A survey of emerging biometric modalities

Sushil Chauhan\(^a\), A.S. Arora\(^b\), Amit Kaul\(^a*\)

\(^a\)National Institute of Technology, Hamirpur 177005, India
\(^b\)Sliet Longowal, Sangrur, India

Abstract

Biometric recognition is the task of identifying an individual on the basis of his/her physiological or behavioral traits. Necessity of developing foolproof security systems has provided biometric research much needed impetus. Over the last three decades there has been a lot of work done on development of systems based on fingerprint, face, iris, voice etc., but in the recent past some new biometric measures have emerged which have shown prospect of enhancing the performance of the traditional biometrics by fusing these new biometric modalities with established ones. Some of these biometric measures have shown tremendous potential in forensic applications. In this paper a review of two of these emerging biometric modalities is presented.

Keywords: Biometrics, ECG, Lipprint

1. Introduction

In an era where people demand flawless security measures that are simple, convenient and user friendly Biometric based systems have has carved a niche for itself. Biometrics (Bio-Life and metrics-measure) deals with automatic authentication of people based on their physiological and behavioral characteristics. These systems provide security based on “what you own” rather than “what you know” (password/PIN) or “what you have” (smart-card). Therefore, such systems are convenient as one need not to memorize anything like incase of passwords and is always with you unlike smart-card etc. while ensuring fool-proof security because no third party can use it [1]. A number of systems based on various physiological and behavioral traits have been developed which include fingerprint [2], face [3], iris [4], retina [5], voice [6], keystroke [7], ear [8], hand geometry [9], signature [10] and gait [11]. Table 1 presents a summary of these traditional biometric measures mentioning the standard approaches adopted in systems based on them and their pros and cons. However none of these biometric measures provide a fool-proof solution with total population coverage. In order to overcome the problem of these traditional biometric measures some new biometric measures have been proposed like ECG [12], EEG [13], lip-print [14], mouse dynamics [15], dental radiograph [16], tongue print [17] etc. Some of these have been already used in forensic applications. In this paper an overview of ECG and lip-print based person identification system has been presented which if used in conjunction with traditional biometric measures as a part of multimodal system may go on to improve the system performance.

* Corresponding author. Tel.: +91-01972-304545; E-mail address: amitkaul9@gmail.com.

© 2010 Published by Elsevier Ltd. Open access under CC BY-NC-ND license.

doi:10.1016/j.procs.2010.11.027
Table 1. A summary of traditional biometric measures.

<table>
<thead>
<tr>
<th>S No.</th>
<th>Biometric Measure</th>
<th>Approaches adopted</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Iris Scan [4,18]</td>
<td>I. Complex valued 2-D Gabor Wavelets [19]. II. Laplacian of Gaussian filters [20]. III. Zero Crossing Wavelet Transform[21]. IV. Circular Symmetry 2-D Filters [22].</td>
<td>✓ Potential for high Accuracy ✓ Resistance to impostors ✓ Long term stability ✓ Fast processing</td>
<td>• Intrusive • Some people think the state of health can be detected • High cost</td>
</tr>
<tr>
<td>2.</td>
<td>Retinal Scan [5]</td>
<td>Feature Based – Retinal vein pattern</td>
<td>✓ High accuracy ✓ Long-term stability ✓ Fast verification</td>
<td>• Difficult to use • Intrusive • Limited applications</td>
</tr>
<tr>
<td>3.</td>
<td>Fingerprint [2]</td>
<td>I. Minutiae-based methods [23] II. Image based methods.</td>
<td>✓ Mature technology ✓ Easy to use/nonintrusive ✓ High accuracy (comparable to PIN authentication) ✓ Long-term stability and ability to enrol multiple fingers ✓ Comparatively low cost</td>
<td>• Inability to enrol some users • Affected by skin condition • Sensor may get dirty • Association with forensic applications</td>
</tr>
<tr>
<td>5.</td>
<td>Voice [6,27]</td>
<td>Low level features I. Pitch II. MFCC</td>
<td>GMM [28] HMM[29] ANN VQ[30]</td>
<td>✓ Use of existing telephony infrastructure or simple microphones ✓ Easy to use/nonintrusive/ hands free ✓ No negative association</td>
</tr>
<tr>
<td>6.</td>
<td>Signature [10]</td>
<td>Feature based methods</td>
<td>✓ Resistance to forgery ✓ Widely accepted ✓ Non-intrusive ✓ No record of the signature</td>
<td>• Signature inconsistencies • Difficult to use • Large templates (1K to 3K) • Problem with trivial signatures</td>
</tr>
<tr>
<td>7.</td>
<td>Ear [8]</td>
<td>Methods using I. Pictures II. Earmarks III. Thermogram</td>
<td>✓ Useful for partial face images</td>
<td>• Ears never stop growing</td>
</tr>
<tr>
<td>8.</td>
<td>Hand Geometry [9]</td>
<td>Feature Based : Finger length, width, thickness curvatures and relative location of features</td>
<td>✓ Not affected by environment ✓ Mature technology ✓ Non-intrusive ✓ Relatively stable</td>
<td>• Low accuracy • High cost • Relatively large readers • Difficult to use for some users (arthritis, missing fingers or large hands)</td>
</tr>
<tr>
<td>9.</td>
<td>Keystroke [7,31]</td>
<td>I. Latencies between successive keystrokes II. Duration of each keystroke</td>
<td>✓ No additional hardware required ✓ Non intrusive and wide user acceptance ✓ Minimal training</td>
<td>• Low accuracy • Narrow range of applications.</td>
</tr>
</tbody>
</table>

2. Electrocardiogram

Human heart is a muscle which can be thought of as a two stage pump that ensures circulation of blood in our body. The heart serves as a pump because of its ability to contract under an electrical stimulus provided by the SA node (pacemaker of heart). The pulse produced by the SA node results in contraction of atria. The action potential generated propagates through atria on reaching AV node is delayed before being transmitted to the ventricles. This entire process involves one cardiac cycle. The contraction of so many cells at one time creates a mass electrical signal that can be detected by electrodes placed on the surface of person’s chest or his extremities. The electrocardiogram (ECG or EKG) is a graphic recording or display of these time-varying voltages produced by heart during cardiac cycle.
The different parts of ECG waveform are designated by letters as shown in figure 1. The P-wave indicates arterial contraction; ventricular systole occurs immediately following the QRS complex, and a refractory period (resting for depolarization) is indicated by the T-wave. ECG has been extensively used for detection of various abnormalities of the heart. In most of these diagnosis the time duration and the amplitude of the various waves is used.

Of late there has been growing interest in using ECG as a biometric measure. The ECG from person to person varies due to the differences in position size and anatomy of the heart, age, sex, relative body weight, chest configuration and various other factors. Beil and et al. [32] had in their work concluded that it is possible to identify individuals on the basis of an ECG signal. A single lead ECG is one dimensional low frequency signal which can be recorded with three electrodes (two active electrodes and a ground electrode). The authors have used 30 features mainly the time intervals of the wave. Kyoso and Uchiyama [33] concluded that four parameters (P wave duration, PQ interval, QRS interval and QT interval) are enough for identification of a person. Shen and Tompkins [34, 35] studied the problem of ECG as biometric using single lead. They also found out a relationship between the Lead I biometric ECG features and body mass index (BMI). Some researchers have studied the applicability of ECG as a biometric measure on diseased patients[36]. ECG based biometric system is a pattern recognition problem comprising of a feature extraction block and a classifier.

2.1. Features [37]

The ECG based biometric approaches can be classified under two main headings:

i. Detection of fiducial points [38]: These are based on extracting features related to duration and amplitudes of PQRST waves and their relative durations. These approaches are dependent upon the accuracy of detection of PQRST points and their respective onsets. The various time durations of ECG waveform are shown in figure 2.

ii. Non fiducial detection [39]: These are basically transform based approaches which use Fourier Transform, Discrete Cosine Transform or Wavelet Transform of the ECG wave for identification. These methods alleviate the need to accurately detect the QRS complex and provide the advantage of making the system insensitive to the heart rate variations.

2.2. Classifier

The various classifiers used for the human identification using ECG are:

i. Artificial Neural Networks and its variants.

ii. Euclidean Distance measure.

iii. Statistical Based approaches

2.3. Advantages of ECG based biometric

A physiological or behavioral characteristic to be used as a biometric measure should possess universality, distinctiveness, permanence, ease in collectability, robust, acceptable to users and immune to spoofing. Universality is required so as to ensure that entire population is covered. However some of the physiological and behavioral characteristics may not be present in all individuals due to some diseased state or work environment conditions e.g. fingerprints of a small fraction of the population may be unsuitable for automatic identification because of genetic factors, aging, environmental, or occupational reasons (e.g., manual workers may have a large number of cuts and bruises on their fingerprints that keep changing). This problem of universality can be easily overcome by the use of ECG as it is present in all living beings. Another problem with the existing systems is that they are vulnerable to direct attacks by use of some artificial template e.g. gummy fingerprints. ECG based system will also overcome this problem as liveness is inherent characteristic of an ECG signal. This characteristic property will be useful in fusion of ECG signal with other robust biometric measures so as to provide a biometric system which is resistant to direct attacks from fake users by use of synthetic biometric sample (e.g. speech, fingerprints or face images).
3. Lip-print [40,41,42]

The study of lip prints is known as cheiloscopy. The lip prints are unique to one person except in monozygotic twins. Santos in 1967 was the first one to classify lip grooves into four types namely:

i. Straight line
ii. Curved Line
iii. Angled line
iv. Sine-shaped curve

Later on Suzuki and Tsuchihashi, in 1970, devised a classification method of lip prints as given below

a) Type I- A clear-cut groove running vertically across the lip.
b) Type II- Partial-length groove of Type I.
c) Type III- A branched groove.
d) Type IV- An intersected groove.
e) Type V- A reticular pattern.
f) Type VI – Other pattern.

In general the lip features can be divided into three different categories: Lips texture features, Lips shape features and Lips motion features. The lip motion features have been employed in speaker recognition tasks. Moreover lip motion and lip –print have been manually employed in forensic applications. One may feel that any one person will have only one of the above mentioned types but it is not so. In fact a person can have a combination of these types. In order to simplify this lips are divided into quadrants which are studied separately. This is done manually in dental forensics for quite sometime. With the recent development in imaging systems and cameras the idea is to use lip print images for person authentication.

3.1. Features

The features required for lip print is the identification of the grooves mentioned above. One of the approaches proposed for it is the multi resolution architecture. The aim is to look at the lip-print images at different resolutions and verify the identity of the subject based on it.

3.2. Advantages of Lip based biometric

Lip print based system offer the advantage of being used in conjunction with face and voice based systems so as to enhance their performance. In addition to this development of lip based authentication system will also be beneficial in forensic applications.

4. Conclusion

The current research trends have shown the prospect of using ECG and lip print as a measure for human identification. ECG has advantage of being immune to direct attack by use of a synthetic template and will provide entire population coverage. The ECG based biometric systems are still in their infancy and there are some open issues which have to be addressed before commercially deploying such systems in unimodal form. The results have been reported for a population of few hundred and needs to be verified for a larger population, Moreover the stability of features extracted from ECG with reference to change in emotional and physiological state of person needs to be studied. Similarly some authors believe that the study has to be carried over a wider class of individuals in order to establish the individuality of the lip prints.

However ECG can be clubbed with other robust biometrics like fingerprint and iris to provide a reliable multi modal biometric system and lip print can combined with face and voice to develop a user friendly biometric system.

References


