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Fingerprint Sensing Technology

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Abstract: ***There exist many human recognition techniques which are based on fingerprints. Most of these techniques use minutiae points for fingerprint representation and matching. However, these techniques are not rotation invariant and fail when enrolled image of a person is matched with a rotated test image. Moreover, such techniques fail when partial fingerprint images are matched. This paper proposes a fingerprint recognition technique which uses local robust features for fingerprint representation and matching. The technique performs well in presence of rotation and able to carry out recognition in presence of partial fingerprints. Experiments are performed using a database of 200 images collected from 100 subjects, 2 images per subject. The technique has produced a recognition accuracy of 99.46% with an equal error rate of 0.54%.***

Keywords: Biometrics, Fingerprint Recognition, Rotation and Occlusion Invariance, Partial Fingerprints, etc.

1. Introduction

Traditional Security Methods are based on things like Passwords and PINs. However, there are problems with these methods. For example, passwords and PINs can be forgotten or stolen. Use of biometrics has helped in handling these issues. Biometrics deals with the recognition of a person using his or her biometric characteristics. There are two types of biometric characteristics a person possesses. One is physiological characteristics where as another is behavioral characteristics. Physiological characteristics are unique characteristics physically present in human body. Examples of physiological biometric characteristics include face, fingerprint, iris, ear etc. Behavioral characteristics are related to behavior of a person. Examples of behavioral biometrics include signature, voice, gait (waking pattern) etc. The advantage of biometrics is that biometric identity is always carried by a person. So there is no chance of losing or forgetting it. Also, it is difficult to forge or steal biometric identity. Fingerprint is one of the popular biometric trait used for recognizing a person. Properties which make fingerprint popular are its Wide acceptability in public and ease in collecting the fingerprint data. Many researchers have attempted to use fingerprints for human recognition for a long time. Most of them make use of minutiae based approach for representation and matching of fingerprints. Fingerprint matching based on minutiae features is a well-studied problem. Well some used Image Based approach for representation and matching of fingerprints.

2. Why we use fingerprints:

Fingerprints are considered as a unique identification of a person and due to easy access its the best and one of the fastest method used in biometric identification systems. They are unique, so secure and reliable to use and doesn't change for one in a lifetime. And beside these things fingerprint recognition specially using minutiae matching technique is cheap, reliable and accurate up to a satisfactory limits. Hence, fingerprint recognition is being widely used in both civilian and forensic applications. If, we will compare with other biometric devices then fingerprint recognition devices will hold the maximum market share and are most proven ones also. And we can also say that it's not only faster than other biometric devices but its energy efficient also, as it consumes very less energy.

3. Issues with existing fingerprint recognition

Most of the existing fingerprint techniques in literature are based on minutiae points which are represented using their co-ordinate locations in the image. When test fingerprint image is rotated with respect to enrolled image or partially available, these techniques face problem in matching due to change in the co-ordinate locations of the minutiae points and perform very poorly. These two cases are discussed below.

3.1 Rotated Fingerprint Matching

An example of a rotated fingerprint image is shown in Figure 1(b). We can see that it is difficult to match minutiae of two images because due to rotation, coordinate locations of all the minutiae points in Figure 1(b) with respect to Figure 1(a) are changed.

Figure 1(a) **Figure 1(b)**

3.2 Partial Fingerprint Matching

An example of partial fingerprint is given in Figure 2(b). We can see that it is difficult to match minutiae of two images because due to missing part of the fingerprint, coordinate locations of all the minutiae points in Figure 2(b) with respect to Figure 2(a) are changed.

Figure 2(a)

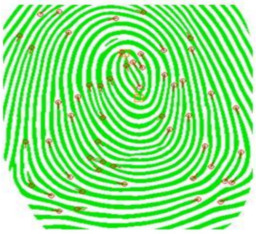

Figure 2(b)

4. Identification of fingerprint

A live-scan fingerprint is usually acquired using the dab method, in which the finger is placed on the surface of the sensor without rolling7. There are a number of sensing mechanisms that can be used to detect the ridges and furrows present in the fingertip. A brief description of a few of these principles is provided below:

4.1 Optical Frustrated Total Internal Reflection (FTIR)

This technique utilizes a glass platen, a laser light-source and a CCD (or a CMOS camera) for constructing fingerprint images. The finger is placed on the glass platen, and the laser light source is directed toward the platen. The CCD captures the reflected light after it has passed through a prism and a lens to facilitate image formation. The light incident on the ridges is randomly scattered (and results in a dark image), while the light incident on the valleys suffers total internal reflection (and results in a bright image). It is difficult to have this arrangement in a compact form, since the focal length of small lenses can be very large. Further, image distortions are possible when the reflected light is not focused properly.

4.2 Ultrasound Reflection

The ultrasonic method is based on sending acoustic signals toward the finger tip and capturing the echo signal. The echo signal is used to compute the range image of the fingerprint and, subsequently, the ridge structure itself. The sensor has two main components: the sender, that generates short acoustic pulses, and the receiver, that detects the responses obtained when these pulses bounce off the fingerprint surface [10]. This method images the sub-surface of the fingerprint and is, therefore, resilient to dirt and oil accumulations that may visually mar the fingerprint. The device is, however, expensive, and as such not suited for large-scale production.

4.3 Piezoelectric Effect

Pressure sensitive sensors have been designed that produce an electrical signal when a mechanical stress is applied to them. The sensor surface is made of a non-conducting dielectric material which, on encountering pressure from the finger, generates a small amount of current. (This effect is called the piezoelectric effect). The strength of the current generated depends on the pressure applied by the finger on the sensor surface. Since ridges and valleys are present at different distances from the sensor surface, they result in different amounts of current. This technique does not capture the fingerprint relief accurately because of its low sensitivity.

4.4 Temperature Differential

Sensors operating using this mechanism are made of pyro-electric material that generate current based on temperature differentials. They rely on the temperature differential that is created when two surfaces are brought into contact. The fingerprint ridges, being in contact with the sensor surface, produce a different temperature differential than the valleys that are away from the sensor surface .The sensors are typically maintained at a high temperature by electrically heating them up.

4.5 Capacitance

In this arrangement, there are tens of thousands of small capacitance plates embedded in a chip. Small electrical charges are created between the surface of the finger and each of these plates when the finger is placed on the chip. The magnitude of these electrical charges depends on the distance between the fingerprint surface and the capacitance plates. Thus, fingerprint ridges and valleys result in different capacitance patterns across the plates. This technique is susceptible to electrostatic discharges from the tip of the finger that can drastically affect the sensor; proper grounding is necessary to avoid this problem.

5. Approaches for fingerprint recognition

There are two types of representation, we can classify for fingerprints which make the two approaches for fingerprint recognition. The first approach is „Minutiae based", which represents the fingerprint by its local feature mainly stated are the two minutiae features as termination and bifurcation. This approach has been studied intensively and is mainly followed in current fingerprint recognition instruments. My project is also related to this technique with possible corrective measures based on experiments.

The second approach uses image-based method; it basically tries to match the whole fingerprint image using the global features. It is the latest and advanced techniques for fingerprint recognition and many researches are still going on to convert it into a cheaper and easy method of use. So, we can say that its an emerging technique. My project does not include this approach and so no further studies will be seen on this approach in my thesis.

6. Recognition Process

With regard to fingerprint recognition, there exists the widely used distinction between identification and verification. Comparing one fingerprint against a reference sample in order to verify an identity claim (i.e., is this person who he claims to be?) is referred to as "verification". In

contrast to this, "identification" refers to the process of potentially recognizing a certain fingerprint within a large database of fingerprints (i.e., within this database, who does this fingerprint belong to?). The reader should be aware of the fact that this technical definition of identification may lead to confusion compared to its usual interpretation in establishing the identity of a person. For the purpose of massive fingerprint identification, automated systems based on special hardware and software have been developed, called Automated Fingerprint Identification Systems (AFIS). Here is a flowchart to show how this process works.
Biometric vendors and independent test groups should begin incorporating interoperable scenarios in their testing protocol. This would help in understanding the effect of changing sensors on a biometric system and would encourage the development of cross-compatible feature extraction (representation) and matching algorithms. In this work, we have reported on experiments carried out using the publicly available MCYT-100, database which includes fingerprint images acquired with an optical and a capacitive sensor.

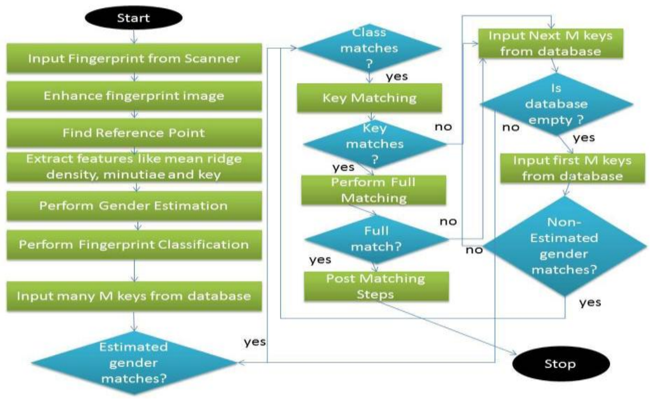

Figure 3: Workflow of the Process

7. Results

The need for biometric sensor interoperability is pronounced due to the widespread deployment of biometric systems in various applications and the proliferation of vendors with proprietary algorithms that operate on a specific kind of sensor. In this paper we have illustrated the impact of changing sensors on the matching performance of a fingerprint system. Almost every biometric indicator is affected by the sensor interoperability problem. However, no systematic study has been conducted to ascertain its effect on real-world systems. Normalization at the raw data and feature set levels of a biometric system may be needed to handle this problem. There is also a definite need to develop matching algorithms that do not implicitly rely on sensor characteristics to perform matching. Biometric vendors and independent test groups should begin incorporating interoperable scenarios in their testing protocol. This would help in understanding the effect of changing sensors on a biometric system and would encourage the development of cross-compatible feature extraction (representation) and matching algorithms.

8. Conclusions

In this work, we have reported on experiments carried out using the publicly available MCYT-100, database which includes fingerprint images acquired with an optical and a capacitive sensor. Three published systems. Have been tested and the results discussed. The three systems implement different approaches for feature extraction, fingerprint alignment, and matching. Furthermore, several combinations of the systems using simple fusion schemes have been reported. A number of experimental findings can be put forward as a result. We can confirm that minutiae have discriminative power but that complementary information, such as second and higher order minutiae constellation, local orientation, frequency, ridge shape or texture information encoding alternative features, improves the performance, in particular in low-quality fingerprints. The minutiae-based algorithm that results in the best performance exploits both a minutiae-based correspondence and a correlation-based matching, instead of using only either of them. Moreover, the HH algorithm extracts minutiae by means of complex filtering, instead of using the classical approach based on linearization, which is known to result in loss of information and spurious minutiae. When combining only two systems we generally obtained significant performance improvement compared to including a third system. The scope of this work to work towards a perfect verification rate but to give an incentive to combine different methods within the same modality and reveal the fundamental reasons for such improvements. Other studies have shown that however the performance of different individual systems can be influenced by database acquisition and the sensors.

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Author Profile

Pratibha Kumari is currently pursuing her engineering from Electronics and Communication branch from Poornima Institute of Engineering and Technology, Jaipur and is in her final year(8th semester) right now. She has completed her industrial training from Doordarshan Relay Kendra, Jaipur in broadcasting field