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An Intelligent Security: A Heart to My Key

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Abstract: Biometrics based on fingerprints and retina scans. It offers ways to get around this by turning the person into the password, but while they improve security, they are not without some shortcomings. Fingerprints can be lifted or forged and there's still the matter of presenting hands or eyes for scans, which can be as tedious as punching in passwords. Researchers have created a security system where a person's heartbeat is their password - offering hope of electronics which people could simply pick up to unlock them. Human heartbeats never quite repeat themselves, and each person's heartbeat is unique, and this is because electrocardiogram signals vary from person to person, and can be used as a new tool for biometric recognition. ECGs are also difficult to clone. Cloning and Spoofing an ECG-based system would be much harder. It is well worth noting that an integrated hardware-based secure element prevents digital skimming and spoofing. The very nature of using a unique ECG to validate an identity is more secured than using other biometrics. Your cardiac rhythm is protected inside your body, making it almost impossible to steal, mimic or circumvent. The developed devices deliver a secure and convenient means of identification that also provides the potential to control devices using gestures. Our paper emphasizes a case study that focuses on the mechanism of intelligent security system, which ensures that our heartbeats can serve as a strong medium protecting against spoofing and hacking.

Key words: Premature ventricular contraction (PVC), Atrial premature contraction (APC), Linear discriminant analysis (LDA).

I. INTRODUCTION

A New identification system has been proposed in this study, which uses the features and makes the decision on the identity of an individual with respect to a given database. Biometric traits offer direct solutions to the critical security concerns involved in identity authentication systems. A heart rate monitor receives a Doppler signal reflected from an artery of a target, performs demodulation and heart beat recognition techniques to determine a set of features in each frame of the signal. Pattern classification is performed to determine if the extracted feature sequence is associated with heart beats. The pattern classification may include finding the optimal state sequence by calculating the probability of each allowable state sequence based on the extracted feature sequence and heart beat models or additional noise models.

II. METHODOLOGY

Biometrics-based human identification is essentially a pattern recognition problem which involves preprocessing, feature extraction, and classification. Figure 1 depicts the general block diagram of the proposed methods. In this paper, we introduce two frameworks, namely, feature extraction with/without fiducial detection, for ECG-based biometric recognition. In ECG monitoring, commonly encountered types of premature heart beats are the premature ventricular contraction

(PVC) and the atrial premature contraction (APC).An ECG based identification system where only temporal features were employed. An input ECG was filtered to eliminate the effects of noise and the signal's peaks were detected in the time domain by finding local maxima in the regions surrounding each of the P, R and T complexes. Then, 15 features were extracted that denote the time distances between detected features. Wilks' Lamda was used for feature selection and linear discriminant analysis (LDA) was used for classification. The system achieved 100% subject recognition and 81% heartbeat recognition rate for a total of 29 subjects.

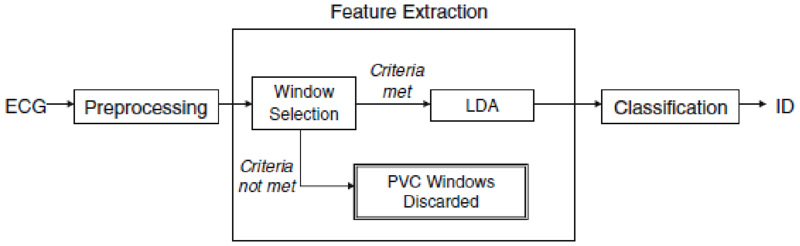

Figure 1: Block diagram of proposed system

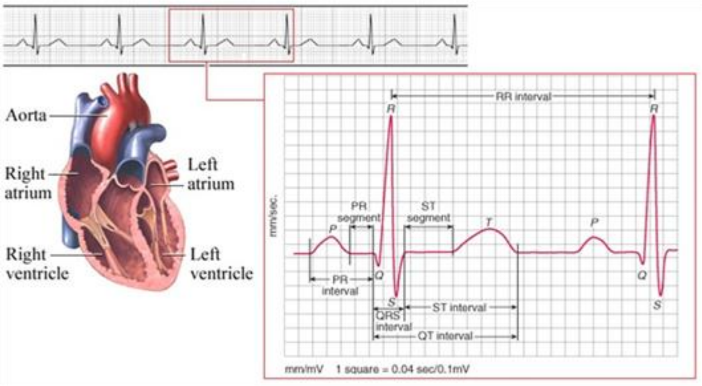

Figure 2: ECG Representation

III. Functioning of the Human Heart

The heart is a four-chambered, muscular organ about the size of your fist. It lies within the chest, between the lungs, and just behind and to the left of the breastbone. The heart's main job is to pump oxygen-rich blood throughout the body. It does this by contracting 60 to 90 times per minute. With each contraction, the heart chambers pump blood either into a ventricle or an artery. During the course of a day, your heart beats more than 100,000 times, pumping 7,000 liters of blood through thousands of miles of blood vessels.

The heart has an electrical conduction system that stimulates it to contract or beat. Each beat begins as an electrical impulse that arises from a specialized area of the right atrium called the sinoatrial (SA) node. The SA node is the heart's natural pacemaker. It receives messages from the brain and other centers directing it to adjust the heart rate to meet the body's needs. This information is important in the study of using a biometric because of the following:

- To use the heart as an inherent liveness biometric we are not referring to the pulse created by the heart beating.
- Also, We are not referring to the sounds that the heart makes (the heart contracting and the valves opening and closing).

When exploring to use the heart beats as a biometric we are considering the electrical activity inside the human heart,

A. The Conduction system of the human heart

The heart has its own system to generate and spread electrical signals from one end of the heart to the other, making the muscle contract. The electrical impulse begins at a bundle of cells called the sinoatrial (SA) node. The electrocardiogram (ECG) is a way that we can “see” certain characteristics of the electrical signals in the heart. There are three waves to the ECG, each of which corresponds to a stage of the heart's contraction.

These waves are called P, QRS, and T. The stages of contraction for each wave are listed below:

- P: Atrial muscle contraction after the SA node fires

- QRS: Ventricular contraction
- T: Ventricular refilling and recharging after contraction

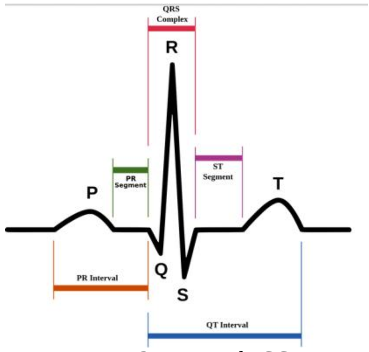

Figure 3: Waves of ECG

The first part, "Obtain signal pattern", is performed as described in Figure 3. The analysis is performed on initial 1-2-minute-long fragments of the analyzed signals, although not longer than 20% of it. This way the average positions of characteristic points of the ECG of a person are calculated. A pattern is obtained by defining both time and voltage interval for all characteristic points in conjunction with P point. The possible voltage difference from average values is defined as ±(maximum R − minimum S) × 0.001. Time difference interval is defined as ±0.5% of frequency. The rest of the signal is acquired and analyzed in 20-second-long spans (this time span is adjustable) which are attached to already sent earlier parts. Recently obtained 20-second-long span is widened for analysis with the end of the previous span, namely the part from the beginning of the last obtained proper heartbeat.

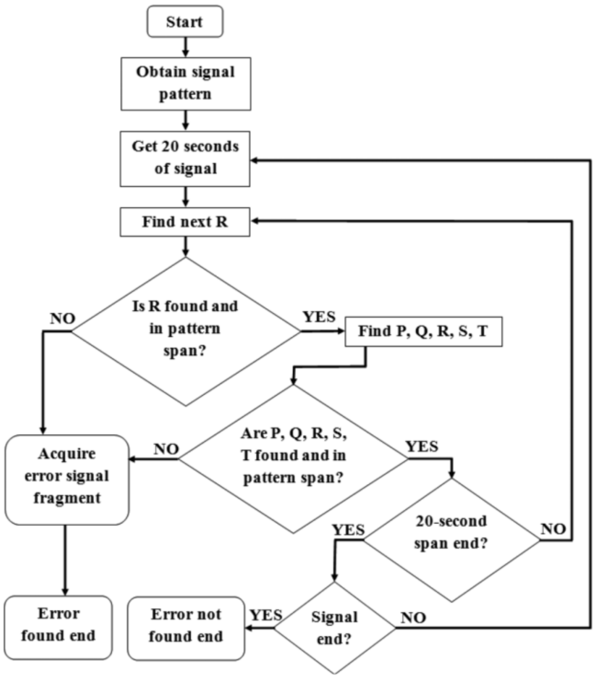

Figure 4: Flow chart for real time simulation

IV. Uniqueness of the Way the Heart Beat

There is no research, reference or information available regarding the application of using the electrical activity in the human heart as an inherent liveness biometric, and there is no information available regarding the uniqueness of the ECG or VCG measurement; this is because of the application of ECG and VCG measurements up to now:

- ECG and VCG measurements have up-to now been used to diagnose a variety of heart diseases, this is done by interpreting the ECG or VCG reading and identifying characteristics that are ***similar*** to the characteristics of the different heart diseases.

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- To use the electrical conductance properties of the heart as a biometric one will have to interpret the ECG and VCG reading a lot differently, one will be looking for ***differences*** between different ECG readings and not similarities.

For this reason the ECG and VCG readings of a human heart might not be the ideal sensing mechanism to use in capturing the needed characteristics of the conductivity of the heart, because of the fact that it was designed to identify ***similarities*** and not ***differences***. Because of the above factors we will still need years of research to be able to capture the correct properties with a specifically designed sensor to prove this exiting possibility of using heart beat based biometric.

V. Feature Extraction based on Fiducial Detection

After preprocessing, the *R* peaks of an ECG trace are localized by using a *QRS* detector. The heartbeats of an ECG record are aligned by the *R* peak position and truncated by a window of 800 milliseconds centered at *R*. This window size is estimated by heuristic and empirical results such that the *P* and *T* waves can also be included and therefore most of the information embedded in heartbeats is retained.

A. Analytic feature extraction

The fiducial points are depicted in Figure 3. As we have detected the *R* peak, the *Q*, *S*, *P*, and *T* positions are localized by finding local maxima and minima separately. The extracted attributes are temporal and amplitude distances between these fiducial points. The 15 temporal features are exactly the same as described in [4, 5], and they are normalized by *P_T_* distance to provide less variability with respect to heart rate. Figure 5 depicts these attributes graphically,while Table1 lists all the extracted analytic features.

B. Benefits of using the way the heart beats as a Biometric

- *The way the heart beats* is a unique & private feature of an individual.
- Identical twins might have different and distinct electrical activities in their hearts.
- The Heart is hidden; it is not possible to easily capture the characteristics of an individual’s heart without his\her consent.
- *The way the heart beats* are not easily observed.
- No liveness testing necessary, an Inherent liveness biometric. The nature of *the way the heart beats* as a biometric proves the liveness of the user in a natural way.
- In the possibility of using the way the heart beats as a biometric one might incorporate a stress level check that will ask a user in an ATM transaction to enter the bank if too high stress levels are detected that might indicate a user being forced against his\her will to conduct a transaction.
- Everybody has a heart. Unlike a fingerprint, some individuals might be disabled and have no hands and thus no fingerprints. This is hindering systems where fingerprints are being used to identify and verify a large population.

VI. Conclusion

To use the way the heart beats as a biometric has got it’s benefits and drawbacks as is the case with all biometric features and technologies. Maybe the most promising benefit regarding the possibility of using the way the heart beats as a biometric is the fact that the biometric feature solves one of the biggest concerns regarding biometrics today namely: Liveness testing. One cannot measure the electrical activity of a human heart if the heart and thus the human are not alive. It is demonstrated that human identification via the ECG is feasible and highly effective. The ECG’s robust nature against falsification makes it rather promising for security systems, as it offers airtight security in all situations. it has been found that although using multiple heart beats of an individual can increase the accuracy of the decision, identification can still be carried out by using just a 10 s ECG recording. The major novelty of the current work lies in addressing identification in presence of cardiac irregularities which are often encountered and which would otherwise jeopardize recognition. It is expected that the ECG will soon find the niche in the biometric world. Future works will investigate the potential of applying ECG based identification under nonfunctional factors, such as stress aging and drug usage.

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