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RESEARCH ARTICLE

CHILDREN TRACKING SYSTEM USING FINGERPRINT VERIFICATION.

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Abstract

Nowadays, parent has difficulty with keeping in touch with their children especially when they are at kindergartens or primary schools. The aim of this research is to design and implement children tracking system by using fingerprint biometrics. Then, the proposed system informs the parents in case their children are late or absent via mobile text messages. The system uses fingerprint verification (minutia extraction and minutia matching) as tool of child identifying because it is one of the most reliable personal identification methods. The proposed technique sends SMS though Hyper Text Transfer Protocol (HTTP) to the parent, in this case, Internet is required for the connection. In order to evaluate the proposed technique, an experiment is run and the result is acceptable and fruitful performance.

Introduction:-

In recent years, biometrics has become a potential authentication tool which can address the inherent weaknesses of the traditional knowledge-based (e.g., password) and possession based (e.g., key or token) recognition systems in terms of authenticating genuine users [1, 2]. There are different types of biometric systems such as physical biometric that include fingerprint, geometry of hand, iris scans etc. Behavioral Biometric that includes modalities such as speech, signature, gait, keystroke dynamics etc. And chemical Biometrics: such as DNA, odor and the chemical composition of human perspiration [1-3]. There are many benefits of using biometric systems such as: increased Security, which is an enhanced level of security to the traditional authentication methods by allowing access only to authorized users and restrict access or protect data from unauthorized users. Biometric data cannot be guessed or stolen in the same way as password or token [1, 3]. Increased Convenience that biometrics are always attached with the person and so there is nothing to forgot. It offers a greater convenience than systems based on remembering multiple passwords or on keeping possession of an authentication token [1, 3]. Increased Accountability that biometrics can be a very useful tool to secure computers and facilities and offer a high degree of certainty as to what a user has accessed in which computer at what time. Although the auditing and reporting capability of a computer system is rarely used, the presence of such system can be an effective deterrent for fraudsters [1, 3]. We use biometric nearly every day in our life like personal computers, network and some application, airports, transaction in online banking, access to secured areas of building, Handheld tokens etc.[1-3]. On the other hand, disadvantages of biometrics such as cost. Different biometric technologies need the use of different devices that have a range of costs. Also, the use of these biometric devices may cause delay in people's day. People are concerned they will have to wait in line to get scanned or fingerprint to gain access to a building or school. More disadvantages deriving from using the finger-scan are, "some users cannot be enrolled because of unreadable fingerprints, whether due to damage, age or ethnicity". Another disadvantage is the fact that people are concerned they might have to touch a device that someone else has to touch which could cause the spread of germs [3]. Going specifically, fingerprints were accepted formally as valid personal identifier in the early twentieth century

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and have since then become a de-facto authentication technique in law-enforcement agencies worldwide [2]. And finger prints are the most important part of human finger, because there is no two people have the same fingerprint in the world. So fingerprints have been using for security applications and identification for a long time [4, 7, 8]. Fingerprint classification is divided into five classes called henry classes [5] as in figure 1.

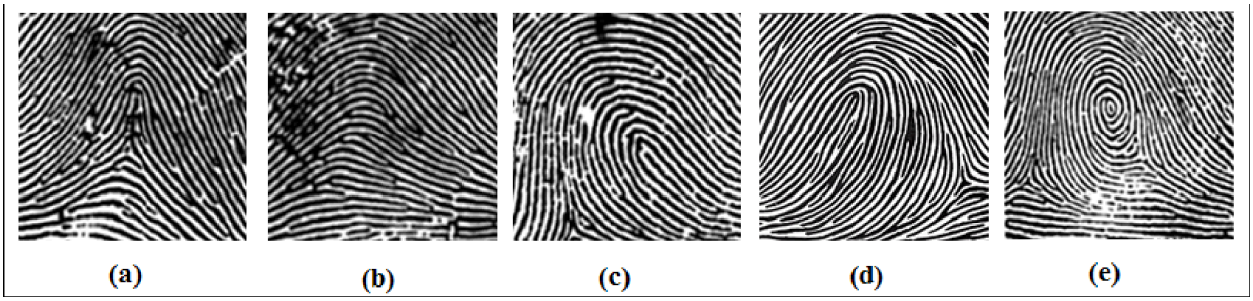

Figure 1:- Fingerprint Classes: (a) Tented Arch. (b) Arch. (c) Right Loop. (d) Left Loop. (e) Whorl.

In this paper FVC 2002 is used, which contains four different datasets. First dataset with optical technology that scanned by Identix TouchView II with image size and Res of (388×374 – 500 dpi). The second dataset also with optical technology that scanned by Biometrika FX2000 with image size and Res of 296×560 – 569 dpi. The third dataset with Capacitive Technology that scanned by Precise Biometrics with image size and Res of 100 SC 300×300 – 500 dpi. While the forth dataset with the Synthetic Technology and scanned by SfinGE v2.51 with image size and Res of 288×384 – 500 dpi [9].

Part of this research will be using TCP/IP (Transmission Control Protocol/Internet Protocol) which is a set of transport and network-layer protocols for machines to communicate with each other over the network. IP (Internet Protocol) is a network-layer protocol, deals with network addressing and routing. In an IP network, each machine is assigned a unique IP address (e.g., 165.1.2.3), and the IP software is responsible for routing a message from the source IP to the destination IP. TCP (Transmission Control Protocol) is a transport-layer protocol, responsible for establish a connection between two machines [7, 10, 11]. Also, Hypertext Transfer Protocol (HTTP) is a client-server application-level protocol. It typically runs over a TCP/IP connection. (HTTP needs not run on TCP/IP, it only presumes a reliable transport, any transport protocols that provide such guarantees can be used). HTTP is an asymmetric request-response client-server protocol [12]. An HTTP client sends a request message to an HTTP server. The server, in turn, returns a response message. In other words, HTTP is a pull protocol, the client pulls information from the server (instead of server pushes information down to the client) [13]. Recently, there are many challenges facing children protection and many cases of missing children between 6 and 17 years old are reported. Also, the parents always worry about the safety of their children. As for the mechanism of action fingerprint that occupy most of the work mechanism of the system, it contains some of the problems that are still under repair, such as low performance, false accept and false reject of the system.

This research proposes a solution to aid parents to track their children in real time. Children tracking system based on fingerprint verification, that alert the parents by SMS message phone when the child is attend and leaving the school. In this research, a new simple approach is proposed for fingerprint image enhancement that increase the performance and reduce the (False accept, False reject) percentage of the system without depending on the orientation estimation and ridge frequency. This paper is organized as follows; Section 2 is on literature review, Section 3 explains the methodology of the proposed technique with testing and analysis. Section 4 comprises results and discussions. Finally, Section 5 concludes this research with a possible future work.

Litreture Review:-

Ratha and his colleagues in 1996, they produced a new method for structural feature based indexing into a large database of fingerprint images, by using different kinds of image quality in the input stage and used NIST dataset for testing also they recommendedthis technique can be used in other similar types of images like fluid flow and lumber images. They used parallel elastic matching algorithm that exploiting the specific characteristics of splash2 architecture that consist of an array of Xilinx 4010 FPGAs, this algorithm based on finding the number of paired minutiae between each database fingerprint and query fingerprint [14]. While Maio and Maltoni in 1997 [15] proposed a direct gray-scale minutiae extraction technique, whose basic idea is to track the ridge lines in the gray-

scale image, by "sailing" according to the local orientation of the ridge pattern. The ridge line extraction algorithm attempts to locate, at each step, a local maximum relative to a section orthogonal to the ridge direction. By connecting the consecutive maxima, a polygonal approximation of the ridge line can be obtained. Hong in 1998 [16], Maltoni, D. in 2005 [17], Nain, N. in 2008 [18] and Babatunde with his colleagues in 2012 [19]. They try to find algorithms for reducing the feature extraction errors that occur in the matching stage (false match) and (false non-match) by trying different techniques on the preprocessing stage to reduce the distortion and increase the performance of the matching stage. Greenberg, et al, . (2000) [20], they propose two methods for enhance the fingerprint image, in the first method they used local histogram equalization to enhance the contrast, wiener filtering for noise reduction and image binarization, the main idea of this algorithm was to eliminate the noise that appear in the thinned binary image, which is: false ridge line connections, and gaps within a true ridge line. While in the second method for the direct gray scale enhancement they tried two algorithms the first one based on Gabor filter, the main idea of this algorithm is to remove the noise from the image and connect the broken ridges. While the second algorithm was based on a unique anisotropic filter that used for the noise reduction, the main idea of this algorithm was to allow the kernel of an image to be shaped or scaled depending on the local features neighborhood. And they did a comparison of binrization based methods and they report the average error percentage with four different schemes based on binrization and thinning. They also did a comparison of direct gray scale methods. After these comparisons they found that the techniques that based on direct scale enhancement perform better than approaches which require binrization and thinning as intermediate steps in term of average error percentage and performance. While in 2001 Kim and colleagues suggested algorithm for removing false minutiae in the post processing stage by detecting all the false minutiae structures based on the orientation and flow of ridges as well as the distance and connectivity between the ridges [21]. In 2003 Thai, R. write a research for the preprocessing stage in fingerprint image enhancement he worked on the following steps: normalization, orientation estimation, ridge frequency estimation, Gabor filter, segmentation, binarization, and thinning. For the post-processing stage in the minutiae extraction used theCrossing Number (CN), and then removed the false minutiae. He used synthetic test images technique to provide performance, and used of real images relay technique to provide more realistic and quality [22]. While Afsar and others in 2004, they try another step to enhance the image: segmentation, orientation estimation, ridge frequency, and thinning. However, in the post-processing stage they used the (CN) to extract the minutiae and next removing the false minutiae, the testing of the related work was on FVC 2000 dataset [23]. On other hand, Zhao in 2007 used the valley of the fingerprint image instead of the ridge to extract the minutiae using (CN), And they produced some post-processing steps to eliminate the false minutiae [24]. Both Kaur in 2008 [6] and Om Sri in 2011 [4] try different steps for preprocessing, minutiae extraction and post-processing stages; histogram equalization, Fast Fourier Transform (FFT), Binarization, ridge direction, Region of Interest (ROI), thinning, removing H-break and spur also extract the minutiae using (CN). As well as they used the (OPEN and CLOSE) morphological operation to enhance the fingerprint image. In the study of Rajanna and others in 2010, they compared between four different methods of feature extraction in fingerprint image: Orientation map, Gabor feature maps with two new methods based on (minutiae map and orientation collinearity), they did the comparison by using NIST-4 dataset also checked the problem of improving classification performance by using "rank-level fusion" algorithm. The main goal of this study was to get the best methods that improve accuracy and time with lower cost. They result indicate that Oms have the best performance, both in terms of accuracy and time. Gabor features fell behind Oms in terms of classification accuracy due to their sensitivity to localization errors of the core point [5]. While Noor, A. developed a new novel algorithm in 2012 for extract the minutiae without depending on the core detection and the orientation of the minutiae points. Matching methodology was based on the local features of each minutiae point like the distances to its nearest neighbors and their internal angle [1]. Both A. Al-Mazloum and others in (2013) [25] and Rohit N. Bhoi and colleges in (2015) [26] developed a system to aim locating missing or lost children using mobile smart phone. They developed the system by taking the advantages of smart phone Android mobiles. The system is consisting of two main components: GPS satellite and GSM telephony services. It also consists of two sides: the parent mobile side which act as server, that use SMS for communicating with the child and maps to view the location of the child on a map. Second the child mobile side which act as a client for the system, it's also communicate with parent mobile by SMS and GPS. The system required internet connection for both parent and child mobile. In this way the parent will know the location of the child and can communicate with him.

Methodology:-

The research is to develop and design child tracing system based on fingerprint verification, as a design and implementation stage figure 2 the system starts with the biometric that read the fingerprint image then the image will

go to an extraction stage which is the training stage to extract the minutiae, then save the template of the fingerprint image and gave it id. When the student wants to arrive to the school or went, the system will check the fingerprint of the student if it available in the database the message will send else he must try again as shown in figure 2.

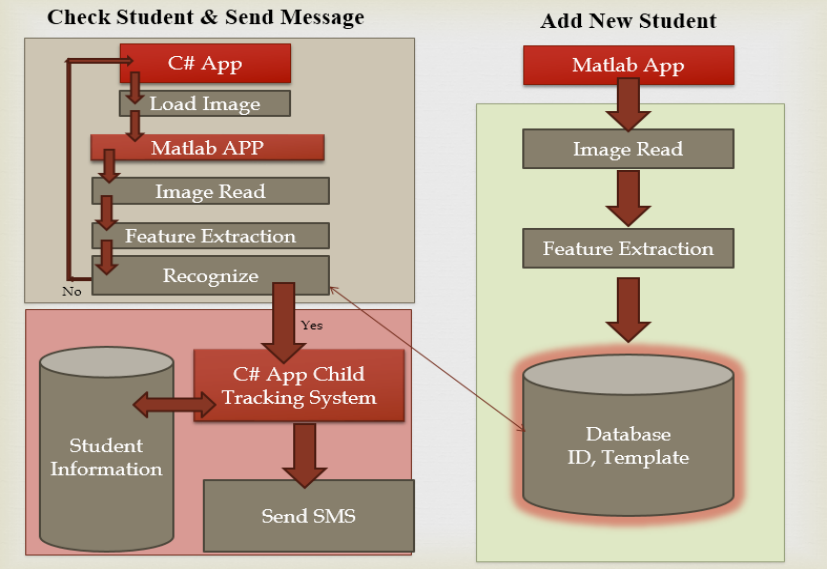

Figure 2:- System Design and Implementation.

Preprocessing and Feature Extraction:-

For fingerprint acquisition, optical or semi-conduct sensors are widely used. They have high efficiency and acceptable accuracy except for some cases that the user's finger is too dirty or dry. However, the testing database for my project consists of scanned fingerprints using the database of FVC (2002) because this database introduces a high level of noise and broken ridges to the image and the goal of designing a recognition system is to work with the worst conditions to get the best results. To implement a minutia extractor, a three-stage approach is widely used by researchers. They are preprocessing, minutia extraction and postprocessing stage [24]. For the preprocessing stage, the proposed operations are as follows: Histogram Equalization, Average Filter, Median Filter, Local Normalization, Segmentation, Binrization and Thinning. For minutia extraction stage, the crossing number (CN) is used. For the post-processing stage, removing false minutia and minutia matcher are processed. Now the output of each aforementioned operation as as follows: for histogram equalization, which is represented by the relative frequency of various types of gray levels in an image. The left at Figure 3 depicts before histogram and the image at right depicts after equalization operation.

Figure 3:- Applying Histogram Equalization on the Original Fingerprint Image.

After that applying average filter and median filter for noise reduction as illustrated in figure 4, the image at the right depicts the filtered finger print.

Figure 4:- Final Result After Applying Average and Median Filters on The Histogram Equalization Image.

Afterward, the local normalization tends to uniforms the mean and variance of an image around a local neighborhood, also to enhance the contrast, brightness and connecting the broken ridge of the fingerprint image as shown in figure 5 at the left (before) and at right after the normalization image

Figure 5:- Applying Local Normalization on the Filtered Image.

Next is the segmentation, there are two regions in the fingerprint image (foreground region and background region), the foreground region corresponds to the clear fingerprint area containing the ridges and valleys, which is the area of interest while the background corresponds to the regions outside the borders of the fingerprint area as shown in figure 6, which do not contain any valid fingerprint information just contain the noise information. Morphological operations (opening and closing) are exploited here for segmentation as explained in figure 6.

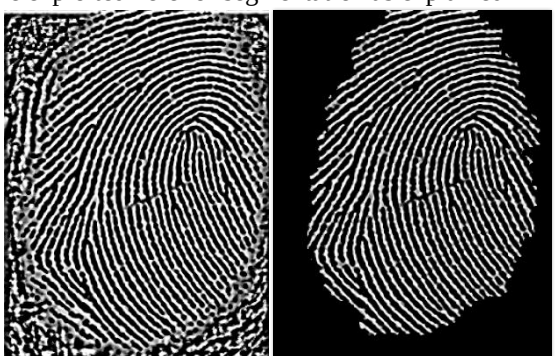

Figure 6:- Applying Segmentation Process on the Local Normalized Image.

Next is the binarization stage, which is setting thresholding to convert the 8-bit gray image to 1-bit binary either “1” or “0” as shown in figure 7 at left side.

Figure 7:- Applying Binarization and Thinning Process.

After that thinning operation, which is a process that reduces the thickness of the ridge pixels till it become one pixel as shown in figure 7 at the right side, each sub iteration begins by examining the neighborhood of each pixel in the binary image, and based on a particular set of pixel-deletion criteria, it checks whether the pixel can be deleted or not. These sub iterations continue until no more pixels can be deleted.

Now, Crossing Number (CN) concept has been selected for Minutiae Extraction, which is done by 3x3 window that scan all the fingerprint image. CN value is the half of summing the differences of adjacent pixels pairs in the eight-neighborhoods as the following formula:

$$Cn(p) = \left(\frac{1}{2}\right)\sum_{i=1}^{8}|\mathrm{P}i - \mathrm{P}i + 1| \qquad (1)$$

Where Pi is the binary pixel value in the neighborhood of P with Pi=(0 or 1) and P9=P1. The final minutiae extraction image is shown in figure 8 at the left side.

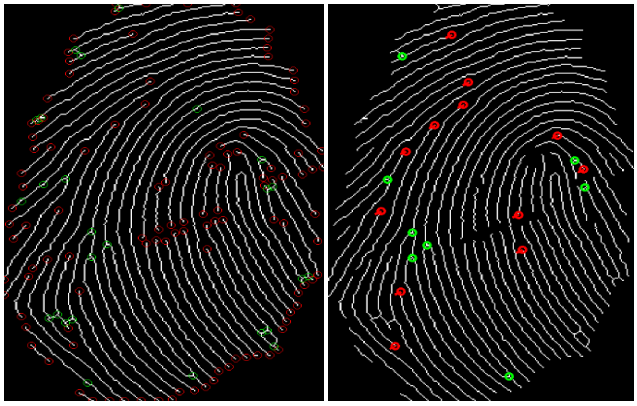

Figure 8:- The Minutiae extracted from the thinned image using CN.

After the minutiae are extracted, it is necessary to Remove False Minutiae as there are many false minutiae after the extracting step will be found in the fingerprint image such as spur, hole, triangle, spike structures and broken ridge structures, that decrease the performance. The result of removing false minutiae is shown in figure 8 at the right side.

Classification:-

The next step is to save the minutiae that extracted from the fingerprint image and preparing to the match step. Here I saved the minutiae in a text file. Each minutia has its own (X, Y coordinates) and orientation, the orientation is to find the angles of each minutiae, for the termination minutiae there are one angle and for the bifurcation minutiae there are three angles because it has three connected lines. To find the orientation first, creating a table with 5 X 5 boundary box is necessary as shown in figure 9 and then analyzing the position of the pixel on the boundary of a 5 x 5 bounding box of the termination then I compare this position to the table variable and the table variable gives the angle in radian. For the bifurcation minutiae I operate the same process than in termination case three times to get the three angles.

```
[3*pi/4 2*pi/3 pi/2 pi/3 pi/4
5*pi/6 0 0 0 pi/6
pi 0 0 0 0
-5*pi/6 0 0 0 -pi/6
-3*pi/4 -2*pi/3 -pi/2 -pi/3 -pi/4];
```

Figure 9:- 5 X 5 Bounding box table.

In terms of Minutiae Matching, an alignment-based matching algorithm is implemented. Recognition by alignment has received a great deal of attention during the past few years, because it is simple in theory, efficient in discrimination, and fast in speed. Our alignment-based matching algorithm decomposes the minutia matching into two stages: Alignment Stage and Match Stage.

Minutiae Alignment: Let I1& I2 be the two minutiae sets given by,

I1= {m1,m 2,m3…..mm} wheremi=(xi,yi,Ɵi)

I2={m'1,m'2,m'3…..m'n} wherem'i=(x'I,y'I,Ɵ'i)

The ridge associated with each minutia is represented as a series of x-coordinates (x1, x2…xn) of the points on the ridge. A point is sampled per ridge length L starting from the minutia point, where the L is the average inter-ridge length. And n is set to 10 unless the total ridge length is less than 10*L.

So the similarity of correlating the two ridges is derived from (2):

$$S = \frac{\sum_{i=0}^{m} x_i X_i}{\sqrt{\sum_{i=0}^{m} x_i^2 X_i^2}} \quad (2)$$

At this stage ($x_i \ldots x_n$) and ($X_i \ldots X_n$) are the set of x-coordinates for the two minutia whish we have chosen. And the least possible of „m" is one of the value of n and N. I will tally the score and if the score is greater than 0.8, then jump to step 2, if not then continue to match the next ridges pair. Then, a transformation each set according to its own reference minutia and then doing matching in a unified x-y coordinate. The new coordinate system is originated at reference minutia M and the new x-axis is coincident with the direction of minutia M. Here scaling effect is not required, it is assumed two fingerprints taken from the same finger are having nearly the same size. Therefore, two sets to be transformed of minutiae I1 & I2.

In terms of matching stage, generally, the two identical minutia are not exactly same due to the slight deformations and also inexact quantization. The algorithm for matching for the aligned minutia patterns should be elastic. The minutia matching elastic is done by keeping a bounding box around each of the template minutia. If the minutia which is to be matched is within that bounding box and the direction discrepancy between them is so small, then the two minutia are taken as a pair of matched minutia. Each of the minutia in that template image either has one corresponding minutia or has no matched. If the match score is greater than a threshold value which is pre-specified, then the two fingerprints taken are from the same finger. The final match ratio for two fingerprints is given by (3):

$$\text{Match Score} = \frac{\textit{number of total matched minutiae pair}}{\textit{number of minutiae of the template fingerprint}} \quad (3)$$

Send SMS Message and GUI Design:-

Once the minutiae are extracted and matched, a client server is set by using Matlab software and C# software, in this case the C# act as a client as shown in figure 10 that will send a request message to Matlab (server) for the recognition inquiry regarding to the child in the database or not, if yes then the Matlab will response a message to C# containing the ID of that child and C# in turn will send an SMS message to the parent phone that the child ID contained in the database, the message will contain the *child ID*, *name*, *date and time*. If the database does not contain the child ID, then the Matlab will send a message to C# informing that "There is not such a child in the database, please try again ".

Server Client

Figure 10:- The Connection Between C# and Matlab.

The C# application which is the (GUI) of the system contain three forms derived from the main form as shown in figure, these forms connected with the database access that contain the student information, also the forms connected with each other.

Figure 11:- The Main Form That the Sub Forms Derived from it in The MenuStrip.

The first sub-form named "Student Information", from this form, the information of the database access and control board are shown as in figure 12.

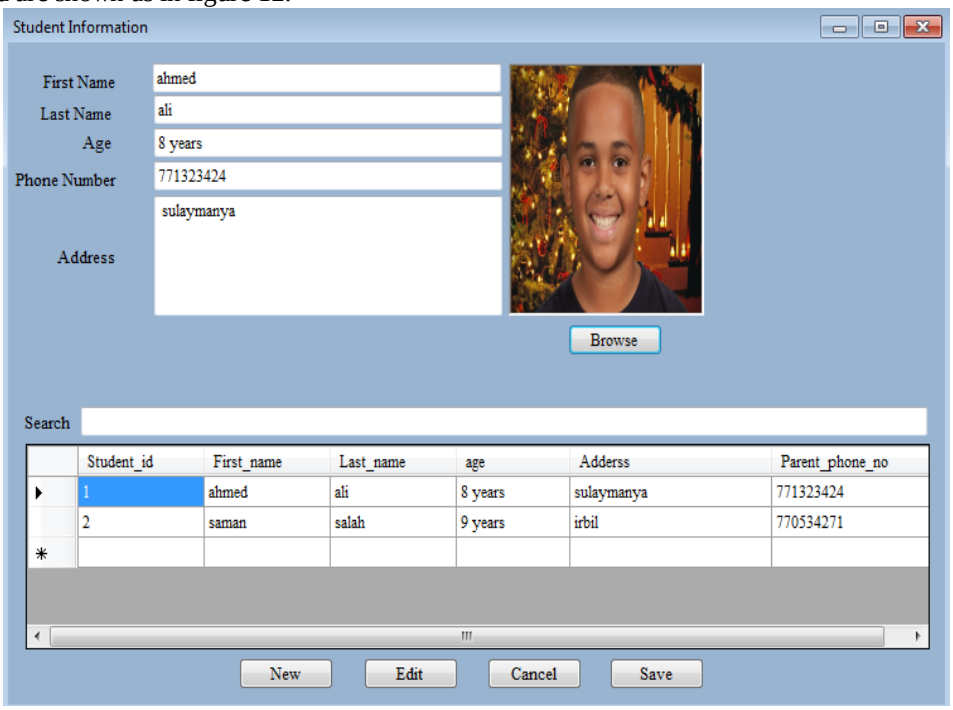

Figure 12:- First Sub Form that Contain and Control the Database.

The second sub-form is named "Find Person ID", from this form a connection is done between the C# software and Matlab software, in figure 13, when I click on the "Load Fingerprint Image" button the image will have loaded manually, and when clicking on the "Find ID" button, the C# application will send the image that loaded to the Matlab software that contain the fingerprint recognition program, the Matlab here will recognize the image and return an ID and similarity of the fingerprint for the C# application.

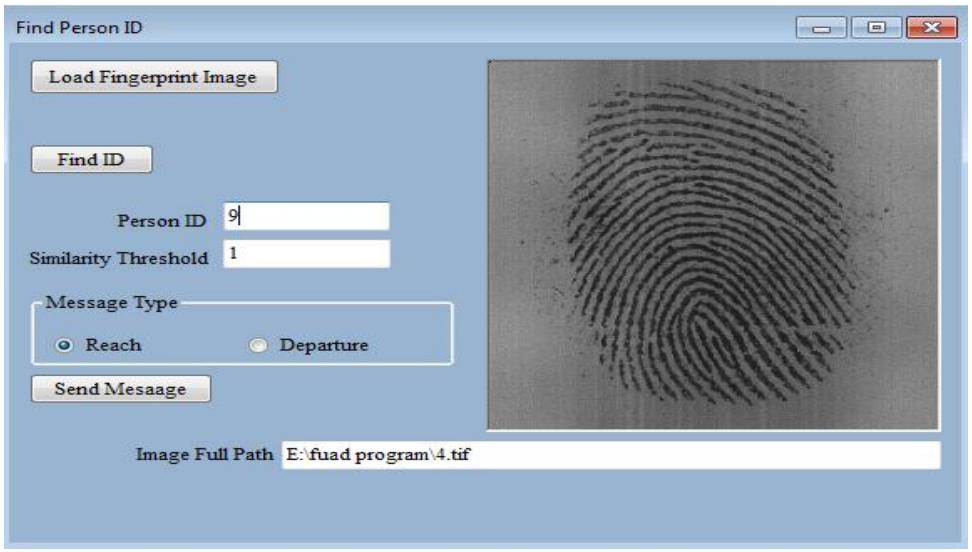

Figure 13:- Second Sub-Form that Connect Between C# and Matlab Software.

When pressing on "Send SMS" in "Find Person ID" form as shown in figure 13 the third sub-form will be displayed, which is named "Send SMS", as shown in figure 14 when this form is loaded, the value of student ID will be brought from Matlab program where will be in the third sub-form.

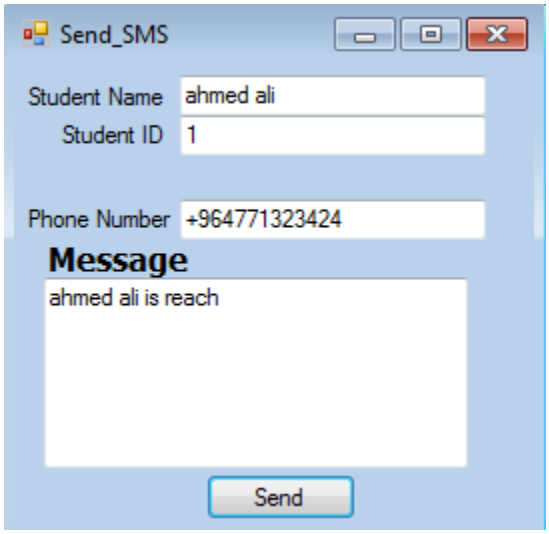

Figure 14:- Third Sub-Form that Send the SMS Message.

Depending on the ID number, the information of the child and parent phone number are retrieved by SMS message. The retrieved phone number will be inside the textbox "To" and the "Message" textbox will contain the child information's, finally when pressing on the "Send" button the SMS message will go to the parent.

Results and Discussion:-

To evaluate the performance of this research, there are two types of performance evaluation indexes to determine the performance of a fingerprint recognition system: False Rejection Rate (FRR) and False Acceptance Rate (FAR).

FRR is resulted from incorrectly reject an access attempt by an authorized user. A system FRR basically states the ratio between the number of false rejections and the number of identification attempts. FRR given by the following formula (4):

$$FRR\% = (FR/N) * 100\% \quad (4)$$

Where *FR*=number of incidents of false rejections and *N*= number of samples.

FAR is second type of biometric error, which incorrectly biometric system accepts an access attempt of an unauthorized user. To measure FAR given by the following formula (5):

$$FAR\% = (FA/N) * 100\% \quad (5)$$

Where *FA*= number of incidents of false acceptance and *N*=total number of samples.

Dataset named FVC (2002) is used in this research which has real fingerprint for testing. The result attained with this experiment as FAR is as 30 % and FRR is 30%. These two errors depend upon the quality of the image whether the quality is good or bad.

Conclusion:-

In this research, a new technique has been proposed to protect children by using fingerprint verification that might be tracking the children attendance at school. In this case, the parents will now feel more comfortable about the safety of their children. This approach uses fingerprint image enhancement without depending on the orientation estimation or ridge frequency. The idea is to connect Matlab with C# as server and client, whereas the Matlab does all the processing for image processing related to finger print verification and C# does send the message to the parent of the children by using TCP/IP protocol. A graphical user interface has been designed and programmed, as well as testing operation gave a promising results.

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