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ECG as Biometric in the Automated World

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ABSTRACT

Biometrics based authentication system provides better security solutions than conventional systems. But, some biological parameters that are used as biometric do not provide the guarantee of the presence and aliveness of the person as voice can be copied through microphone, finger print can be collect on silicon surface and iris can be copied on contact lances. ECG doesn't have these problems and it is unique in every individual. In this paper study has been carried out to find out useful of ECG as biometric in automated word for authentication purpose.
Keyword: Biometrics, ECG, Authentication System.

1. INTRODUCTION

In the present day of automated world, machine is replacing the human in every aspect of life. Due to this, the security concern regarding the authenticity of the user goes on increasing. Hence, it become necessary to include some constrains in order to reject imposters and allow only the authorized user to access automated services. Biometric is the solution to this problem. Biometrics refers to methods for uniquely recognizing humans based upon one or more intrinsic physical or behavioral traits.

Theoretically psychological or behavioral characteristics of human being can be used to make personal identifications only if it has following properties [1, 2]:

- Universality, which means that every person, should have the required characteristic which can be used as a biometric.
- Uniqueness, which means that any characteristic to be used as a biometric, possessed by two different persons must be distinctive enough.
- Permanence means that the characteristics must be invariant with time, position and conditions.
- Collectability means that the required characteristic must be easily measureable.

Practically following parameters are also required:

- Performance means that a system needs to perform quickly and accurately.
- Acceptability means that the people must accept the system easily.
- Circumvention refers to how easy it is to fool the system by fraudulent techniques?

Some biological parameters are unique but could not provide the guarantee of the presence and aliveness of the person as voice can be copied through microphone, finger print can be collect on silicon surface and iris can be copied on contact lances. It has been observed that ECG is different in different individuals even in identical twins, means the uniqueness of ECG is very high. So it can be used as biometrics [3,4]. ECG based biometrics authentication system detects the aliveness of the person, means person's presence is necessary in alive form [5]. Only single lead ECG signal is required for processing [6]. ECG is easy to record and it requires low cost effective hardware. Therefore, ECG based biometrics system may be easily implemented. A comparative study of different biometric modalities including ECG is presented in table 1.

2. PRIOR WORK

As ECG is a new concept in biometrics some related work published in this field is discussed below. Biel, L. were among the first to manifest the applicability of ECGs as biometric [3]. Their approach is to extract a set of temporal and amplitude features from heart beats that are normally used in clinical diagnosis. The features were obtained directly from a siemens ECG equipment and their dimensionality was reduced by simple analysis of the correlation matrix they had achieved 100% accuracy but their approach was machine dependent. Shen reported another method for one lead ECG identity verification [6]. The approach was divided in two steps, first to compute the correlation coefficient among QRS complexes in order to verify possible candidates template matching and then a decision based neural network (DBNN) was been used to strengthen the validation of the identity resulting from the first step they test on the database of 100 person and got 96% accuracy.

Table 1
Comparison of Different Biometric Modalities

	Universality	*Uniqueness*	*Permanence*	*Collectability*	*Performance*	*Acceptability*	*Circumvention*
Fingerprint	M	H	H	M	H	M	M
Iris	H	H	H	M	H	L	L
Retina	H	H	M	L	H	L	L
Hand Geometry	M	M	M	H	M	M	M
Palmprint	M	H	H	M	H	M	M
Hand Vein	M	M	M	M	M	M	L
Voice	M	L	L	H	L	M	H
Face	H	L	M	H	L	H	H
Signature	L	L	L	H	L	H	H
DNA	H	H	H	L	H	L	L
Keystroke	L	L	L	M	L	M	M
ECG	H	H	H	M	H	M	L

*M= Medium, *H=High, *L=Low

H.H.P. Silva presented a scheme of ECG measurement in biometrics [7]. In their approach each heartbeat waveform was sequentially segmented from the full recording, and after this, all individual waveforms were aligned by their R peaks. From the resulting collection of ECG heartbeat waveforms, the mean wave for groups of 10 heartbeat waveforms (without overlapping), was computed to minimize the effect of outliers they got 92% accuracy in 50 classification runs.

3. ELECTROCARDIOGRAM (ECG)

The electrocardiogram (ECG) is a technique of recording bioelectric currents generated by the heart. Clinicians can evaluate the conditions of a patient's heart from the ECG and perform further diagnosis. ECG records are obtained by sampling the bioelectric currents sensed by several electrodes, known as leads. An ECG signal is shown in figure 1.

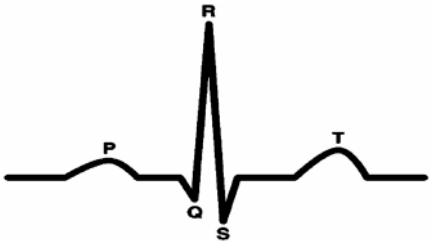

Fig. 1: Standard ECG Waveform

Generally, the recorded ECG signal is often contaminated by noise and artifacts that can be within the frequency band of interest and manifest with similar characteristics as the ECG signal itself. In order to extract useful information from the noisy ECG signals, you need to process the raw ECG signals. ECG signal processing can be roughly divided into two stages by functionality: preprocessing and feature extraction (as shown in Figure 2). The preprocessing stage removes or suppresses noise from the raw ECG signal and the feature extraction stage extracts diagnostic information from the ECG signal.

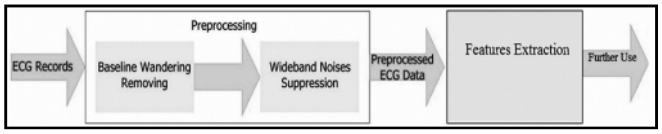

Fig. 2: Preprocessing of ECG Signal

4. SELECTION OF FEATURES

After the preprocessing ECG signal, features are required to be extracted from it. There are various features classes that can be extracted from ECG signal are:

4.1. Amplitude Features

The various amplitude features that can be extracted from an ECG signal are shown in Figure 3. The features can be selected that gives the difference of amplitude of two peaks, or a peak and a valley, or two valleys.

4.2. Angle Features

The angle between PQR, QRS, and RST point of the ECG signal can be used for the authentication purpose. The Figure 4 shows the various angle features that can be extracted from the ECG signal.

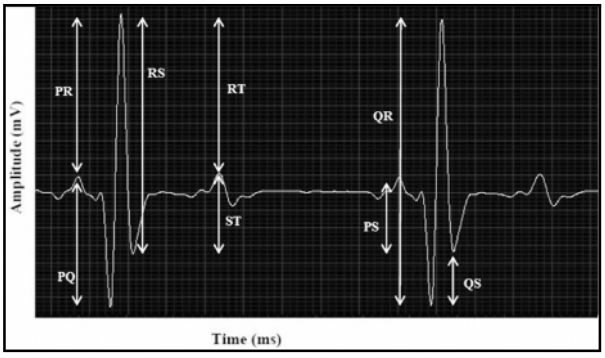

Fig. 3: Amplitude Features

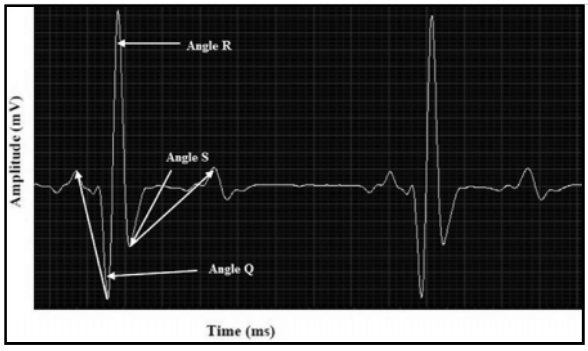

Fig. 4: Angle Feature

4.3. R-R Interval

R-R interval is the time difference of two R peak in the ECG signal. By detecting the occurrence of two consecutive peaks in the ECG signal RR interval can be measured as shown in Figure 5.

4.4. Interval Features

Time differences between various peaks, valleys, and the duration of peaks of a single ECG signal can also be measure as shown in Figure 6 and used for the authentication work.

Fig. 5: RR Interval

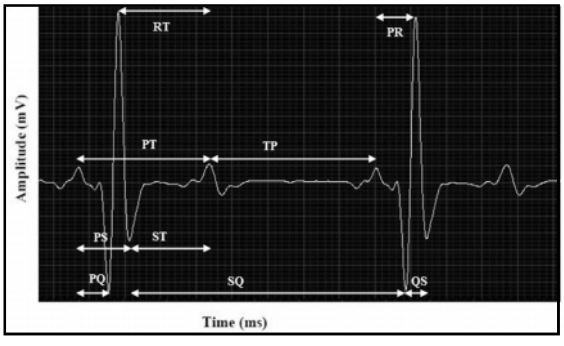

Fig. 6: Interval Feature of ECG

The selection of the features of ECG signal to be used as biometric is very critical. Apart from being easily measured the selected features must be invariant with respect to position and age. It has been observed that heart beat of a person changes from infant to adult person, so the time duration between various peak and valley changes. This means that the internal and angle features will change with time so these features should not be used as biometric features. The amplitude features have minimum change with age (amplitude of P wave remain constant throughout life) so maximum amplitude features should be selected for a biometric authentication system based on ECG.

5. CONCLUSION

The ECG based biometric authentication system can be used in the automated word because of their uniqueness, universality, collectivity and acceptability. Moreover, the requirement of the authorized person to be present at the place of authentication further enhances the security of the system**.** The property of the ECG that amplitude features do not change with age (amplitude of P wave remain constant throughout life) further makes it front runner to be used as biometric in future.

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