Multimodal Biometrics An Effective Approach of Person Identification : A Review

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Abstract — In new era, the biometric systems high security applications must match with perfect requirement of real world. This paper gives an overview of multimodal biometrics as well as different fusion of multiple biometrics which helps in minimizing the system error rate & maximizing the recognition rate. The Fusion methods sequentially process biometric modalities until an acceptable match is obtained. This paper also listed the challenges in the progress of multimodal biometrics, the main research areas and its applications to develop the security system for high security areas and enhancing the automation with maximum success rate.

Keywords - Unimodal, Multimodal, Traits, Authentication, Biometrics, etc.

I. INTRODUCTION

Humans recognize each other according to their various characteristics. Generally people recognizes each other by their face when they meet or by their voice as they speak to each other. There are many traditional methods like PIN (Personal Identification Numbers), Passwords and token based methods like passports and licenses for personal identification. To achieve correct verification or identification the term comes into focus is biometrics. The meaning of Biometrics comes from the Greeks. The Greek hybrid of the words is bio means life and metry means to measure. In simpler manner the body is used as a password in biometrics [1]. In biometrics personal identification based on “who are you”. The Biometrics offers different automated methods which uses measurable physiological or behavioral characteristics for person verification or identification. The characteristics should be measurable, unique and should not be duplicable, invariant over time [2]. Physical characteristic includes iris, face, handgeometry, fingerprints, palm, retina etc. & behavioral characteristics includes signature, keystroke patterns, gait, voice, speech, etc [3]. A good biometric is characterized by use of highly unique features by this there is minimal chance of any two people having the same characteristic stable. For person identification with the biometrics system he/she must be registered to the biometrics system. This process of registration of user is called as Enrollment [4].

The Biometrics is science of measuring the unique physical characteristics of a person. These personal features are analysed and stored as bio-prints in database and used to verify the identity of the person by comparing the existing record with previously stored bio-prints. As Unimodal biometrics has many problems such as noisy data, intra-class variations, restricted degrees of freedom, non-university, spoof attacks, and unacceptable error rates. In order to overcome the limitations provided by unimodal system and to achieve high recognition rate there is new biometrics system which is known as multimodal biometrics system. Studies have demonstrated that multimodal biometric systems can achieve better performance compared with unimodal systems.

This paper presents the review of multimodal biometrics. This includes overview, applications, challenges and areas of research in multimodal biometrics. The different fusion techniques of multimodal biometrics have been discussed. The paper is organized as follows. The need of multimodal biometrics is illustrated in Section II, the review of related work is discussed in section III. Multialgorithm and multi sample approach is discussed in Section IV whereas, different fusion techniques are presented in Section V, Finally, applications, challenges and research areas are given in Section VI respectively. Conclusions are presented in the last section of the paper.

II. NEED OF MULTIMODAL BIOMETRICS

The Unimodal biometrics has many problems such as noisy data, intra-class variations, restricted degrees of freedom, non-university, spoof attacks, and unacceptable error rates. The use of single trait works as single source of information for authentication (e.g. fingerprint, face, voice etc.) generally leads to high false acceptance rate (FAR) and false rejection rate (FRR). In order to overcome the limitations provided by

unimodal system there is need of system which can combine of two or more types of biometrics systems known as multimodal biometric systems. These systems are more reliable due to the presence of multiple, independent biometrics. These systems strongly fulfill requirements imposed by various applications. The problem of non-universality is solved by multimodal system as multiple traits ensure enough population coverage. The spoofing problem is solved easily because it is very difficult for an impostor to spoof multiple biometric traits of a genuine user simultaneously. In unimodal biometrics system if the specific modality is unavailable for identification the whole system fails, while in case of multimodal system any modality is unavailable for identification then the system can used with some other modality for identification purpose. i.e. the system never fail in multimodal biometrics. Hence recognition rate of multimodal biometrics system is higher than unimodal system.

III. RELATED WORK

The different purposes of multimodal biometrics system described in [1-3]. Gawande, U. et al [4] proposed a feature-level fusion framework for combining features of Iris and Fingerprint and algorithm Radial Basis Function based neural network (RBFNN) with accuracy rate 97.3%. The researchers also gives various scenarios in multimodal biometric systems using fingerprint, face and iris recognition, the levels of fusion that are possible and the integration strategies that can be adopted to fuse information and improve overall system accuracy. How the image quality of traits will affect the overall identification accuracy and the need of staffing for the secondary human validation and general working of multimodal biometrics system with Iris and Palmprint and fusion is done at the matching score level by Sum Rule technique , k-Nearest Neighbourhood (k-NN) based classifiers, adapted HYPER method, Wavelet transform, Multi-scale wavelet decomposition [5-10].
V. Conti, et al [11] have proposed multimodal biometric system using two different fingerprints. The matching module integrates fuzzy logic methods for matching score fusion. Both decision level fusion and matching score level fusion were performed. Antonia Azzini, et al [12] given idea about using a fuzzy control system to manage a multi-modal authentication system, checking the identity of a user during the entire session. The first biometric acquisition takes matching score 0.725and the second biometric acquisition takes score 0.4860.
Gawande, et al [13, 14] used log Gabor filter and 2D Gabor filter that can be used to extract the feature vectors from both Iris and Fingerprint and then they are concatenated. Hamming distance (HD) is used to generate a final match score. Asim Baig, et al [15] proposed a state of the art framework for multimodal biometric identification system which can be adapted for any type of biometrics to provide smaller memory footprint and faster implementation. The recognition rate is 90%. Cheng Lu, et al [16] suggested idea which utilizes two or more individual modalities, like face, ear, and fingerprint, to improve the recognition accuracy by new dimensionality reduction method called Dimension Reduce Projection (DRP). The recognition rate is 95.8%.
Mohammad Imran, et al [17, 18] proposed a new hybrid approach to verification aspect of a multibiometric system and comparative analysis with traditional approaches such as multialgorithmic and multimodal versions of the same. As well as the system based on fusion of whole dorsal hand geometry and fingerprints that acquires right and left (Rt/Lt) near-infra-red (NIR) dorsal hand geometry (HG) shape and (Rt/Lt) index and ring fingerprints (FP). Accuracy rate is 99.71%. Feifei CUI, et al [19] proposed multimodal biometrics recognition based on score level fusion of fingerprint and finger vein. Recognition rate is 98.74%. Nishant Singh, et al [20] presents an efficient multimodal biometric system based on 4 slap fingerprint images. The system utilizes 4 slap fingerprint scanner to simultaneously collect fingerprints of multiple fingers on a hand in one image. Decision threshold is 0.9869 and FAR is 5.08%.

IV. OVERVIEW OF MULTIBIOMETRICS SYSTEMS

There are different types of Multibiometrics system, which can be differentiated with the working mechanism.

A. *Multialgorithmic biometric systems*

This system take a single sample from a single sensor and process that sample with two or more different algorithms. The technique could be applied to any modality. Maximum benefit would be derived from algorithms that are based on distinctly different and independent principles.

B. *Multi-instance biometric systems*

These system use one sensor (or possibly multiple sensors) to capture samples of two or more different instances of the same biometric characteristics. For example, systems capturing images from multiple fingers. However, systems capturing, for example, sequential frames of facial or iris images are considered to be multi-presentation rather than multi-instance. This is whether or not the repeated captured images are combined at the feature level, some other level of combination or a single image is selected as the one best used for pattern matching.

C. Multi-sensorial biometric systems

In this sample the same instance of a biometric trait is captured by two or more distinctly different sensors. One algorithm or some combination of multiple algorithms are used to process the multiple

samples. For example, visible light camera and an infrared camera coupled with several frequencies of infrared illumination in face recognition.

V. FUSION TECHNIQUES

A biometric Sample is the signal that has been captured by a biometric sensor. The different biometrics combined to improve the performance. This process is called as fusion. The fusion occurs at different levels. These includes:

A. *Sensor Level Fusion*

Fusion at sensor level occurs before the matching module is invoked. In this strategy images are fused directly or using some transform technique then features are extracted from fused image.

B. Feature Level Fusion

Fusion at feature level occurs before the matching module is invoked. Each individual biometric process outputs a collection of features. When features extracted from one biometric trait are independent of those extracted from the other then it is reasonable to concatenate the two vectors into a single new vector. The new feature vector has higher dimensionality and represents a person's identity in a very efficiently.

C. Match Score Level Fusion

Match score level fusion occurs after the matcher output its result. Each individual biometric outputs a match score which shows proximity of the feature vector with the template vector. This fusion process fuses these scores can be combined into a single score, which is then compared to the system acceptable threshold. If the classification approach applied to score fusion, then the output may be direct decisions.

D. Decision Level Fusion

Decision level fusion occurs after the matcher output its result. Each individual biometric process and its feature vectors give its own Boolean result such as accept or reject. The fusion process fuses them together by a combination of different algorithms such as AND, OR, etc

VI. APPLICATIONS & CHALLENGES

The different countries used biometrics system as National Identity. For e.g India's national ID program called Aadhar is important application of biometric system. The Biometric Residence Permit is proof of the holder's right to stay, work or study in the United Kingdom. It is also be used as a form of identification. With the help of biometric technology it is possible to develop the system by the smart phone industry, are driving toward biometrically secured smart phone data, and continuous authentication for protection against theft. Criminal Investigation and Fraud Detection, ATMs, Credit Card and Debit Card, Monitoring and Surveillance applications also used biometrics in at Airports, stations, public places. In Amsterdam Airport Schiphol, Netherlands, iris recognition is used to permit the passport-free immigration. The HealthCare Application also uses biometrics. Banking and Finance sector also uses biometrics as per their need. For e.g. The private banking division of Barclays was the first financial services which uses voice biometrics to authenticate customers to their call centers.

There are different challenges in designing of multimodal biometric sensors, which automatically recognize the operating environment and communicate with other system components to automatically adjust settings to deliver optimal data, is also the challenging area. The sensor should be fast in collecting quality images from a distance and should have low cost with no failures to enroll. The image quality captured by sensor also affects the recognition as well as if the position, pressure of biometrics trait on the sensor is improper during acquisition of data, this also leads to poor recognition.

The multimodal biometric systems can be improved by enhancing matching algorithms, integration of multiple sensors, analysis of the scalability of biometric systems. This can be followed by research on scalability improvements and quality measures to help decision making in matching process.

VII. CONCLUSIONS

This paper presents the brief overview related to multimodal biometric systems. This paper focuses on the approach which mainly combining multiple sources and enhancing the performance of biometric system is achieved. The different multibiometrics strategies are also well-defined in this paper. The different fusion levels and scenarios of multimodal systems are discussed. The challenges faced by multimodal biometric system and possible research areas are also discussed in the paper.

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