tell us whether there is a match or no match. Next will be the fingerprint number of the employee. Then we have the three x and y co-ordinates of the original image patches (totally 6 values), and the three x and y co-ordinates of the scanned image patches (totally 6 values). It contains the error term of the angles of the two triangles.

### 7.5 Displaying the two images to show the result

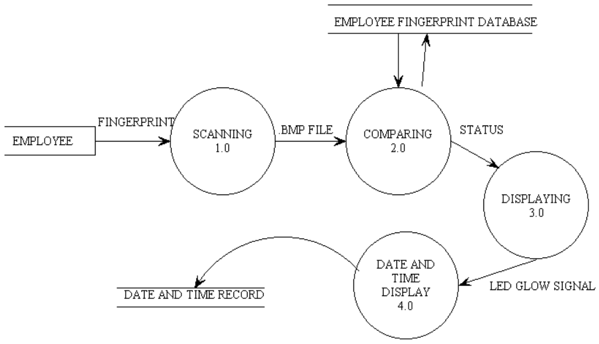
This algorithm is used to display the two fingerprints and pictorially show where the match is found and the triangle made. This gives a very clear idea of how the algorithm works. It shows us the triangle location, thus tells us where the patches matched. It displays the 2 fingerprints, so that we can clearly see if the fingerprints look the same or are of the same person or not. The input to this program is match.dat which gives us the x and y co-ordinates of both the images. It also gives us the status which tells us if there is a match or not as shown in Figure 6. It gives us the fingerprint number of the employee and the error term. The fingerprint number tells us with which employee the match is found. So the matrix.dat of that employee is got, converted back into the bmp file and displayed. (matrix.dat is that file which contains the integer values. The picture file originally converted to an integer file for easy computations is stored in matrix.dat).

Similarly, the random image is got back from its integer file. The points x and y are marked on the image at their respective locations. This is got from match.dat. Now lines are drawn connecting the x and y co-ordinates so that it forms a triangle. The status is then printed. It tells where the patches have matched, if there are any matches. Else, it gives the location where maximum match is found. The error in each angle and the total angle error is displayed. If there is no match, then error is displayed as 100%. The status can be printed with the error values (the angle differences). The final output will be seen as follows.

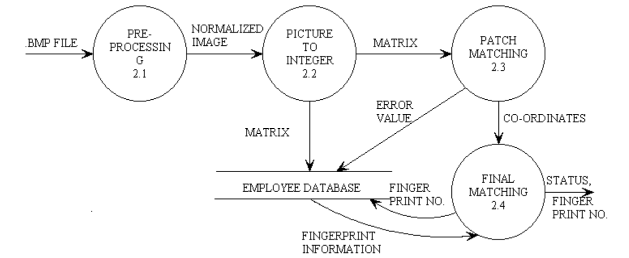
## 8. Data flow diagrams



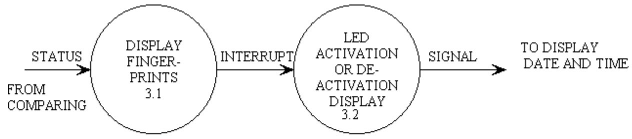

CONTEXT DIAGRAM




FIRST LEVEL DFD




SECOND LEVEL DFD




SECOND LEVEL DFD

**Fig. 6:** Data flow diagrams of identification

**Implementation**

The implementation of the Personal Identification System requires usage of filters and other algorithms, which enable the system to identify an employee quickly and correctly. For implementing this we will use software which is good at handling graphics and files. Thus, the system is implemented in C language.

## 9. Conclusions

The work undertaken in this paper has used fingerprints in attendance systems which had surely made it much more reliable, foolproof and comparatively simple to implement as compared to other biometric identification systems. It has definitely surpassed the old and manual attendance, which had some, or the other flaw. A value is added to the work by making use of the hardware devices like the micro controller and the real time clock, which keeps track of correct time and date and continues to perform for years. At the times of the match the time is extracted from the real time clock by the micro controller and is stored in its EPROM.

This surely makes it inaccessible to the employees and hence gives good security. For matching the live fingerprints with the ones stored in the database a patch-matching algorithm is used, which gives satisfactory results. The algorithm chooses 3 fixed somewhere close to the center of the normalized fingerprint or above it, hence the algorithm will still work if the employee places just the half of his finger on the scanner screen. However, future enhancements are always possible. Firstly, the number points that are taken on any fingerprint can be increased from 3 to 5 or more. This has to be done when the number of employees increases. The work undertaken considers a small database of about 20 to 30 people. Hence if the organization expands to increase the accuracy of the system we will increase the number of points and hence the number of patches. This will surely increase the efficiency. Classification of fingerprints can also be carried out if the database is too large to reduce the search time and hence to speed up the procedure. Several image enhancement techniques can be used if the quality of the image is poor. Thus by making suitable modifications to the current algorithm, the work can be made more accurate speedy and more sophisticated.

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