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A study on Fingerprint Sensors

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Abstract

The personal authentication systems verify the identity of an individual who is requesting service. The aim of these systems is to ensure that the services are accessed only by legal users and not by others. A fingerprint is an impression of the epidermal ridges of a human fingertip. Fingerprint sensors are devices used for recognizing and authenticating an individual's fingerprint. They are also called as fingerprint scanners. They are used in industries, smart phones, police stations, institutions and other mobile devices. This paper gives a review of various fingerprint sensors.

Keywords: ***fingerprint, sensor, optical, thermal, ultrasound.***

I. INTRODUCTION

Fingerprint biometric data acquisition is placing fingerprint sample to the fingerprint sensor. It can be either off-line or on-line. 1**).** Off-line Fingerprint Acquistition 2) On-line Fingerprint Acquisition. An inked fingerprint is used in off-line fingerprint acquisition. A person's finger is spread with black ink and pressed against the paper card. The fingerprint on the paper card is converted into digital form by using scanner or camera. The resolution of the image is 500 dpi. It is called as Rolled inked fingerprint. Since finger is rolled over the paper to obtain the fingerprint. This is used for criminal identification. In forensics, a special kind of inked fingerprint called as latent fingerprint is used. When a person touches an object, a film of moisture pattern leaves the fingerprint pattern of the person on that object. Latent fingerprints are of very low quality. The fingerprint is obtained from electronic sensor in real time. This type of fingerprint is called as live-scan fingerprint. The user presses his finger in the flat surface of the fingerprint scanner. No ink is used for fingerprint acquisition. Fig. 1 shows the types of fingerprint images

II. FINGERPRINT SENSORS:

There are various types of fingerprint scanners available to capture the fingerprint [1]: a) Optical Sensor b) Solid-state Sensor c). Ultrasound Sensor.

Fig. 1 a) Inked Fingerprint b) Live-scan Fingerprint c) Latent Fingerprint

A. Optical Sensors:

These sensors are oldest technique of capturing live san fingerprints. This method is based on capturing an optical image to detect unique patterns on the finger surface such as ridges and valleys. It analyzes the darkest and lightest parts of the image. Optical sensors capture images of higher contrast than regular camera. They have large number of diodes per inch. The various types of optical sensors are described below.

I. Frustrated Toal Internal Reflection (FTIR):

The principle of this technique is total internal reflection. When the finger touches the glass prism in the fingerprint sensor, the ridges are touching the glass prism and valleys are present at some distance. The fingertip is illuminated by a collection of LEDs (Light Emitting Diodes). The light is absorbed by the ridges and reflected by the valleys. The light rays exit from the prism are focused by a lens in a CMOS (Complementary Metal Oxide Semiconductor) or CCD (Charge Coupled Device) image sensor. FTIR based sensor shown in Fig.2 senses three dimensional finger surface. So this type of sensor cannot be fooled by photograph of a fingerprint images. The FTIR based optical sensor produces geometrical distortion due to the perspective view of the imaging surface. This type of distortion is known as keystone or trapezoidal distortion. Since these sensor is large in size, they are not suitable to embed with PDA or mobile phone.

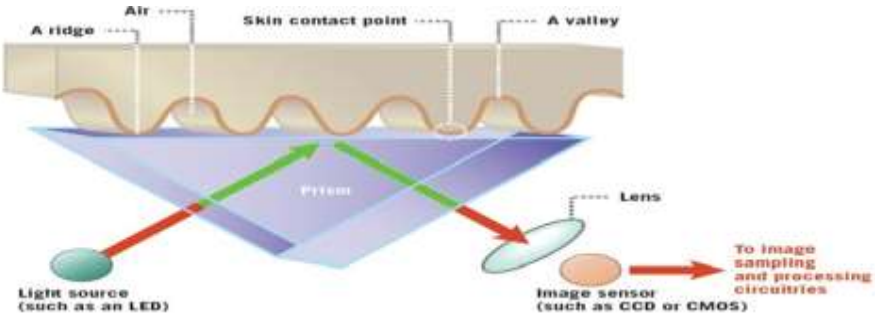

Fig. 2 FTIR with glass prism

II. FTIR with a Sheet Prism:

In Optical sensor instead of a single large prism, a sheet prism shown in Fig. 3 which is made of a number of prismlets adjacent to each other is used and the size is reduced. But the quality of the image acquired using FTIR with sheet prism is lower than the image obtained using FTIR with glass prism.

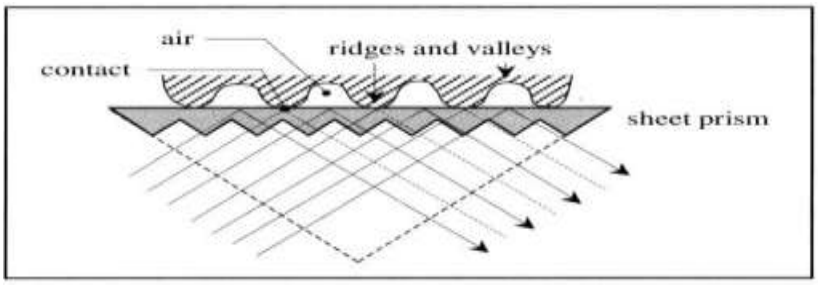

Fig.3 FTIR with Sheet Prism

III. Optical Fiber Sensor:

In the optical fiber sensor [2] shown in Fig. 4, the prism and lens present in FTII optical sensor is replaced by an optical fiber. So packaging size is significantly reduced to some extent. The CCD or CMOS detector is in direct contact with the platen. The fingertip is placed on the upper side of the platen. The CCD or CMOS detector which is coupled with the platen receives the finger residual light produced by the glass fiber.

IV. Electro-Optical Sensor:

This sensor contains two main layers as shown in Fig. 5. The first layer consists of polymer. The second layer consists of photo diode array. The polymer layer emits light that depends on the voltage applied on one side. The finger is placed on the top of the first layer. The amount of light emitted by the layer varies across the finger surface. Because the ridges touch the layer. The valleys do not touch the layer. A fingerprint pattern is generated as luminous representation. The second layer is used to receive the light emitted by the first layer. The second layer converts the light into digital image.

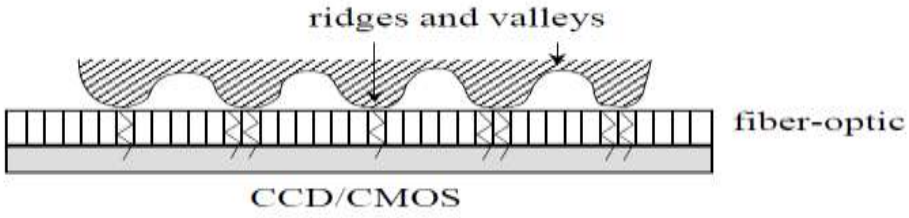

Fig. 4 Optical fingerprint Sensor

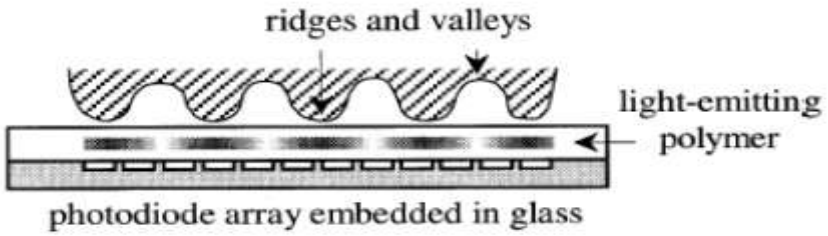

Fig. 5 Electro-Optical fingerprint Sensor

V. Direct Reading (Touch less) Fingerprint Sensor:

A high quality camera is used to capture the fingerprint from the fingertip. The finger does not touch any surface. The user presents his finger at uniform distance from the fingerprint scanner. This method is more hygienic. There is no nonlinear distortion in touch less fingerprint scanner. But this nonlinear distortion is present in touch based scanner. This distortion is caused by pressing the finger on the scanner platen. The high contrast image acquisition is a challenging problem in touch less scanner.

VI. Multi spectral Imaging Sensor:

This sensor is used to capture multiple images of the same finger. The images are obtained at different orientations, different wavelengths and different polarization conditions. The multiple images are combined to produces a single composite image. Multi spectral imaging technique is more robust than other techniques. But it is expensive and complex to implement.

B. Solid-state Sensor:

They contain an array of pixels. Each pixel is a tiny sensor itself [3]. There is no optical component and CMOS/CCS detectors. The user touches the silicon present in the sensor .Solid-state sensors are designed to overcome the size and cost issues present in the optical sensor. There are four methods to covert fingerprint information into electrical signals which are using different types of sensors; 1) Capacitive Sensor 2) Thermal Sensor 3) Elecric field Sensor 4) Piezo-Electric field Sensor.

1) Capacitive Sensor:

A capacitive sensor [4] shown in Fig. 6 consists of an two dimensional array of micro-capacitor plates embedded in a chip. When the finger is placed on the sensor, the finger skin acts as other plate of the capacitor. Small electrical charges are formed between the silicon plates and the surface of the finger. The magnitude of the electrical charges varies according to the distance between the silicon plates and finger surface. The magnitude will be different for ridges and valleys. These capacitive sensors cannot be deceived using photographs .because the sensor can sense only three dimensional surface from which distance is measured.

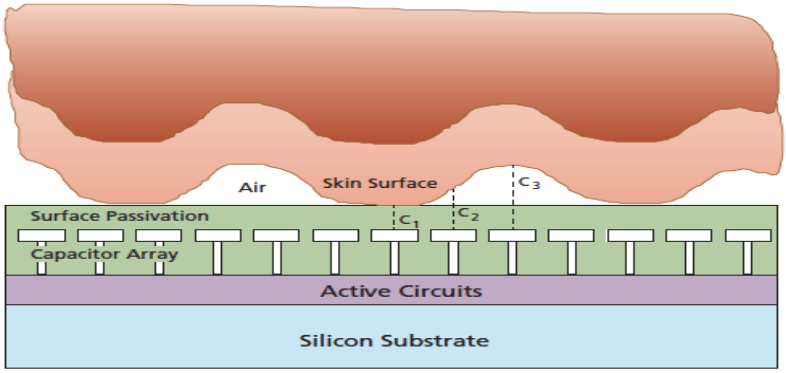

Fig. 6 Capacitive Sensor

2) Thermal Sensor:

Thermal sensor consists of pyro electric material which generates current according to the temperature differentials. The ridges are in contact with the sensor and valleys are at some distance from the sensor. The temperature differential produced by ridges are different from valleys. When the finger is placed on the sensor, the temperature differential produces an image. The sweeping method is used to get the stable image otherwise the image will disappear suddenly.

3) Electric Field Sensor:

An Electric Field Sensor contains a drive ring. The finger surface is in contact with both the sensor and drive ring simultaneously. This ring is used to generate a radio frequency (RF) Sinusoidal Signal. A matrix of antennas are used to receive the signal transmitted by the drive ring. The sign al is modulated by the dermastructure(subsurface) of the finger skin. The analog value of the matrix is amplified and digitized to get the finerprint image.

4) Piezo Electric Sensor:

These are pressure sensitive sensors. These sensors detect the mechanical stress and convert them into electrical signal. The surface of the sensor is made of a piezo electric (non-conducting) material. This surface detects the pressure given by the finger. The pressure is converted into electrical current. This phenomenon is called as piezoelectric Effect. The ridge and valleys of the finger produced different amount of the current.

C. Ultrasound Sensor:

Ultrasound sensor [5] shown in Fig. 7 is based on the concept of echography. The scanner consists of two components: 1) Transmitter 2) Receiver. The acoustic signals are sent from the transmitter towards the fingertip and echo signals are captured by the receiver. The echo signal is used find the ridge structure of the fingerprint. This ultrasound scanner captures good quality image. This scanner is bulky and expensive.

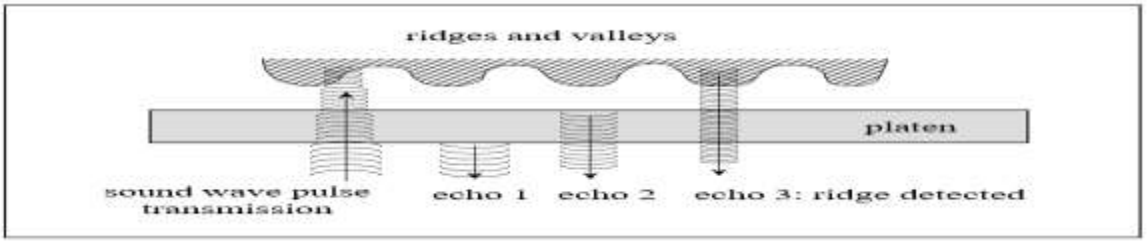

Fig. 7 Ultrasound Sensor

III. CONCLUSION

Biometrics devices are involved in our daily life for security purpose. Fingerprints are used for identifying people for more than 2000 years. Fingerprint recognition system is most widely used and popular biometric system in many applications such as forensics, border control, and law enforcement. Nowadays fingerprint is most widely used authentication system in our day to day life from smart phone to attendance system. This paper gives a study of various fingerprint sensors.

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