



You are unique in many ways. And this is what biometrics exploits to distinguish you from the rest.

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Biometrics: Standing out in the Crowd

JUST as two popcorns cannot be identical, it is absolutely unusual that the ridges on the fingertips of any two persons can be identical. The fingerprint distinguishes an individual from others and helps in identifying a person with almost hundred percent accuracy.

Today, a much more accurate identification of an individual is possible by scanning the eye or by DNA test. The physiological or behavioural identification of an individual is known as biometric. Greek 'bios' means life and 'metric' means to measure. This term was coined by a French anthropologist and criminologist Alphonse Bertillion in 1870.

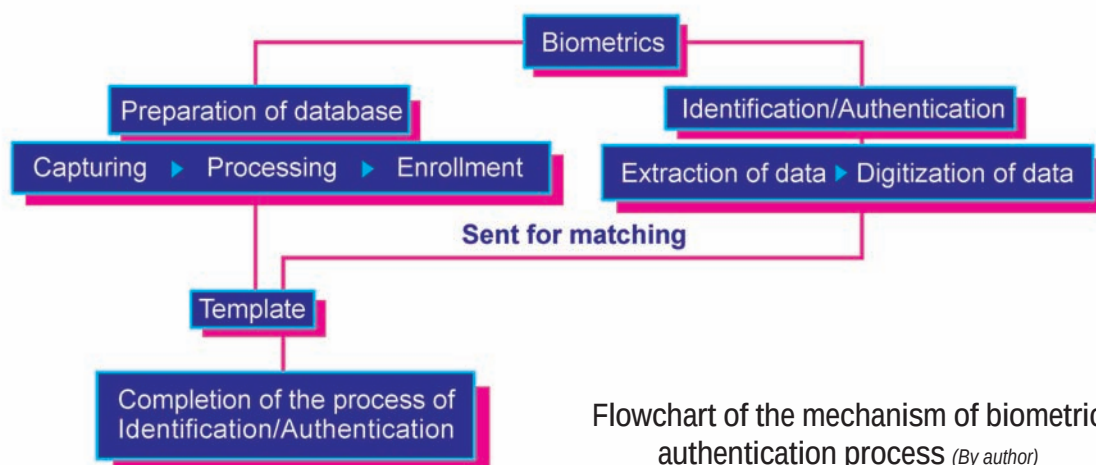
Fingerprint authentication is one of the oldest forms of the biometric authentication process. Apart from criminal detection and other security purposes, now a days the application of biometric authentication has got an extra edge in banking, transportation, corporate sector, libraries, educational institutes, public sectors, military departments, forensic departments and many others.

In 2009, the Planning Commission of India introduced the AADHAR card system to facilitate unique identification of every Indian with the help of biometric information such as finger scan, eye scan, etc. This biometric information of an individual remains valid through life (although due to epidermal injury or

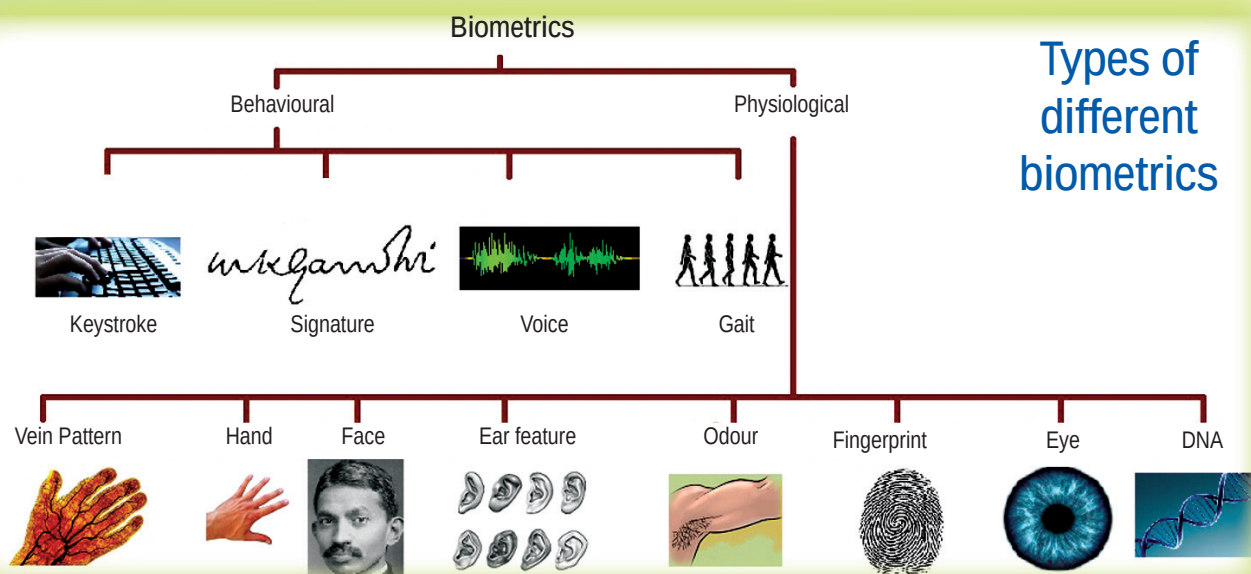
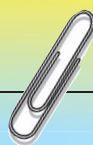
leprosy or surgery, changes can take place in the fingerprint ridges).

Technology has gradually developed from manual microscopic identification to identification by computerised data based algorithms. A person's biometric data which is already stored in the database is called the 'template' and the captured data is matched with the template for authentication. Template size is therefore an important factor for determining the cost of the biometric device.

There are several types of biometric traits such as typing rhythm (keystroke dynamics), signature, voice and gait that belong to behavioural biometrics whereas physiological biometrics include vein pattern, hand geometry (shape of hand),



Flowchart of the mechanism of biometric authentication process (By author)



facial feature, ear feature, body odour, fingerprint, eye scan characteristics (retina and iris) and DNA test. In addition there are some more possible areas of biometry such as analysing the brainwave signals or swallowing of a password microchip in the form of pill that would produce a password signal from the whole body. According to the nature of the detection mechanism, the various methods have their own terminologies also, such as identification by DNA test is known as chemical biometry.

Keystroke Dynamics

The combination of typing rhythm (duration between two strokes) and the typing characteristics (pressure and placement of fingers) of a person is known as keystroke dynamics and this is one of the unique biometric features of a person. This is a kind of behavioural biometry and it is used in computer security arena in order to prevent malicious attacks. During console login for accessing the server, only typing the password is not sufficient. Access is only granted if the keystroke dynamics along with the password matches within the reasonable threshold.

Signature

Analysing the handwriting style, especially the signature of a person is a very useful tool for biometric authentication and is exclusively used in the field of education and job, banking, official work, legal prosecution, etc. This

is also a kind of behavioural biometry sometimes referred as visual biometry.

The technology for signature verification is known as 'signature verification algorithm' and it may be both static and dynamic for online verification. For offline verification, only the static process is applied.

The static process analyses the texture and topological features – the length and the height of the signature along with the pressure value, number of breakpoints and the total number of pixels in it. The dynamic process analyses the speed of signing the name.

Voice

Recognition of voice manually (rarely) or by using computer software is called auditory biometry. The voice template of an individual is also known as the 'voice print' or 'voice model'. The tone, frequency, pitch and intonation of the voice of a person are analysed in this technology. This is applied in forensic departments, customs departments, border checkpoints, police departments, etc. for the purpose of identification/authentication by matching the voice print of the incumbent with the template. It is a low cost method and the template size is low.

Gait

The manner of walking or running, the gait, is a type of behavioural biometry. This is important in case of analysing the CCTV footage, where the vision is

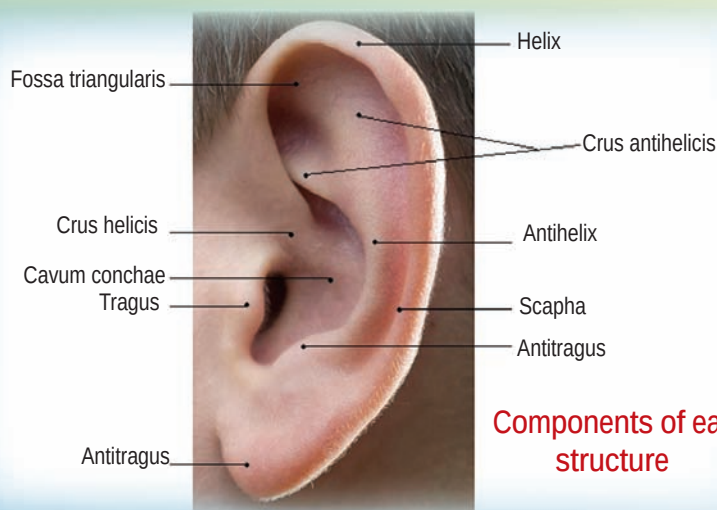
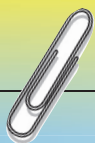
obscure. If a sequence of images are collected (in 3D form if possible) followed by analysis, then a set of signature data is obtained. The advantages of this technique are the efficiency to analyse data that is obscure or taken from distance and that does not require the consent of the sample (individual). This is a very useful and popular biometric technology and has fruitful applications in airports, parks, military camps, railway stations, shopping mall and so on wherever CCTV surveillance is attached.

Hand Geometry

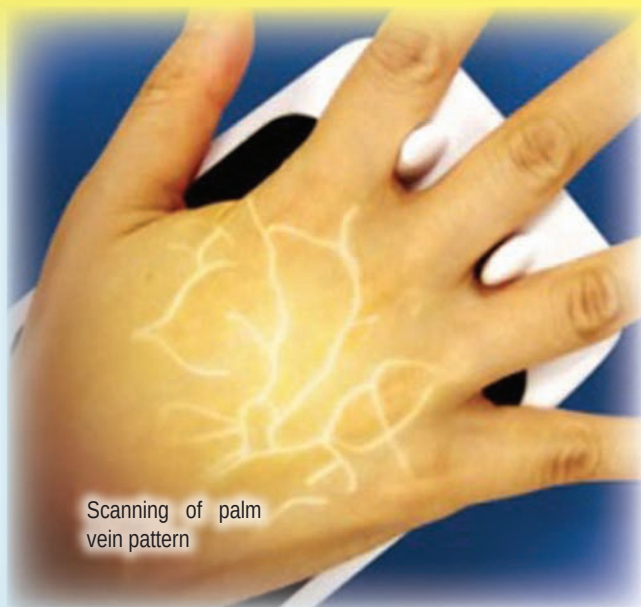
If the three-dimensional geometric feature of hand, relative angle and distance between the fingers are analysed minutely then it would be found that this is also a unique feature of an individual. This visual biometry is also sometimes referred as spatial biometry. This is not among the popular biometrics due to its low level accuracy and short-term stability.

Facial Features

Recognition of facial characteristics is a commonly used process of authentication and belongs to visual biometry. By analysing the critical points and areas in the face obtained from the camera scanned data and matching against the known database, one can be identified from within a crowd. The advantage of this technique is that it is non-intrusive. But it has several disadvantages such as low accuracy level and large template size, and hence the costing is high.



Components of ear structure



Ear Features

Biometrics by analysing ear feature was first proposed long ago by Sir Bertillion. This is similar to other visual biometrics such as recognition by hand geometry or facial features. The characteristic ear features are formed by helix, crus antihelics, fossa triangularis, crus helcis, antihelix, cavum conchae, scapha, tragus, antitragus and lobule (or lobe). This is an example of phenotype (discussed later), that takes a permanent shape during the embryonic stage. This is such a unique characteristic that there is no resemblance of the left ear with the right one! In Germany, criminals are detected with the help of ear feature biometrics.

Odour

Detectives or the police often use sniffer dogs to detect the suspect by means of his or her body odour. Detection of a person with the help of body odour is called olfactory biometry.

A person's body odour has three degrees of characteristics such as, primary (due to axillary secretion), secondary (due to food habit and the impact of the existing environment) and tertiary (due to the use of external sources such as perfume, body spray etc.). Of this, the primary body

odour is stable over time and it is the unique feature of an individual.

The computer database of body odour is prepared by sucking the air from around the sample; the chemical components thus collected are then interacted with the metal oxide semiconductors to produce electrical signals towards the sensor followed by digitization of the received signals and storage of the data. This is a non-intrusive biometry and the device is termed as the electronic nose. It is used in airport security checkpoints. In the near future the electronic nose could be used in detecting humans buried in coalmines, earthquake rubble or in other disasters.

Fingerprint

Fingerprints are formed due to surface buckling of growing skin followed by the formation of ridges and the valleys (minutiae) on the tip of the fingers. Just like the features of the ear, fingerprint is also an example of phenotype.

The environmental influence plays an important role in their formation during the foetal development in the uterus within the first three to four months of pregnancy. The overall position of the foetus in the womb is an important environmental factor for the development

of the ridges on the fingers. The other environmental factors during pregnancy are the nutrition level and blood pressure.

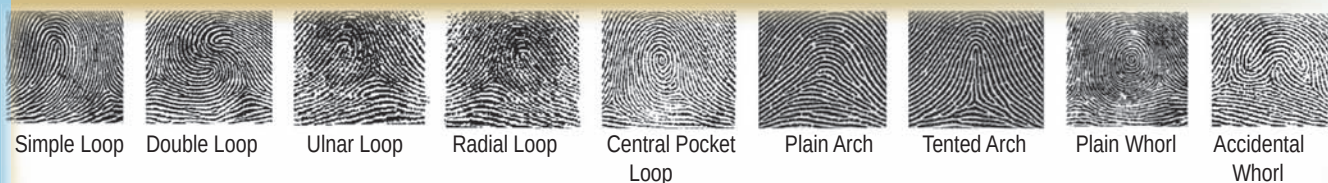
The ridges thus developed has three main characteristics – dots (very short ridge), ridge endings (a simple ridge with an end point) and bifurcations (splitting of one ridge into two having a shape like 'Y'). They combine to form the general pattern of the three types of fingerprints, such as Loop, Arch and Whorl. These general patterns in turn are of nine types. There are five varieties of Loops (simple, double, ulnar, radial and central pocket) and two each of Arch (plain and tented) and Whorl (plain and accidental).

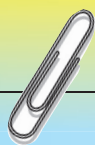
According to doctors' terminology, similar fingerprint means similar class of pattern out of these nine. But the general ridge flow must be unique for each person. Clones, twins, and siblings may have similar fingerprint patterns due to similar genes, but still they would have their own fingerprints. The advantage of fingerprint scanning is that it has small template size and therefore costs less.

Vein Pattern

The distribution pattern of the veins inside the palm or finger is unique for

Different types of fingerprint patterns





FEATURE ARTICLE

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Right: A biometric device for thumb/forefinger scanning



an individual and hence it is another type of biometry. In this biometric device, the near-infrared radiation from an LED source is absorbed by deoxy-haemoglobin present in the blood to produce a series of dark lines according to the vein pattern. This method has higher level of accuracy and long term stability in comparison to voice recognition and fingerprint authentication. In future this technology can be employed in accessing the ATM or the transactions via credit card without any card. One may forget his ATM card in hurry towards the office, but would never forget his finger with him! This would have some more advantages such as it would prevent cyber-crime because replicating the magnetic tape of the card is possible but the same for vein pattern is extremely difficult due to their presence inside the body. And finally the bank and the income tax department would have a complete information about the number of credit and ATM cards possessed by a single user.

Eye (Iris/Retina)

Eye scanning is one of the fastest forms of biometric measurements and is a type of visual biometry. There are two types of eye recognition, one being iris recognition and the other retina recognition. The feature of iris, that is the coloured ring surrounding the pupil of the eye, is unique. Similar uniqueness is also found in the capillary vessels present in the back of the eye – the retina. Images are obtained by using low intensity lights.

Two persons with very high degree of genetic similarities (such as twins, clones, etc.) thus have different physiological expressions. When the genetic effect

combines with the environmental impact, it is called phenotypic effect. This effect is finally reflected in the different physiological and behavioural manifestations of an individual.

DNA Test

DNA of every species is unique. The chimpanzee has the maximum closeness to human DNA as there is 97% similarity. But if the species is same, then is there any dissimilarity present in the DNA structures? The answer is not as simple. For example, for humans the similarity level is 99.90%. That means 0.10% genome is unique for every person, and interestingly this small percentage represents 3 million base pairs (Adenine::Thymine, Guanine::Cytosine) in the DNA (the fact can be compared with the 3% dissimilarity with chimpanzees!).

The blueprint of this DNA sequencing is known as the DNA fingerprint (the term fingerprint is borrowed from the uniqueness of fingerprint pattern of an individual), which in turn is used as the template in biometrics. The technique was discovered by British geneticist and FRS Sir Alec Jeffreys in 1984.

Its application is not only limited to individual identification. It also has other applications in, say, paternal identification, identification of missing or dead persons, anthropological research, etc. It is exclusively used by the forensic departments in nailing suspects, when the sample required for investigation is available from the spot of crime. Although intrusive, samples can also be collected without the consent of the convict – these include pieces of hair or nail or tissue or skin or any kind of body component

(blood, saliva, urine etc.) which is available from shirt, hat, drinking vessel or from the place used by the convict at the time of crime. The possibility of sample degradation and contamination is the only drawback of this process.

Apart from all kinds of security purposes, the use of biometrics is becoming very popular in the research labs, educational institutions, offices, industries and other working places, to exactly record the time of arrival and departure of the employees and to restrict the entrance of unauthorised outsiders. Various devices for scanning thumb/forefinger, eye, etc. are available in the market (it is to be noted that metal detectors or the whole body scan devices do not belong to biometrics as they are used for detecting either metals or other objects apart from biometric features). The selection of the device depends upon the requirements and the capability to meet the expenses.

Each and every out of over 7.4 billion humans living on this earth has his or her own physical traits, not one but of several types. Among them characterisation by 'DNA fingerprint' is the ultimate device in biometrics. However, since this is quite an expensive and complicated process, the most popular method in biometrics is 'finger scanning'. If a biometric database of every human can be prepared and applied appropriately, modern crimes can be reduced to a large extent.

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