



# A Review of Advancements in Biometric Systems

Shradha Tiwari , Prof. J.N. Chourasia, Dr. Vijay S.Chourasia  
Electronics & Communication  
RTM, Nagpur University

---

**ABSTRACT--** *Biometric systems for today's high security applications must meet stringent performance requirements. In this paper, we provide an overview of the fundamentals of biometric identification, together with a description of the main biometric technologies currently in use, all of them within a common reference framework. Conventional biometric identification systems such as iris, fingerprint, face, DNA and speech have common weakness which is their vulnerability to possibility to falsify feature. We survey of some of the unimodal and multimodal biometrics presented that are either currently in use across a range of environments or those still in developing stage. We had tried to explain processes, application, instrument required, advantages, limitation and a general look on various existing system. Multimodal biometric systems are becoming more and more popular; they have more accuracy as compared to unimodal biometric systems. A comparison on different qualitative parameters of these technologies is also given, so that the reader may have a clear perspective of various parameters which should be taken into account. Things must change in all levels, ensuring that openness is achieved, and in which our way of life will play a major role. To solve problems is characteristic of present civilization and as far as, we are concerned our role is limited.*

---

## 1. INTRODUCTION -

A new race of human being is drawing on the horizon. Which will be capable of acknowledging what some humans of today are preparing for them beyond traditional teachings, it no longer corresponds to the current era. In recent years, it has become very important to identify a user in applications such as personnel security, finance, airport, hospital and many other important areas [1]. Human verification has traditionally been carried out by using a password and / or ID cards. To increase reliability and to reduce the, fraudulent use of identity a wide range of biometric is emerging e.g. fingerprint, face and iris [18]. The reliability of any biometric identification depends on ensuring that the signal acquired and compared has actually been recorded from a live body part of the person to be identified and is not a manufactured template [33].

Biometric is technique of using unique non transferable, physical characteristics, such as to gain entry for personal identification. It is a method of automatic verification of person based on some specific biometric features derived from his or her physiological and behavioral characteristics .However all these identification methods have weaknesses such as [2,3,4]:

1. Face and iris can be recorded by camera.
2. Speech can be recorded and replayed.
3. Fingerprint can be recreated in lack using an object touched by that person.
4. Signature can be reproduce easily.
5. It is easy to steal a piece of DNA from an unsuspecting subject.

All circumstances motivate to think in multi-dimension identification which is very active area of research. New systems using features like hand vascular pattern, vein, gait, human tissue, knuckle, ear canal and even evoked brain signal have been proposed [5]. However much reliance cannot be placed in to this biometrics as it can be forged by others. Another new and prospective candidate for identification is the electrocardiogram (ECG) which yields relative high results for human identification tasks [6, 7]. However, we note that ECG for identification is generally cumbersome due to the many (at least three) electrodes required.

Things should be defined by man and detected by science Biometric means :

*"Application of modern statistical method to measure biological objects" [15]. "To identifying an individual based on his or her distinguishing characteristics" [16].*

*"In general, feature extraction is a form of non-reversible compression, meaning that the original biometric image cannot be reconstructed from the extracted features" [21].*

Biometrics the term covers a wide range of technologies that can be used to identify and verify the person by measuring and analyzing human characteristics. Most of the system requires personal reliable recognition systems to confirm or determine the identity of an individual who require particular service [14, 17 and 121]. It operates by acquiring biometric data from an individual, extracting a feature set from the acquired data, and comparing this feature set against the template set in the database.

The design of a biometric system takes account of five objectives: cost, user acceptance and environment constraints, accuracy, computation speed and security as shown in fig. Reducing accuracy can increase speed. Typical examples are hierarchical approaches. Reducing user acceptance can improve accuracy.

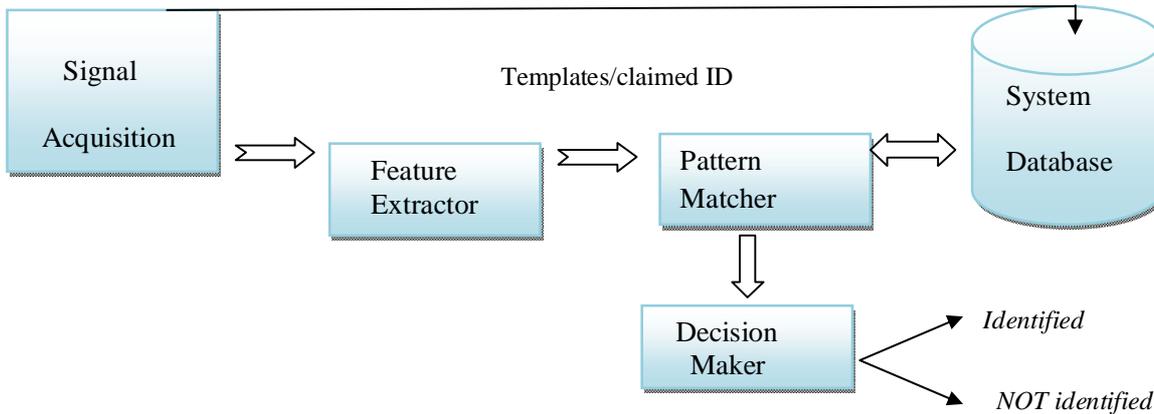
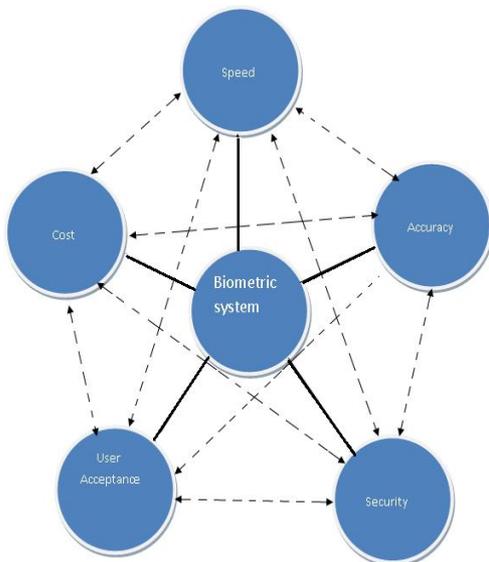


Fig explains general biometrics system and its output processes.

The main benefit of biometric technology is that it is more safe and comfortable than traditional systems.



#### Objectives of Biometric System

Biometric traits can be split into two main categories [14]:

1. *Physiological Biometrics: It is based on direct measurements of a part of the human body. Fingerprint, face, iris, and hand scan recognition belong to this group.*
2. *Behavioral Biometrics: It is based on asurements and data derived from an action performed by the user, and thus indirectly measures some characteristics of the human body. Signature, gait, gesture, and key stroking recognition belong to this group.*

#### 2. EXISTING TECHNIQUES OF HUMAN AUTHENTICATION AND IDENTIFICATION -

In information technology, biometrics refers to technologies that measure and analyzes human body characteristics, such as DNA, fingerprints, eye, retinas and irises, voice patterns, facial patterns and hand measurements, for authentication purposes. Since there are various biometrics characteristics in use, a brief over view on various biometrics characteristic is given.

##### 2.1 FINGERPRINT -

Fingerprint identification is probably the best known biometric technique, because of its widespread application in forensic sciences and law enforcement scenarios. Archeological evidence says that finger print impression were the only authentic identification since B.C. The pattern of fingerprint ridges and pores is different in each person; no two people have the same pattern of ridges. Even for the identical twins, they may have similar general pattern but fine details are different.



#### 2.1.1 PRINCIPLE OF OPERATION -

There are three main technologies available today for the capture of fingerprint images [19]:

1. Optical technology-this is the oldest and most popular form used for image capture. Essentially, a camera (located in the fingerprint recognition device) takes raw images of the fingerprint.
2. Silicon technology-a silicon chip is used, and the capacitive characteristics of the fingerprint are captured into images.
3. Ultrasound technology-Basically, an ultrasound image of the fingerprint is captured. This technology has proved to work better than the other two, because it can penetrate through different types of fingerprint dirt and residue.

#### 2.1.2 AREA OF APPLICATION -

Fingerprint recognition is the most stable biometric technology; it is longest and has more commercial applications. These are widely used in forensic department, in network access, physical access entry configuration; it is also choice of financial institutions.

#### 2.1.3 INSTRUMENTATION REQUIRED -

- Fingerprint scanner can be of various types (such as optical, solid state e.t.c).
- Fourier transforms.
- Gabor filters.

#### 2.1.4 ADVANTAGES -

It has relatively outstanding features of universality, permanence, uniqueness, Accuracy and low cost which makes it most popular and a reliable technique so is the leading biometric technology [133].there is archeological evidence that Assyrians and Chinese ancient civilizations have used fingerprints as a form of Identification since 7000 to 6000 BC [134].

#### 2.1.5 LIMITATION -

- Fingerprint can be recreated in latex using an object touched by the person.
- Noisy data can also result film accumulation of dirt on a sensor or from ambient conditions.[3]
- Since the finger actually touches the scanning device, reduce sensitivity and reliability of optical scanners.

#### 2.1.6 SIGNIFICANT DEVELOPMENT IN THIS AREA [14, 18, 33, 34] -

Jain and Prabhakar [143] (2001) Most of the fingerprint identification system employs techniques based on minutiae points. Chikkerur et al. [144] (2006) Although the minutiae pattern of each finger is quite unique, noise and distortion during the acquisition of the fingerprint and errors in the minutiae extraction process results in a number of missing and spurious minutiae. Ridge feature-based method is used to remove this problem. It uses orientation of frequencies of ridges, ridge shape and texture information for fingerprint matching. Yusufi et al. [145] (2007) The correlation based technique uses two fingerprint images superimposed and correlate the corresponding pixels for different alignment.Latter on Agrawal et al. [146] (2008) proposed gradient based approach to capture textural information by dividing each minutiae neighborhood locations into several local regions of which histograms of oriented gradients are then computed to characterize textural information around each minutiae location.

#### 2.2 FACE -

Face recognition for its easy use and non intrusion has made it one of the popular biometric [135]. Basically face recognition is done by verification and watch list [22]. Face recognition can be made from still Images, video sequences, stereo, range images; etc Face recognition under well controlled acquisition conditions is more accurate and provides high recognition rates even when a large number of subjects are in the gallery [23, 24].

#### 2.2.1PRINCIPLE OF OPERATION -

Some facial recognition software algorithms identify facial features by extracting land marks or features from image of the subject's face [26]. For example an algorithm may analyze the relative position, size, and/or shape of eyes, nose, cheekbones, and jaws [27].These features are then used to search for other image with matching features. A newly emerging trend, claimed to achieve improved accuracies, by 3D face recognition. This technique uses 3D sensors [29].

#### 2.2.2 AREA OF APPLICATION -

The image capturing is done by with or without cooperation of the subject. Face recognition for its easy use and non instruction has made it one of the popular biometric [135]. Properly designed systems installed in airports, multiplexes, and other public places can identify individuals among the crowd. Facial recognition systems are also beginning to be incorporated into unlocking mobile devices. The android market is working with facial recognition and integrating it into their cell phones.

#### 2.2.3 INSTRUMENTATION REQUIRED -

- CCTV camera
- Any low-cost camera ("webcam") is usable for 2D face recognition
- Laser camera

2.2.4 ADVANTAGES - Advantage is that it does not require aid (or consent) from the test subject. This makes the system popular in typical application in security purpose. Properly designed systems installed in airports, multiplexes, and other public places can identify individuals among the crowd.



One advantage of 3D facial recognition is that it is not affected by changes in lighting like other techniques. The sensors work by projecting structured light onto the face which does a better job of capturing 3D face imagery [30].

#### 2.2.5 LIMITATION -

- Uncontrolled lighting, changes in facial expression, aging, and the recognition rate decreases significantly.
- Another problem is the fact that the face is a changeable social organ displaying a variety of expressions [14].
- The bad quality of the input data used for 3D facial recognition systems [18].

#### 2.2.6 SIGNIFICANT DEVELOPMENT IN THIS AREA [14, 18, 33, 34] -

During 1964 and 1965, Bledsoe, along with Helen Chan and Charles Bisson, worked on using the computer to recognize human faces (Bledsoe 1966a, 1966b; Bledsoe and Chan 1965). He was proud of this work, but because the funding was provided by an unnamed intelligence agency that did not allow much publicity, little of the work was published [30]. Bledsoe (1966a) described the following difficulties - "This recognition problem is made difficult by the great variability in head rotation and tilt, light intensity and angle, facial expression, aging, etc. Some other attempts at facial recognition by machine have allowed for little or no variability in these quantities. Yet the method of correlation (or pattern matching) of unprocessed optical data, which is often used by some researchers, is certain to fail in cases where the variability is great. In particular, the correlation is very low between two pictures of the same person with two different head rotations." Recognition algorithms can be divided into two main approaches, geometric, which look at distinguishing features, or photometric, which is a statistical approach that distills an image into values and compares the values with templates to eliminate variances [28]. K. W. Bowyer et al. [147] (2004) in opposition to 2D face recognition using in most cases normal intensity images, 3D face recognition consists acquired by one or several sensors. The use of additional information, as the depth and surface curvatures, can clearly increase the performance and the accuracy of such recognition systems. Damien Dessimoz et al. [18] (2006) focus on face recognition on single scene images defined as matching a scene image or sequence of scene images (video) with a stored template of the face. Alice et al. [148] (2007) presents paper which uses algorithms partial least square regression (PLSR). In the first experiment, we applied PLSR to face-pair similarity scores generated by seven algorithms participating in the Face Recognition Grand Challenge. The PLSR produced an optimal weighting of the similarity scores, which they tested for generality with a jackknife procedure.

#### 2.3 IRIS -

Iris is the process of recognizing a person by analyzing the random pattern of the iris [31]. This process of identification is relatively young. The performance of iris recognition systems is impressive.

#### 2.3.1 PRINCIPAL OF OPERATION [18, 31, 33] -

Iris recognition uses camera technology with subtle infrared illumination to acquire images of the detail-rich, intricate structures of the iris without causing harm or discomfort to subject. Digital templates encoded from these patterns by mathematical and statistical algorithms allow the identification of an individual or someone pretending to be that individual. Databases of enrolled templates are searched by matcher engines at speeds measured in the millions of templates per second per (single-core) CPU, and with infinitesimally small false match rates.

#### 2.3.2 AREA OF APPLICATION -

Many millions of persons in several countries around the world have been enrolled in iris recognition systems, for convenience purposes such as passport-free automated border-crossings, and some national ID systems based on this technology are being deployed [33].

#### 2.3.3 INSTRUMENTS REQUIRED -

- Monochrome CCD camera
- High quality digital camera (use infrared lights)
- 2D Gabor wavelet filter

#### 2.3.4 ADVANTAGES -

Responses of the iris to changes in light can provide an important secondary verification that the iris presented belongs to a live subject. The iris is stable, as it is an internal organ. This modality does not vary with age starting from the first year after birth until death. No foreign material usually contaminates the iris

#### 2.3.5 LIMITATION -

- The accuracy of scanners can be affected by changes in lighting.
- Iris scanners are significantly more expensive than some other forms of biometrics,
- There would be problem for disabled people.

#### 2.3.6 SIGNIFICANT DEVELOPMENT IN THIS AREA -

Adler in 1965 said that the human iris, which has a very complex layered structure unique to an individual, is an extremely valuable source of biometric information [32].

Vanaja et al. [149] (2011) focus on an efficient methodology for identification and verification for iris detection, even when the images have obstructions, visual noise and different levels of illuminations and we use the CASIA iris



database it work for UBIRIS Iris database which has images captured from distance while moving a person. Ashish et al. [150] (2012) presented work which involved developing an 'open-source' iris recognition system in order to verify both the uniqueness of the human iris and also its performance as a biometric. Gargi et al. [151] (2012) in this paper localization of the inner and outer boundaries of the iris is done by finding the maximum blurred partial derivative. Normalization of iris has been achieved by projecting the original iris in a Cartesian coordinate system into a doubly dimensionless pseudo polar coordinate system.

#### 2.4 PALMPRINT -

Palmprint is the region between the wrist and fingers. Palm prints are stable and shows high accuracy in representing each individual's identity wrinkles and texture can used for personal verification [136]. Palmprint-based identification is currently a potential alternative to human identification method of a well known fingerprint-based identification.

##### 2.4.1 PRINCIPAL OF OPERATION -

Palmprint research employs either high resolution or low resolution images. High resolution images are suitable for forensic applications such as criminal detection [39]. Low resolution images are more suitable for civil and commercial applications such as access control.

##### 2.4.2 AREA OF APPLICATION -

It offers promising future for medium-security access control system. Digital cameras and video cameras can be used to collect palmprint images without contact [37], an advantage if hygiene is a concern. Palm print based personal verification has quickly entered the biometric family due to its ease of acquisition, high user acceptance and reliability.

##### 2.4.3 INSTRUMENTS REQUIRED -

- CCD-based palmprint scanners
- Digital cameras
- Digital scanners and video cameras
- Unsharp masking

##### 2.4.4 ADVANTAGES -

Collection approaches based on digital scanners, digital cameras and video cameras require less effort for system design and can be found in office environments. Since palm is larger than a finger, palm print is expected to be even more reliable than fingerprint. Palm print images can be acquired with low resolution cameras and scanners and still have enough information to achieve good recognition rates. Permanence it is resistance to aging.

##### 2.4.5 LIMITATION -

- Digital and video cameras used to collect palm print images and images may be recognition problem as their quality is low,
- Collect image in an uncontrolled environment with illumination variations and distortions due to hand movement [41].

##### 2.4.6: SIGNIFICANT DEVELOPMENT IN THIS AREA -

Zhang et al. and Han [88, 89] (2004) were the first two research teams developing CCD-based palmprint scanners. CCD-based palmprint scanners capture high quality palmprint images and align palms accurately because the scanners have pegs for guiding the placement of hands. Nicholas Sia Pik Kong et al. [94] (2010) proposed multiple layers block overlapped histogram equalization for local content emphasis. This method consists of three stages, which are enhancement stage, noise reduction stage and merging stage. Hashemi et al. [96] (2012) uses a chromosome representation together with corresponding operators. This method makes natural looking images especially when the dynamic range of input image is high. S. Palanikumar et al. [36] (2012) developed EOPE method for image contrast enhancement enhances image quality. The simulation results show that the method can enhance image contrast effectively by improving the information and preserving the brightness.

#### 2.5 HAND GEOMETRY -

Around the paintings of the cave there exist palms used to identify the creator of the painting.

Hand geometry, as the name suggests, refers to the geometric structure of the hand [137]. It refers to the geometric structure of the hand that is composed of the lengths of fingers, the widths of fingers, and the width of a palm, etc. One of the physiological characteristics for recognition is hand geometry, which is based on the fact that each human hand is unique [57].

##### 2.5.1 PRINCIPAL OF OPERATION -

Hand geometry measurement is non intrusive and the verification involves a simple processing of the resulting features [42]. One of the cheapest is the hand geometry. Hand geometry readers measure a user's hand along many dimensions and compare those measurements to measurements stored in a file.

2.5.2 AREA OF APPLICATION - The availability of low cost, high speed processors and solid state electronics made it possible to produce hand scanners at a cost that made them affordable in the commercial access control market. There are even verification systems available that are based on measurements of only a few fingers instead of the entire hand.



### 2.5.3 INSTRUMENTS REQUIRED -

- Scanner
- Digital cameras
- Video cameras

### 2.5.4 ADVANTAGES -

The advantages of a hand geometry system are that it is a relatively simple method that can use low resolution images and provides high efficiency with great users 'acceptance [90, 139]. The main advantage of biometric methods is the ability to recognize, which is made by means of a physical feature or a unique pattern [140]. With these methods and individual can hardly be victim of plagiarism.

### 2.5.5 LIMITATION -

- Since it is not very distinctive it cannot be used for identification, but rather in a verification mode.
- It may not be invariant during the growth period of children.
- Limitations in dexterity (arthritis) or even jewelry may influence extracting the correct information [14].

### 2.5.6 SIGNIFICANT DEVELOPMENT IN THIS AREA -

Ratha et al. in 1988 exist evidence to believe that since more than 3200 years ago the geometry of the hand was used to identify humans. Singh et al. [141] (2009) present an overview of biometric hand geometry recognition. Five different methods were compared and the authors talk about the advantages and disadvantages of each method. An approach that uses the color of the skin of the hand as a feature for recognition is recommended. The best classifier proposed was Gaussian Mixture Models (GMM). Osslan Osiris et al. [42] (2011) Use 31 wavelet features for human hand geometry identification is presented. Related works about hand geometry identification, presents the tests and results obtained. Conclusions and further works are presented. Mathivanan et al. [152] (2012) paper focuses on developing an efficient human identification and verification system using Multi Dimensional hand based biometrics for secured access control. They investigate a new approach to achieve performance improvement by simultaneously acquiring and combining three-dimensional (3-D) and 2-D Hand Geometry Features from the human hand.

### 2.6 ODOR -

It's absolutely clear that people with differing immunity genes produce different body odors. Electronic/artificial noses: developed as a system for the automated detection and classification of odors, vapors, gases. Frequently, odor testing is overlooked as a valuable tool for engineering and operations.

#### 2.6.1 PRINCIPAL OF OPERATION -

Each object spreads around an odor that is characteristic of its chemical composition and this could be used for distinguishing various objects. This would be done with an array of chemical sensors, each sensitive to a certain group of compounds. Analogous to the human nose, the paper explains a method by which an electronic nose can be used for substance identification.

#### 2.6.2 AREA OF APPLICATION

The use of electronic noses (EN) is a rapidly developing technique used in substance identification. In the food industry, electronic noses can be used for quality testing [43]. As a safety device, the use of electronic noses is often employed to ensure a low level of toxicity, and through emerging technologies, electronic noses have found potential in the medical industries as a diagnostic tool [44]. In addition to its various applications as a stand-alone device, electronic noses can be combined with other sensor systems, such as electronic tongues [46][45] and mobile robots [44], to diversify its use.

### 2.6.3 INSTRUMENTS REQUIRED -

- Conductivity Sensors
- Piezoelectric Sensors
- Metal-oxide-silicon field-effect-transistor (MOSFET)
- Optical Fiber Sensors

### 2.6.4 ADVANTAGES -

It was also shown in some cases that it is possible to identify mixtures of odors through the recognition of the mixture's components.

### 2.6.5 LIMITATION -

- There are no available commercial applications on the market yet.
- Artificial noses are not yet sophisticated enough to do all the job
- Difficult senses to quantify.
- Deodorants and perfumes could lower the distinctiveness.

### 2.6.6 SIGNIFICANT DEVELOPMENT IN THIS AREA -

David Tin Win [155] (2005) considers the principles of the e-nose; identifies possible applications; and lists some commercial instruments.

Sichu Li et al. [157] (2009) purpose are to review sensor systems and other field deployable detection systems with respect to their potential application for human odor detection and identification.



Jacek Gębicki et al. [62] (2014) presents potentialities of the electronic nose as a tool for identification of particular organic aroma compounds and their mixtures differing in functional group and compares this approach with the classical sensory analysis. A prototype of electronic nose designed by the authors was able to identify and differentiate solutions of aroma compounds in a specific proportion.

#### 2.7. DNA -

DNA is unique to an individual and remains constant through life; it follows the laws of Mendelian inheritance, with a child's DNA composed of equal parts of its parents' DNA [47]. Among the various possible types of biometric personal identification system, deoxyribonucleic acid (DNA) provides the most reliable personal identification. It is intrinsically digital, and does not change during a person's life or after his/her death [49].

##### 2.7.1 PRINCIPAL OF OPERATION -

A human body is composed of approximately of 60 trillion cells. DNA, which can be thought of as the blueprint for the design of the human body, is folded inside the nucleus of each cell. DNA is a polymer, and is composed of nucleotide units that each has three parts: a base, a sugar, and a phosphate [49].

##### 2.7.2 AREA OF APPLICATION -

When identifications are difficult to obtain, particularly in the aftermath of armed conflict, it may be technically feasible to initiate a DNA-led identification.

##### 2.7.4 ADVANTAGES -

DNA can be analyzed to produce a profile that can be reliably compared with other profiles. DNA is intrinsically digital and unchangeable during a human's life and even after death. DNA is the structure that defines who we are physically and intellectually, unless an individual is an identical twin, it is not likely that any other person will have the same exact set of genes.

##### 2.7.5 LIMITATION -

- The most serious flaw is that DNA analysis is time-consuming
- No real-time application is possible because DNA matching requires complex chemical methods involving expert's skills.
- All this limits the use of DNA matching to forensic applications [14].

##### 2.7.6 SIGNIFICANT DEVELOPMENT IN THIS AREA -

Ranbir Soram et al. [158] (2010) propose a method to utilize biometric DNA information and the intractability of Elliptic Curve Discrete Logarithm Problem (ECDLP) for personal authentication in information security systems. Also present background information on DNA and the elliptic curve discrete logarithm problem, as well as the commonly applied respective mathematics.

Sandra Maestre et al. [159] discuss the advantages and disadvantages of using DNA biometrics as compared to other authentication methods as well as other biometrics. Further go into depth in comparing the biometrics of DNA alongside other biometrics using human characteristics in six distinctive parameters.

Masaki Hashiyada et al.[49] (2011) personally identifying information be obtained from DNA sequences in the human genome personal ID be generated from DNA-based information the advantages, deficiencies, and future potential for personal IDs generated from DNA data (DNA-ID).

#### 2.8 SIGNATURE -

Handwritten signatures are considered as the most natural method of authenticating a person's identity. A signature by an authorized person is considered to be the "seal of approval" and remains the most preferred means of authentication. However human signatures can be handled as an image and recognized using computer vision and neural network techniques [67].

##### 2.8.1 PRINCIPAL OF OPERATION -

With modern computers, there is need to develop fast algorithms for signature recognition [66].

The goal of signature verification is examination of an input signature to determine whether it is genuine or forgery [68]. On-line or Dynamic Signature Verification Technique is based on dynamic characteristics of the process of signing.

##### 2.8.2 AREA OF APPLICATION -

The method of signature verification reviewed in this paper benefits the advantage of being highly accepted by potential customers [66]. The use of the signature has a long history which goes back to the appearance of writing itself [68]. widely accepted by people as it is oldest means of verification.

##### 2.8.3 INSTRUMENTS REQUIRED -

- scanner
- camera
- PDA
- Laptop



#### 2.8.4 ADVANTAGES -

The hand written signature is regarded as the primary means of identifying the signer of a written document. It is easier for people to migrate from using the popular pen-and-paper signature to one where the handwritten signature is captured and verified electronically.

#### 2.8.5 LIMITATION -

- Non-linear changes with size changing and dependency to time and emotion.
- Limitation of signature verification is examination of an input signature to determine whether it is genuine or forgery.
- Signature gradually changes over time.
- Sometimes same person has variations in sign.

#### 2.8.6 SIGNIFICANT DEVELOPMENT IN THIS AREA -

Diana Kalenova et al. [68] (2005) developed methods of verification include both online (and dynamic) and off-line (static) signature verification algorithms. The dynamic methods covered, are based on the analysis of the shape, speed, stroke, pen pressure and timing information. While static method involves general shape recognition technique. Kiani et al. [78] (2009) extracted appropriate features by using Local Radon Transform applied to signature curvature and then classified them using SVM classifier. Their proposed method is robust with respect to noise, translation and scaling. Experimental results were implemented on two signature databases: Persian (Iranian) and English (South African). O.C Abikoye et al. [66] (2011) created a system with the ability to recognize hand written signature and verify its authenticity and get the computer to solve a problem with a method of solution that goes outside the convention of writing an algorithmic process. Pradeep Kumar et al. [67] (2013) presented method of image preprocessing, geometric feature extraction, neural network training with extracted features and verification. A verification stage includes applying the extracted features of test signature to a trained neural network which will classify it as a genuine or forged. The Off-line Signature Recognition and Verification is implemented using MATLAB.

#### 2.9. VOICE -

The underlying premise for voice authentication is that each person's voice differs in pitch, tone, and volume enough to make it uniquely distinguishable [59]. A convenient and user-friendly interface for Human Computer Interaction is an important technology issue. Spoken languages dominate communication among human being and hence people expect speech interface with computers [72].

#### 2.9.1 PRINCIPAL OF OPERATION -

The pattern matching algorithms used in voice recognition are similar to those used in face recognition [14]. Today, speaker recognition systems and algorithms can be subdivided into two broad classes: Text-dependent systems rely on the user pronouncing certain fixed utterances, which can be a combination of digits, a password, or any other phrase. Thus; the user will prove her knowledge of the passphrase in addition to providing her biometrics [18].

#### 2.9.2 AREA OF APPLICATION -

Speaker recognition is highly suitable for applications like tele-banking. Voice biometric is primarily used in verification mode.

#### 2.9.3 INSTRUMENTS REQUIRED -

- A simple telephone
- microphone

#### 2.9.4 ADVANTAGES -

A simple telephone or microphone is all that a user needs to authenticate using her voice [59] so the cost is low. Voice authentication is easy to use and easily accepted by users. Perhaps most important to the future of voice biometrics is that it is the only biometric that allows users to authenticate remotely. It is quick to enroll in a voice authentication system. Authentication is very fast. Microphone is all that a user needs to authenticate using her voice [59].

#### 2.9.5 LIMITATION -

- Changes over time due to age, medical conditions and emotional state.
- This means that voice identification is not stable.
- It is quite sensitive to background noise and Playback spoofing.

#### 2.9.6 SIGNIFICANT DEVELOPMENT IN THIS AREA -

Doddington [65] (1970) automatic speaker recognition was pioneered, and subsequently became a very active research area. Lisa Myers et al. [59] (2004) examine in more depth voice biometrics, voice biometrics comparison with other biometric technologies, its accuracy, and its uses to accomplish identity authentication. Privacy issues with the technology. Finally, explore how the technology has evolved, and some current and future applications of voice biometrics in our daily lives, illustrating voice biometrics have significant future potential. Neema Mishra et al. [64] paper Feature extraction is implemented using well-known Mel-Frequency Cepstral Coefficients (MFCC). Pattern matching is done using Dynamic time warping (DTW) algorithm. H'ebert et al. [162] (2008) the text-dependent systems, however, require a user to repronounce



some specified utterances, usually containing the same text as the training data. A survey of text-dependent verification techniques is given.

#### 2.10. EAR -

It has been suggested that the shape of the ear and the structure of the cartilaginous tissue of the pinna are distinctive. Matching the distance of salient points on the pinna from a landmark location of the ear is the suggested method of recognition in this case.

##### 2.10.1 PRINCIPAL OF OPERATION -

Human ear recognition system is a new technology in this field [103]. The change of appearance with the expression was a major problem in face biometrics but in case of ear biometrics the shape and appearance is fixed. There are at least three methods for ear identification: (i) taking a photo of an ear, (ii) taking “earmarks” by pushing ear against a flat glass and (iii) taking thermogram pictures of the ear. The most interesting parts of the ear are the outer ear and ear lobe, but the whole ear structure and shape is used [109].

##### 2.10.2 AREA OF APPLICATION -

The major application of this technology is crime investigation. Ear features have been used for many years in the forensic sciences for recognition. It appears that ear biometrics is a good solution for computerized human identification and verification systems [103].

##### 2.10.3 INSTRUMENTS REQUIRED -

- CCTV camera
- 1D log-Gabor and 2D Gabor filters

##### 2.10.4 ADVANTAGES -

In case of ear biometrics the shape and appearance is fixed [103]. It is most stable biometric system. Ear is large as compared to iris [104] and fingerprint. It has been found that no two ears are exactly the same even that of identical twins [106], [107]. Comparatively Computational complexity is very less. Time for processing is reduced as only one contour is used making identification faster. An infrared image can be used to eliminate hair.

##### 2.10.5 LIMITATION -

- As the images are not ideal an error in the outer shape of the ear can occur, which result in the failure of approach.
- The effect of such as hair, hats, and earrings on the performance of ear recognition algorithms is unclear.
- This method is not believed to be very distinctive.

##### 2.10.6 SIGNIFICANT DEVELOPMENT IN THIS AREA -

A. Bertillon et al. [161] in as early as 1890 the potential for using the ear’s appearance as a means of personal identification was recognized and advocated by the French criminologist. Moreno et al., 1999 Ears have several advantages over complete faces: reduced spatial resolution, a more uniform distribution of color, and less variability with expressions and orientation of the face. In face recognition there can be problems with e.g. changing lightning, and different head positions of the person. Mohamed Ibrahim et al. [108] (2007) presents a novel approach to recognize individuals based on their outer ear images through spatial segmentation. This approach to recognizing is also good for dealing with occlusions. The study present several feature extraction techniques based on spatial segmentation of the ear image. Anam Tariq et al. [103] (2012) proposed a new approach for an automated system for human ear identification. Author suggest first Stage, preprocessing of ear image is done for its contrast enhancement and size normalization. In the second stage, features are extracted through haar wavelets followed by ear identification using fast normalized cross correlation in the third stage. Singh Amarendra et al. [112] (2012) investigate a new approach for the automated human identification using ear imaging. It completely automated approach for the robust. Segmentation of curved region of interest using morphological operator sand Fourier descriptors.

#### 2.11 HEART SOUND -

The heart sound can be used as a potential new biometrics since it is generally acceptable, and is sufficiently robust to various fraudulent methods and attacks to the system [8]. Human heart sounds are very natural signals, which have been applied in the doctor’s auscultation for health monitoring and diagnosis for thousands of years [123].

##### 2.11.1 PRINCIPAL OF OPERATION -

The human heart has four chambers, two upper chambers called the *atria* and two lower chambers called *ventricles*. There are valves located between the atria and ventricles, and between the ventricles and the major arteries from the heart [124]. These valves close and open periodically to permit blood flow in only one direction. Two sounds are normally produced as blood flows through the heart valves during each cardiac cycle. The first heart sound S1 is a low, slightly prolonged “lub”, The second sound S2 is a shorter, high-pitched “dup”[123].

##### 2.11.2 AREA OF APPLICATION -

The method enables near-real time application using Low power embedded systems, such as those require to implement in health solutions [127].



### 2.11.3 INSTRUMENTS REQUIRED -

- Electronic stethoscope
- Microphone

### 2.11.4 ADVANTAGES -

Universal as every living human being has a pumping heart Easy to measure heart sound signals it is recorded using an electronic stethoscope. Vulnerability it cannot be copied or reproduced easily.

### 2.11.5 LIMITATION -

- Medium Distinctiveness
- Low Permanence
- Low Collectability

### 2.11.6 SIGNIFICANT DEVELOPMENT IN THIS AREA -

Koksoon Phua et al. [121] (2007) propose a novel biometric method based on heart sound signals. The biometric system comprises an electronic stethoscope, a computer equipped with a sound card and the software application. The approach consists of a robust feature extraction scheme which is based on cepstral analysis with a specified configuration, combined with Gaussian mixture modeling.

T. Chen et al. [129] (2009) present an article preliminary work performed on a gold standard database and a cellphone platform. Results indicate that HR and HRV can be accurately assessed from acoustic recordings of heart sounds using only a cellphone and hands-free kit. Fatemian et al. [11] (2010) studied for the fusion of ECG and PCG signals into a multi-modal biometric framework. It is expected for a security system to boost its accuracy when relying on more than one biometric trait for recognition decisions. Based on this fact, this work advocates that fusion of the two cardiac signals has not only standard biometric performance benefits, but can also provide a higher level view of the cardiac function with the emphasis placed on the particular characteristics of every individual.

### 2.12. MULTIMODAL BIOMETRIC SYSTEM -

Limitations of the unimodal biometric systems can be alleviated by using multimodal biometric systems. It uses multiple sensors or biometrics to overcome the limitations of unimodal biometric systems.

The goal of multi-biometrics is to reduce one or more of the following[101]:

- False accept rate (FAR)
- False reject rate (FRR)
- Failure to enroll rate (FTE)
- Susceptibility to artifacts or mimics

This century information technology, network technology fundamentally changes our traditional way of life. The biometric authentication technology began to flourish in high-tech, will occupy in social life more and more important position [14].

Multimodal biometric systems use multiple sensors or biometrics to overcome the limitations of unimodal biometric systems. While unimodal biometric systems are limited by the integrity of their identifier, it is unlikely that several unimodal systems will suffer from identical limitations [133].

- 1) Multiple sensors: the information obtained from different sensors for the same biometric are combined. For example, optical, solid-state, and ultrasound based sensors are available to capture fingerprints.
- 2) Multiple biometrics: multiple biometric characteristics such as fingerprint and face are combined. These systems will necessarily contain more than one sensor with each sensor sensing a different biometric characteristic.
- 3) Multiple units of the same biometric: fingerprints from two or more fingers of a person may be combined, or one image each of the two irises of a person may be combined.
- 4) Multiple snapshots of the same biometric: more than one instance of the same biometric is used for the enrollment and/or recognition.
- 5) Multiple representations and matching algorithms for the same biometric: this involves combining different approaches to feature extraction and matching of the biometric characteristic.

### SIGNIFICANT DEVELOPMENT IN THIS AREA -

A Biometric Identification System Based on Eigen palm and Eigen finger Features -

Slobodan Ribaric et al. [99] in 2005 proposed multimodal biometric identification system 1. Features extracted by projecting palm images into the subspace obtained by the K-L transform are called eigenpalm features, whereas those extracted by projecting strip-like images of fingers are called eigenfinger features. Fusion at the matching-score level is used.

#### *Human Identification from Body Shape*

Afzal Godilb et al. [100] investigate the utility of static anthropometric distances as a biometric for human identification. The 3D landmark data from the CAESAR (Civilian American and European Surface Anthropometry Resource) database is used to form a simple biometric consisting of distances between fixed rigidly connected body locations. Distance between fixed rigidly connected body locations is fixed. This biometric is over, and invariant to view and body posture. We use this to quantify the asymmetry of human bodies, and to characterize the interpersonal and intrapersonal distance distributions.

Face and Ear -

Mohamed Ibrahim Saleh [108] in 2007 A multimodal approach is also investigated where face and ear images are combined to enhance the identification process of the individuals. Another approach is also presented by combining two segmentation methods together, and also combining face images with ear segments.

Hossain et al. [119] in 2011 survey several important researches works published in this area and we found our new technology to identify a person using multimodal physiological and behavioral biometrics.

Visible - and thermal-spectrum face -

Arandjelović, Hammoud, and Cipolla 2006 achieved a 97% recognition rate using a combination of visible- and thermal-spectrum face images on a dataset whereas their visible-spectrum face recognition algorithm achieved by itself, and their thermal-spectrum algorithms achieved.

Face and gait feature fusion model -

Hossain et al. [119] in 2011 Introduces new fusion approach will allow recognition of non-cooperating individuals at a distance in video, who expose side views to the camera. Information from two biometric sources, side face and gait, will be utilized and fused at feature level. For face, a high- resolution side face image will be constructed from multiple video frames.

Fusion of face and speech -

Ishwar S. Jadhav et al. [63] in 2011 proposes new technique for human identification using fusion of both face and speech which can substantially improve the rate of recognition as compared to the single biometric identification for security system development.

Fingerprints, Iris and DNA Features based Multimodal Systems -

Prakash Chandra Srivastava et al. [160] in 2013 research paper discussed the analysis and shortcomings of fingerprints, iris image and DNA sequence based multimodal systems. Biometric systems based on thumbprint, iris image, finger veins, palates, DNA sequence, voice, and gait signature can identify a person but multiple features based biometric systems give better matching scores in comparison to single feature based biometric systems.

3. Comparison to other biometric traits -

The acceptance of a Biometric system depends on one hand on its operational, technical, and manufacturing characteristics and, on the other, on the final application and its financial possibilities[122]. It is also related to many other parameters which we are going to discuss.

Jain et al. (2004) and Luis-Garsia et al. (2003) present a classification of available biometric traits with respect to various qualities that, according to the authors, a trait should possess [121, 122, and 133]:

- *Universality*: each person should possess it;
- *Accuracy*: results should be accurately measured;
- *Distinctiveness*: it should be helpful in the distinction between any two people;
- *Permanence*: it should not change over time;
- *Acceptability*: the users of the biometric system should see the usage of the trait as a natural and trustable thing to do in order to authenticate;
- *Easy to use*: There is a practical trade of between the complexity of use and the security level to be assured;
- *Real time access*: verification should on the basis of real time;
- *User Friendly*: usually users will not accept cumbersome systems, and they will consider as such any one that is difficult to be used;
- *Cost Effective*: BISs have developed into very cost effective business solutions, there are a number of issues to consider when estimating the total cost to deploy such a system.

Comparison of various existing Biometric Technology on the basis of various parameters

(L-low, M-medium, H-high)

Biometric	Universal	Accuracy	Distinctiveness	permanence	Acceptability	Easy to use	Real time Access	User Friendly	Cost Effective
FINGERPRINT	M	H	H	H	M	M	M	L	M
FACE	H	L	L	M	H	H	M	H	L
IRIS	H	M	H	H	L	M	H	M	H
PALMPRINT	M	M	H	H	M	H	M	M	H



HAND GEOMETRY	M	M	M	M	M	H	M	M	H
ODOR	H	L	H	M	M	L	H	L	H
DNA	H	H	H	H	L	L	L	L	H
SIGNATURE	L	M	L	L	H	M	L	H	M
VOICE	M	M	L	L	H	H	L	H	L
EAR	M	M	H	H	H	M	M	L	L
HEART SOUND	H	H	M	H	M	M	H	M	M
MULTIMODAL	H	H	M	H	M	M	H	M	L

The advantage that Biometrics presents is that the information is unique for each individual and that it can identify the individual in spite of variations in the time. The pillars security is: authentication, privacy authorization, data integrity and non-repudiation. Biometrics can provide all this requirements with quite lot reliability. Although biometrics is considered the most effective and safe method, we have to bear in mind its disadvantages, for example, that since it is a relative new technology, it is not still integrated in personal computers. Medical problems, aging, cost as well as social acceptability are few serious drawbacks which should be taken into account. Finger, Iris is some so far established systems.

#### 4. CONCLUSIONS -

The aim of this paper is to review the usefulness of biometric identification systems, their types, principle of operation, application area, instruments required, advantages, disadvantages and significant development in recent years. The biometrics systems are effective for human identification and authentication over various levels of implementation, such systems are difficult to forge and can be made secure by combining more than one biometric traits, that is multimodal biometric systems. The latest research indicates avenues for human identification is more effective, and far more challenging. We studied various research papers, journals, international conferences summarizing we can say that development in direction of an innovative and cost-effective module has to be done.

#### 5. REFERENCES -

1. J. Ortega-Garcia, J. Bigun, D. Reynolds, J. Gonzalez-Rodriguez, Authentication gets personal with biometrics, *IEEE Signal Process. Mag.* 21 (2) (2004) 50–62.
2. M. Faundez-Zanuy, On the vulnerability of biometric security systems, *IEEE Aerosp. Electron. Syst. Mag.* 19 (6) (2004) 3–8.3. F. Dario, Biometrics: future abuses, *Comput. Fraud Secur.* 2003 (10) (2003) 12–14.
4. T. Matsumoto, H. Matsumoto, K. Yamada, S. Hoshino, Impact of artificial gummy fingers on fingerprint systems, *Proc. SPIE* 4677 (2002) 275–289.
5. R. Palaniappan and P. Raveendran. “Individual identification technique using visual evoked potential signals”, *IEE Electronics Letters*, vol.138, issue 25, pp.1634-1635, December 2002.
6. S. A. Israel, J. M. Irvine, A. Cheng, M. D. Wiederhold, B. K. Wiederhold. “ECG to identify individuals”, *Pattern Recognition*, vol. 38, no. 1, pp. 133-142, January 2005.
7. I. Biel, O. Pettersson, L. Philipson, and P. Wide. “ECG Analysis: A New Approach in Human Identification”, *IEEE Transactions on Instrumentation and Measurement*, vol. 50, no. 3, pp. 808 – 812, June 2001.
8. K. Phua, J. Chen, T. H. Dat, L. Shue, Heart sound as a biometric, *Pattern Recognition, The Journal of the pattern recognition society*, *Pattern Recognition* 41 (2008) 906 – 919.
9. Tran, D. H., Leng, Y. R. & Li, H. (2010). Feature integration for heart sound biometrics, *Acoustics Speech and Signal Processing (ICASSP)*, 2010 IEEE International Conference on, pp. 1714 –1717.
10. Jasper, J. & Othman, K. (2010). Feature extraction for human identification based on envelopogram signal analysis of cardiac sounds in time-frequency domain, *Electronics and Information Engineering (ICEIE)*, 2010 International Conference On, Vol. 2, pp. V2–228 –V2–233.
11. Fatemian, S., Agrafioti, F. & Hatzinakos, D. (2010). Heartid: Cardiac biometric recognition, *Biometrics: Theory Applications and Systems (BTAS)*, 2010 Fourth IEEE International Conference on, pp. 1 –5.
12. El-Bendary, N., Al-Qaheri, H., Zawbaa, H. M., Hamed, M., Hassanien, A. E., Zhao, Q. & Abraham, A. (2010). Hsas: Heart sound authentication system, *Nature and Biologically Inspired Computing (NaBIC)*, 2010 Second World Congress on, pp. 351 – 356.
13. Justin Leo Cheang Loong, Khazaimatol S Subari, Muhammad Kamil Abdullah, Nurul Nadia Ahmad and Rosli Besar Comparison of MFCC and Cepstral Coefficients as a Feature Set for PCG Biometric Systems *World Academy of Science, Engineering and Technology* 68 2010
14. S. Sumathi and R. RaniHema Malini research Scholar, Sathyabama University, Chennai-96 An Overview of Leading Biometrics for Human Identity
15. Oxford English Dictionary. Oxford Edition, 2004.



15. Person Identification Using Ear Biometrics Md. Mahbubur Rahman, Md. Rashedul Islam, Nazmul Islam Bhuiyan, Bulbul Ahmed, Md. Aminul Islam Computer Science and Engineering Discipline, Khulna University, Khulna-9208, Bangladesh. International Journal of the Computer, the Internet and Management Vol. 15#2 (May - August, 2007) pp 1 - 8
16. R. M. Bolle, J. H. Connell, S. Pankanti, N. K. Ratha, and A. W. Senior, Guide to Biometrics. New-York: Springer-Verlag, 2003.
17. A. K. Jain, R. P. W. Duin, and J. Mao, "Statistical pattern recognition: A review," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 22, no. 1, pp. 4–37, 2000.
18. Damien Dessimoz, Jonas Richiardi, Prof. Christophe Champod, Dr. Andrzej Drygajlo Research Report "Multimodal Biometrics for Identity Documents" Research report version-2.0, June- 2006 .
19. [www.htgadvancesystem.com](http://www.htgadvancesystem.com).
20. A. K. Jain, A. Ross, "Multibiometric Systems", Appeared in Communication of the ACM Special Issue on Multimodal Interfaces, Vol. 47, No.1, pp. 34-40, January 2004.
21. J. L. Wayman, A. K. Jain, D. Maltoni, and D. Maio, "An introduction to biometric authentication systems," in Biometric Systems: Technology, De-sign and Performance Evaluation, J. L. Wayman, A. K. Jain, D. Maltoni, and D. Maio, Eds. London: Springer-Verlag, 2005, ch. 1, pp. 1–20.
22. Phillips, P.J., Micheals, P.J., Blackburn, R.J., Tabassi, D.M., Bone, J.M.: FaceRecognition vendor test 2002: Evaluation Report. Technical report, NIST (2003)
23. Tolba, A., El-Baz, A., El-Harby, A.: Face recognition: A literature review. International Journal of Signal Processing 2 (2006)
24. Zhao, W., Chellappa, R., Phillips, P.J., Rosenfeld, A.: Face recognition: A literature survey. ACM Comput. Surv. 35 (2003)
25. Robust and Scalable Approach to Face Identification William Robson Schwartz, Huimin Guo, Larry S. Davis University of Maryland
26. Bonsor, K. "How Facial Recognition Work"(2008)
27. Smith, Kelly "Face Recognition"(PDF)(2008)
28. The Wikimedia Foundation, Inc. on 24 June 2013.
29. Williams, Mark. "Better Face-Recognition Software" Retrieved 2008-06-02.
30. Facial recognition system From Wikipedia, the free encyclopedia.
31. [www.biometrics.gov](http://www.biometrics.gov) up dated in 7 August 2006.
32. R. P. Wildes, "Iris recognition: An emerging biometric technology," in Proceedings of the IEEE, vol. 85, no. 9, 1997, pp. 1348–1363.
33. Wikipedia, the free encyclopedia last modified on 15 July 2013 at 05:48.
34. Mir A.H, Rubab, S and Jhat, Z. A. Biometrics Verification: a Literature Survey. Journal of Computing and ICT Research, Vol. 5, Issue 2, pp 67-80.
35. Zetter, Kim (2012-07-25)." Reverse-Engineered Irises Look So Real, They Fool Fool Eye scanners" *Wired Magazine*. Retrieved 25 July 2012.
36. Entropy Optimized Palmprint Enhancement Using Genetic Algorithm and Histogram Equalization S. Palanikumar, M. Sasikumar, J. Rajeesh . International Journal of Genetic Engineering 2012, 2(2): 12-18 DOI: 10.5923/j.ijge.20120202.01
37. A Survey of Palmprint Recognition Adams Kong, David Zhang, and Mohamed Kamel.
38. S.Palanikumar, M.Sasikumar, J.Rajeesh , "Curvelet Based Palmprint Enhancement ", Proceedings of the International Conference on Computing Technologies ICONCT 2009 pp.79-84
39. NEC Automated Palmprint Identification System <http://www.necmalaysia.com.my/Solutions/PID/products/ppi.html>
40. D.D. Zhang, Ed., Biometrics Solutions for Authentication in an E-World. Norwell, MA: Kluwer, July 2002.
41. Jof the First IEEE International Conference on Biometrics: Theory, Applications, and Systems, 2007, pp. 1–6.
42. Biometric Human Identification of Hand Geometry Features Using Discrete Wavelet Transform Osslan Osiris Vergara Villegas, Humberto de Jesús Ochoa Domínguez, Vianey Guadalupe Cruz Sánchez, Leticia Ortega Maynez and Hiram Madero Orozco Universidad Autónoma de Ciudad Juárez Instituto de Ingeniería y Tecnología Mexico in 2011.
43. Odor Source Identification by Grounding Linguistic Descriptions in an Artificial Nose Amy Loutfi, Silvia Coradeschi, Tom Duckett and Peter Wide Center for Applied Autonomous Sensor Systems Department of Technology University of Örebro S-70182 Örebro, Sweden.
44. T. Duckett, M. Axelsson and A. Saffiotti. Learning to Locate an Odor Source with a Mobile Robot. IEEE International Conference on Robotics and Autonomous Systems (ICRA), Seoul, Korea, 2001.
45. P. Wide, M. Lindquist, *Water Quality tests by on-line measurements with an electronic tongue*, Conference on Food safety objectives, Washington, USA, 2000.
46. P. Wide, F. Winquist, P. Bergsten and E. Petriu, The human based Multisensor Fusion Method for Artificial Nose and Tongue Sensor Data, IEEE transactions on Instrumentation and measurement, 1998.



47. ICRC, November 2009.
48. Wikipedia, the free encyclopedia last modified on 18 July 2013 at 14:01.
49. DNA Biometrics Masaki Hashiyada Division of Forensic Medicine, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine Japan (2011).
50. Butler, J.M., et al. (2004). Forensic DNA typing by capillary electrophoresis using the ABI Prism 310 and 3100 genetic analyzers for STR analysis. *Electrophoresis*, 25(10-11): p. 1397-412.
51. Butler, J.M. (2010). Fundamentals of Forensic DNA Typing: ELSEVIER.
52. Collins, F.S., et al. (2004). Finishing the euchromatic sequence of the human genome. *Nature*, 431(7011): p. 931-45. Gill, P. (2001). An assessment of the utility.
53. Vijaya Kumar, B.V., et al. (2004). Biometric verification with correlation filters. *Appl Opt*, 43(2): p. 391-402.
54. Watson, J., Baker, T., Bell, S., Gann, A., Levine, M., Losick R. (2004). *Molecular Biology of the Gene*, San Francisco, CA, USA: Benjamin Cummings, Cold Spring Harbor Laboratory Press.
55. Zwijnenburg, P.J., et al. (2010). Identical but not the same: the value of discordant monozygotic twins in genetic research. *Am J Med Genet B Neuropsychiatr Genet*, 153B(6): p. 1134-49. [www.intechopen.com](http://www.intechopen.com).
56. Human Voice Recognition Depends on Language Ability by Tyler K. Perrachione, Stephanie N. Del Tufo, John D. E. Gabrieli.
57. Using of Hand Geometry in Biometric Security Systems Peter VARCHOL, Dušan LEVICKÝ Dept. of Electronics and Multimedia Communications, Technical University of Košice, Park Komenského 13, 041 20 Košice, Slovak Republic Peter.
58. Biometrics of Next Generation: An Overview Anil K. Jain, Ajay Kumar Department of Computer Science and Engineering Michigan State University, East Lansing, MI 48824-1226, USA.
59. An Exploration of Voice Biometrics by Lisa Myers GSEC Practical Assignment version 1.4b 2004.
60. Human Voice Recognition Depends on Language Ability Tyler K. Perrachione, Stephanie N. Del Tufo, John D. E. Gabrieli.
61. Human Recognition Using Biometrics :An Overview by Arun Ross and Anil Jain 2007.
62. Environment Protection Engineering Vol. 40 2014 No. 1 DOI: 10.5277/epel40108 Jacek Gębicki, Tomasz Dymerski, Szymon Rutkowski Identification Of Odor Of Volatile Organic Compounds Using Classical Sensory Analysis and Electronic Nose Technique.
63. Human Identification using Face and Voice Recognition Ishwar S. Jadhav, V. T. Gaikwad, Gajanan U. Patil International Journal of Computer Science and Information Technologies, Vol. 2 (3) , 2011, 1248-1252.
64. Automatic Speech Recognition Using Template Model for Man-Machine Interface: Neema Mishra, Urmila Shrawankar, Dr. V. M. Thakare.
65. G. Doddington, "A method of speaker verification," Ph.D thesis, University of Wisconsin, Madison, USA, 1970.
66. Offline Signature Recognition & Verification using Neural Network O.C. Abikoye, M.A. Mabayoje, R. Ajibade Department of Computer Science University of Ilorin P.M.B 1515, Ilorin, Nigeria Dec 2011.
67. Hand Written Signature Recognition & Verification using Neural Network Pradeep Kumar, Shekhar Singh, Ashwani Garg, Nishant Prabhat, Samalkha PIET. Volume 3, Issue 3, March 2013.
68. Offline Handwritten Signature Identification and Verification Using Multi-Resolution Gabor Wavelet, Mohamad Hoseyn Sigari Muhammad Reza Pourshahabi, Hamid Reza Pourreza Machine Vision Res. Lab, Computer Eng. Department, Ferdowsi University of Mashhad, Mashhad, Iran. International Journal of Biometrics and Bioinformatics (IJBB), Volume (5): Issue (4): 2011.
69. A. Pacut, A. Czajka, "Recognition of Human Signatures", pp. 1560-1564, 2001.
70. American Heritage Dictionary, Third Ed., ver. 3.6a, SoftKey Intl. Inc., 1994.
71. Ozgunduz, E., Karşligil, E., and Senturk, T. 2005. Off-line Signature Verification and Recognition by Support Vector Machine. Paper presented at the European Signal processing Conference.
72. Y. Gu, "Approaching Real Time Dynamic Signature Verification from a Systems and Control Perspective", M.Sc Thesis, University of the Witwatersrand, Johannesburg, 2003.
73. Weiping Hou, Xiufen Ye, Kejun Wang, "A Survey of Off-Line Signature Verification", International Conference on Intelligent Mechatronics and Automation, Chengdu, China pp.536-541, August, 2004.
74. Edson J. R. Justino, Flavio Bortolozzi, Robert Sabourin, "A comparison of SVM and HMM classifiers in the off-line signature verification", Elsevier Pattern Recognition Letters, vol. 26, no. 9, pp. 1377-1385, 2004.
75. R. Sabourin, G. Genest, "An extended-shadow-code-based approach for off-line signature verification: Part I. Evaluation of the bar mask definition", Proc. Of 12th ICPR, Jerusalem, Israel, 1994, pp. 450-453.
76. R. Sabourin, G. Genest, F. J. Preteux, "Off-Line Signature Verification by Local Granulometric Size Distributions", IEEE Trans. Pattern Anal. Mach. Intell. 19 (9) (1997), pp. 976-988.



77. Emre Ozgunduz, Tulin Senturk, M. Elif Karsligil, "Off-Line Signature Verification and Recognition by Support Vector Machine", European Signal Processing Conference, Antalya, Turkey, pp., September, 2005.
78. Vahid Kiani, Reza Pourreza, Hamid Reza Pourreza, "Offline Signature Verification Using Local Radon Transform and Support Vector Machines", International Journal of Image Processing, vol. 3, no. 5, pp. 184-194, 2009.
79. J.K. Guo, D. Doermann, A. Rosenfeld, "Local correspondence for detecting random forgeries", Proc. 4th IAPR Conf. On Doc. Analysis and Recognition, Ulm, Germany, 1997, pp. 319-323.
80. Meenakshi K. Kalera, Sargur Sriharly, Alhua Xu, "Offline Signature Verification and Identification Using Distance Statistics", International Journal of Pattern Recognition and Artificial Intelligence, vol. 18, no. 7, pp. 1339-1360, 2004.
81. Ben Herbst, Hanno Coetzer, "On An Offline Signature Verification System", 9th Annual South African Workshop on Pattern Recognition, pp. 39-43, 1998.
82. E. Frias-Martinez, A. Sanchez, J. Velez, "Support Vector Machines versus Multi-Layer Perceptrons for Efficient Off-Line Signature Recognition", Engineering Applications of Artificial Intelligence, vol. 19, no. 6, pp. 693-704, September, 2006.
83. S. Shaywitz, Overcoming Dyslexia Vintage Books, New York, 2003.
84. J. D. E. Gabrieli, *Science* 325, 280 2009.
85. Biometric Person Authentication: Odor Zhanna Korotkaya Department of Information Technology, Laboratory of Applied Mathematics, Lappeenranta University of Technology.
86. Using of Hand Geometry in Biometric Security Systems Peter VARCHOL, Dušan LEVICKÝ Dept. of Electronics and Multimedia Communications, Technical University of Košice, Park Komenského 13, 041 20 Košice, Slovak Republic.
87. Multi Dimensional Hand Geometry Based Biometric Verification and Recognition System B.Mathivanan, Dr.V.Palanisamy, Dr.S.Selvarajan International Journal of Emerging Technology and Advanced Engineering Website: [www.ijetae.com](http://www.ijetae.com) ISSN 2250-2459, Volume 2, Issue 7, July 2012.
88. D. Zhang, W.K. Kong, J. You and M. Wong, "On-line palmprint identification", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 25, no. 9, pp. 1041- 1050, 2003.
89. C.C. Han, "A hand-based personal authentication using a coarse-to-fine strategy", Image and Vision Computing, vol. 22, no. 11, pp. 909-918, 2004.
90. M. Golfarelli, D. Miao, D. Maltoni, On the error-reject trade-off in biometric verification systems, IEEE Trans. Pattern Anal. Mach. Intell. 19 (7) (1997) 786-796.
91. M. Wong, D. Zhang, W.K. Kong and G. Lu, "Real-time palmprint acquisition system design", IEEE Proceedings, vision and signal processing, vol. 152, no. 5, pp. 527-534, 2005.
92. J. Canny, "A computational approach to edge detection", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 8, no. 6, pp. 450-463, 1986.
93. Sara Hashemi, Soheila Kiani, Navid Noroozi, Mohsen Ebra-himi Moghaddam, "An image contrast enhancement method based on genetic algorithm", Pattern Recognition Letters Volume 31, Issue 13, October 2010. pp.1816-1824.
94. Nicholas Sia Pik Kong, Haidi Ibrahim, "Multiple layers block overlapped histogram equalization for local content emphasis", Computers and Electrical Engineering 2010.
95. R. C. Gonzalez, R. E. Woods, Digital image processing, Prentice-Hall, Inc., 2001.
96. Sara Hashemi, Soheila Kiani, Navid Noroozi, Mohsen Ebra-himi Moghaddam, "An image contrast enhancement method based on genetic algorithm", Pattern Recognition Letters Volume 31, Issue 13, October 2010. pp.1816-1824.
97. C. Munteanu, A. Rosa, "Towards automatic image enhancement using genetic algorithms" Proceedings of the congress on evolutionary computation, 2000.
98. Omid Khayat , Javad Razjouyan, Mina Aghvami, Hamid Reza shahdoosti, babak Loni, "An automated GA-based fuzzy image enhancement method", IEEE Symposium on Computational Intelligence for Image Processing, CIIP '09, May 2009 ,pp. 14-19.
99. A Biometric Identification System Based on Eigenpalm and Eigenfinger Features Slobodan Ribaric, Member, IEEE, and Ivan Fratric ,VOL. 27, NO. 11, NOVEMBER 2005.
100. Human Identification from Body Shape Afzal Godil, Patrick Grother and Sandy Ressler National Institute of standards and Technology, Gaithersburg.
101. Multimodal Biometrics it is: Need for Future Systems Ashish Mishra, Assistant Professor, Department of Computer Science, GGCT, Jabalpur. International Journal of Computer Applications (0975 – 8887) Volume 3 – No.4, June 2010.
102. MULTIMODAL BIOMETRICS: AN OVERVIEW Arun Ross and Anil K. Jain West Virginia University Michigan State University Vienna, Austria, pp. 1221-1224, September 2004.
103. Personal Identification Using Ear Recognition Anam Tariq, M. Usman Akram National University of Sciences and Technology, College of E&ME, Rawalpindi, Pakistan, TELKOMNIKA, Vol.10, No.2, June 2012, pp. 321~326.
104. Arnia F, Pramita N. Enhancement of Iris Recognition System Based on Phase Only Correlation. TELKOMNIKA, 2011; 9(2): 387-394.



105. Hurley DJ, Nixon MS, Carter JN. Force Field Feature Extraction for Ear Biometrics. *Computer Vision and Image Understanding*. 2005; 98(3): 491-512.
106. Victor B, Bowyer K, Sarkar S. An Evaluation of Face and Ear Biometric. 16th International Conference of Pattern Recognition. 2002: 429-432.
107. Chang K, Bowyer K, Barnabas V. Comparison and Combination of Ear and Face Image in Appearance-Based Biometrics. *IEEE Transactions on Pattern Analysis and Machine Intelligence*. 2003; 25: 1160-1165.
108. USING EARS FOR HUMAN IDENTIFICATION, Mohamed Ibrahim Saleh, May 7, 2007 Blacksburg, Virginia.
109. EAR BIOMETRICS Hanna-Kaisa Lammi Lappeenranta University of Technology, Department of Information Technology, Laboratory of Information Processing, Lappeenranta, Finland.
110. The Human Identification System Using Multiple Geometrical Feature Extraction of Ear –An Innovative Approach. Jitendra B. Jawale, Dr. SMT. Anjali S. Bhalchandra ISSN 2250-2459, Volume 2, Issue 3, March 2012.
111. M. Burge, and W. Burger, Ear biometrics for Computer vision, In 23rd Workshop Austrian Association for Pattern Recognition, 2000.
112. Ear Recognition for Automated Human Identification Singh Amarendra and Verma Nupur KNIT Sultanpur, UP, INDIA.
113. Yazdanpanah AP, Faez K. Ear Recognition Using Biorthogonal and Gabor Wavelet Based Region Covariance Matrices. *Applied Artificial Intelligence*. 2010; 24(9): 863-879.
114. Daramola S A, Oluwaninyo OD. Automatic Ear Recognition System Using Back Propagation Neural Network. *International Journal of Video & Image Processing and Network Security, IJVIPNS-IJENS*. 2011; 11(1): 28-32.
115. M. Choras, "Ear Biometrics Based on Geometric Feature Extraction", *Electronic Letters on Computer Vision and Image Analysis* 5(3), 84-95, 2005.
116. D. J. Hurley, M. S. Nixon, and J. N. Carter, "Force Field Feature Extraction for Ear Biometrics," *Computer Vision and Image Understanding*, vol. 98, pp. 491-512, June 2005.
117. A Multimodal Biometric System Using Finger, Face and Speech Anil Jain, Lin Hong and Yatin Kulkarni West Virginia University Michigan State University Vienna, Austria.
118. L. Hong and A. K. Jain, "Integrating faces and fingerprints for personal identification," *IEEE Transactions on PAMI*, vol. 20, pp. 1295–1307, Dec 1998.
119. Human Identity Verification by Using Physiological and Behavioural Biometric Traits S. M. E. Hossain and G. Chetty *International Journal of Bioscience, Biochemistry and Bioinformatics*, Vol. 1, No. 3, September 2011.
120. Human Identification from Video: A Summary of Multimodal Approaches Project Leads Charles Schmitt, Allan Porterfield, Sean June 2010.
121. Heart sound as a biometric Koksoon Phua\*, Jianfeng Chen, Tran Huy Dat, Louis Shue Institute for Infocomm Research, 21 Heng Mui Keng Terrace, Singapore 119613, Singapore Received 20 April 2007; received in revised form 24 July 2007.
122. Biometric identification systems Rodrigo de Luis-García, Carlos Alberola-López, Otman Aghzout, Juan Ruiz-Alzola; *Signal Processing* 83 (2003) 2539 – 2557.
123. Human identification using heart sound Koksoon Phua, Tran Huy Dat, Jianfeng Chen and Louis Shue Institute for Infocomm Research 21 Heng Mui Keng Terrace, Singapore 119613.
124. Human Identity Verification based on Heart Sounds: Recent Advances and Future Directions Francesco Beritelli and Andrea Spadaccini Dipartimento di Ingegneria Elettrica, Elettronica ed Informatica (DIEEI) University of Catania Italy.
125. F. G. William. Review of Medical Physiology, Prentice Hall, 1997.
126. V. Nigam and R. Priemer, "Cardiac sound separation," *Computers in Cardiology*, pp. 497–500, 2004.
127. NEAR REAL TIME NOISE DETECTION DURING HEART SOUND ACQUISITION D. Kumar, P. Carvalho, M. Antunes, J. Henriques, R. Schmidt, J. Habetha 15th European Signal Processing Conference (EUSIPCO 2007), Poznan, Poland, September 3-7, 2007.
128. Detection and Identification of Heart Sounds Using Homomorphic Envelopogram and Self-Organizing Probabilistic Model D Gill, N Gavrieli, N Intrator, Tel Aviv University, Jerusalem, Israel.
129. Intelligent Heart Sound Diagnostics on a Cellphone using a Hands-free Kit T. Chen, K. Kuan, L. Celi, G. D. Clifford Massachusetts Institute of Technology, Harvard Medical School, University of Oxford.
130. The Use of Mel-frequency Cepstral Coefficients in Heart Sounds Identification Mrs. Kiran Kumari Patil, Dr. B. S. Nagbhushan, Dr. Vijaya Kumar B.P.
131. AN EFFICIENT RETRIEVAL TECHNIQUE FOR HEART SOUNDS USING PSYCHOACOUSTIC SIMILARITY. Kiran Kumari Patil et al. / *International Journal of Engineering Science and Technology* Vol. 2 (12), 2010, 7324-7328.
132. Efficient Speaker Verification System Based on Heart Sound and Speech Osama I. Alhamdani, Ali. Chikma, Jamal. Dargham and Sh-Hussain. Salleh, Fuad. *International Conference on Latest Computational Technologies (ICLCT'2012)* March 17-18, 2012 Bangkok.



133. An Introduction to Biometric Recognition Anil K. Jain, Arun Ross, and Salil Prabhakar, IEEE, vol. 14, no. 1, January 2004.
134. D. Maltoni, D. Maio, A. K. Jain, and S. Prabhakar, Handbook of Fingerprint Recognition. New York: Springer-Verlag, 2003.
135. R. Chelleppa; C.L. Wilson and S. Sirohey” Human and Machine Recognition of Face, A Survey” Proc. IEEE, Vol. PP.705-740, 1995.
136. W. Shu and D. Zhang, “Automated personal identification by palmprint”, *Optical Engineering*, vol. 38, no. 8, pp. 2359-2362, 1998.
137. Singh, A.; Agrawal, A. & Pal, C. Hand geometry verification system: A review, *International Conference on UltraModern Telecommunications & Workshops (ICUMT)*, pp. 1-7, St. Petersburg, 12-14 October 2009.
138. A. Ross, K. Nandakumar and A. K. Jain, "Handbook of Multibiometrics", Springer Publishers, 1st edition, May 2006. ISBN: 0-3872-2296-0.
139. JAIN, A., ROSS, A. A prototype hand geometry-based verification system. In Proceedings of 2nd Int. Conference on Audio- and Videobased Biometric Person Authentication. Washington (USA), 1999.
140. Jain, A.; Flynn, P. & Ross A. (2008). Handbook of Biometrics, Springer
141. Singh, A.; Agrawal, A. & Pal, C. Hand geometry verification system: A review, International Conference on UltraModern Telecommunications & Workshops (ICUMT), pp.1-7, St. Petersburg, 12-14 October 2009.
142. Polat, O. & Yildirim T. (2008). Hand Geometry Identification without Feature Extraction by General Regression Neural Network. *Experts Systems with Applications*, Vol. 34, No. 2, February 2008) pp. 845-849.
143. JAIN A. K. AND PRABHKAR S. 2001. Fingerprint Matching Using Minutiae and Texture Features. Proceeding of International Conference on Image Processing (ICIP), pp. 282-285.
144. CHIKKERUR S., PANKANTI S., JEA A., AND BOLLE R. 2006. Fingerprint Representation using Localized Texture Features. *The 18th International Conference on Pattern Recognition*.
145. YOUSIFF A. A. A., CHOWDHURY M. U., RAY S., AND NAFAA H. Y., 2007. Fingerprint Recognition System using Hybrid Matching Techniques. 6th IEEE/ACIS International Conference on Computer and Information Science, pp. 234-240.
146. AGGARWAL G., RATHA N. K., TSAI-YANG J., AND BOLLE R. M. 2008. Gradient based textural characterization of fingerprints. In proceedings of IEEE International conference on Biometrics: Theory, Applications and Systems.
147. K. W. Bowyer, K. Chang, and P. J. Flynn, “A survey of 3D and multimodal 3D and 2D face recognition,” Department of Computer Science and Engineering of the University of Notre Dame, Tech. Rep., 2004.
148. Fusing Face-Verification Algorithms and Humans Alice J. O’Toole, Hervé Abdi, Fang Jiang, and P. Jonathon Phillips, Senior Member, IEEE transactions on systems, man, and cybernetics—part b: cybernetics, vol. 37, no. 5, October 2007 1149.
149. Iris Biometric Recognition for Person Identification in Security Systems Vanaja Chirchi, Dr.L.M.Waghmare and E.R.Chirchi International Journal of Computer Applications (0975 – 8887) Volume 24– No.9, June 2011
150. Human Identification and Verification Using Iris Recognition by Calculating Hamming Distance Ashish kumar Dewangan, Majid Ahmad Siddhiqui International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-2, Issue-2, May 2012.
151. International Journal of Advanced Research in Computer Science and Software Engineering Iris Preprocessing Gargi Amoli Nitin Thapliyal Nidhi Sethi, Volume 2, Issue 6, June 2012 ISSN: 2277 128X.
152. Multi Dimensional Hand Geometry Based Biometric Verification and Recognition System B.Mathivanan, Dr.V.Palanisamy, Dr.S.Selvarajan International Journal of Emerging Technology and Advanced Engineering ISSN 2250-2459, Volume 2, Issue 7, July 2012, 348.
153. P.E. Keller and L. Kangas, *Electronic Noses and their applications*, Pacific Northwest Laboratory, PNL-SA-26597. Diana Kalenova, 2005. Personal Authentication using Signature Recognition.
154. Biometric Person Authentication: Odor Zhanna Korotkaya Department of Information Technology, Laboratory of Applied Mathematics, Lappeenranta University of Technology.
155. The Electronic Nose – A Big Part of Our Future David Tin Win Faculty of Science and Technology, Assumption University Bangkok, Thailand AU J.T. 9(1): 1-8 (Jul. 2005).
156. Identification of Odor Causing Compounds in a Commercial Dairy Farm Mingming Lu & Prabhat Lamichhane & Fuyan Liang & Eric Imerman & Ming Chai February 2007 /July 2007.
157. Overview of Odor Detection Instrumentation and the Potential for Human Odor Detection in Air Matrices by Sichu Li March 2009.
158. Biometric DNA and ECDLP-based Personal Authentication System: A Superior Possession of Security Ranbir Soram, Memeta Khomdram, Manipur Institute of Technology, Takyelpat, Imphal -795004, India. IJCSNS International Journal of Computer Science and Network Security, VOL.10 No.1, January 2010.



- 159.DNA BIOMETRICS by Sandra Maestre and Sean Nichols ISM 4320-001
- 160.Fingerprints, Iris and DNA Features based Multimodal Systems: A Review Prakash Chandra Srivastava, Anupam Agrawal, Kamta Nath Mishra, P. K. Ojha, R. Garg *I.J. Information Technology and Computer Science*, 2013, 02, 88-111  
Published Online January 2013 in MECS.
- 161.A. Bertillon, *La Photographie Judiciaire, avec un Appendice sur la Classification et l'Identification Anthropometriques*, Gauthier-Villars, Paris, 1890.
- 162.H'EBERT M. 2008. Text-dependent speaker recognition. In *Springer handbook of speech processing*, J. Benesty, M. Sondhi, and Y.Huang, Eds., Springer Verlag, pp. 743–762.