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Original Article

ECG based biometrics verification system using LabVIEW

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Abstract

Biometric based authentication systems provide solutions to the problems in high security which remain with conventional security systems. In a biometric verification system, human's biological parameters (such as voice, finger print, palm print or hand geometry, face, iris etc.) are used to verify the authenticity of a person. These parameters are good to be used as biometric parameters but do not provide the guarantee that the person is present and alive. As voice can be copied, finger print can be picked from glass on synthetic skin and in face recognition system due to genetic factors identical twins or father-son may have the same facial appearance. ECG does not have these problems. It can not be recorded without the knowledge of the person and ECG of every person is unique even identical twins have different ECG. In this paper an ECG-based biometrics verification system which was developed using Laboratory Virtual Instruments Engineering Workbench (LabVIEW) version 7.1 is discussed. Experiments were conducted on the database stored in the laboratory of 20 individuals having 10 samples each and the results revealed a false rejection rate (FRR) of 3% and false acceptance rate (FAR) of 3.21%.

Keywords: biometrics, ECG, LabVIEW, false acceptance rate, false rejection rate

1. Introduction

Biometric offer automated methods of identity verification or identification on the principle of measurable physiological or behavioral characteristics which are universal and unique in nature. It has been observed that ECG is unique in the sense that it is different in different individuals (even in identical twins and father-son). So it can be used as a biometric as discussed by Biel *et al.* (2001), Irvine *et al.* (2001) and Israel *et al.* (2003). ECG-based biometric authentication system has the advantage that apart from providing the usual benefits of biometric based systems, it also detects that the person is alive, meaning that the person's live presence is necessary as pointed out by Preez *et al.* (2005). ECG is easy to record as only single lead ECG signal is required for processing and the system requires only low cost hardware. Therefore, the ECG-based biometrics system may be easily implemented and accepted by the people.

As ECG is a new concept in biometrics system, little research work has been published in the field of ECG-based biometrics systems. Biel *et al.* (2001) were among the first to demonstrate the applicability of ECGs as a biometric. Their approach was 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. Shen *et al.* (2002) reported another method for one lead ECG identity verification. The approach was divided into two steps, first to compute the correlation coefficient among *QRS* complexes

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in order to verify possible candidates for template matching and then a decision-based neural network (DBNN) was used to strengthen the validation of the identity resulting from the first step. Silva *et al.* (2007) presented an approach in which each heartbeat waveform had been sequentially segmented from the full recording and all individual waveforms had been aligned by their *R* peaks and then the mean wave for groups of 10 heartbeat waveforms (without overlapping) had been computed to minimize the effect of outliers. Wang *et al.* (2006) suggested an integration of analytic and appearance features from heart beats. The preprocessed ECG signal had been subjected to fiducial point detection to measure temporal and amplitude distances.

In this paper an ECG-based biometrics verification system using LabVIEW is discussed. LabVIEW is a graphical programming language in which icons are used instead of text and is different from the text based-languages which have a sequential order of programming. LabVIEW uses data flow programming that executes according to the flow of data.

In section 2, an ECG-based biometrics verification system is described that includes the acquisition of the ECG signal, preprocessing of the ECG signal, calculation of features and comparison of test and reference signal features. Section 3 includes the results of the proposed work. The conclusion of this work is discussed in section 4.

2. ECG Based biometrics verification system

The ECG-based biometric verification is a process of verifying the identity of claimant. It performs one-to-one comparison between features of a newly input ECG signal and the features of the ECG signal for the claimed identity that is stored in the database. The system comprises mostly software portion but has some hardware involved too. The hardware required is an ECG recorder, DAQ card and a PC. The software part for the ECG-based biometrics verification system has two stages:

Stage 1: Enrollment of the new user

Stage 2: Testing the authenticity of the already enrolled users

The block diagram of the ECG- based biometrics verification system using LabVIEW is given in Figure 1. As shown in the diagram various steps for verification includes collection of ECG signal from the body using surface electrodes, transferring the ECG signal from Polyrite to computer using BNC 2120 connector accessory & PCI6024E DAQ card, preprocessing ECG signal to remove baseline wandering and noise, extraction of features from the ECG signal and recording/ verification of the features.

During enrollment new users were added to the existing database of the system. The flow chart for the enrollment of a single user is shown in Figure 2. Firstly, the system asks the user to enter name and then the system checks whether the name already exists in the database or not. If a match is found then the system prompts a message to enter a new name. This process continues until the name is not been matched with the database entries. The system then asks for the password. The name and password for various users have been stored along with their extracted features of the ECG signals, in the database in the form of records in a special type of file called a data log file, which is available exclusively in LabVIEW.

The various steps used for recoding the ECG are as follows:

1. Configuring the Input channel i.e. to make a channel to measure the applied voltage because ECG signal is a bio-potential, and can be measured in volts.
2. Fixing the electrodes at the right place on the body of the subject.
3. Turning ON the ECG/EKG module of the Polyrite

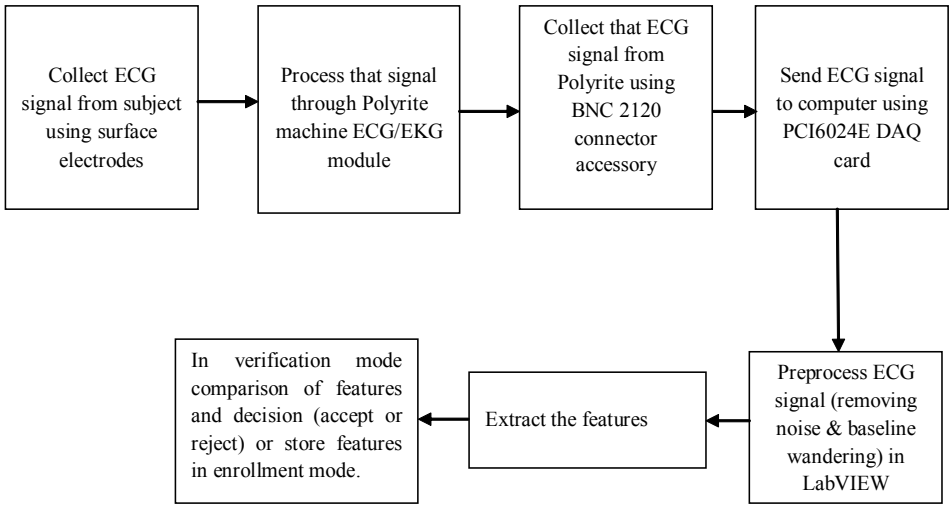

Figure 1. Block Diagram of ECG Based Biometrics Verification System

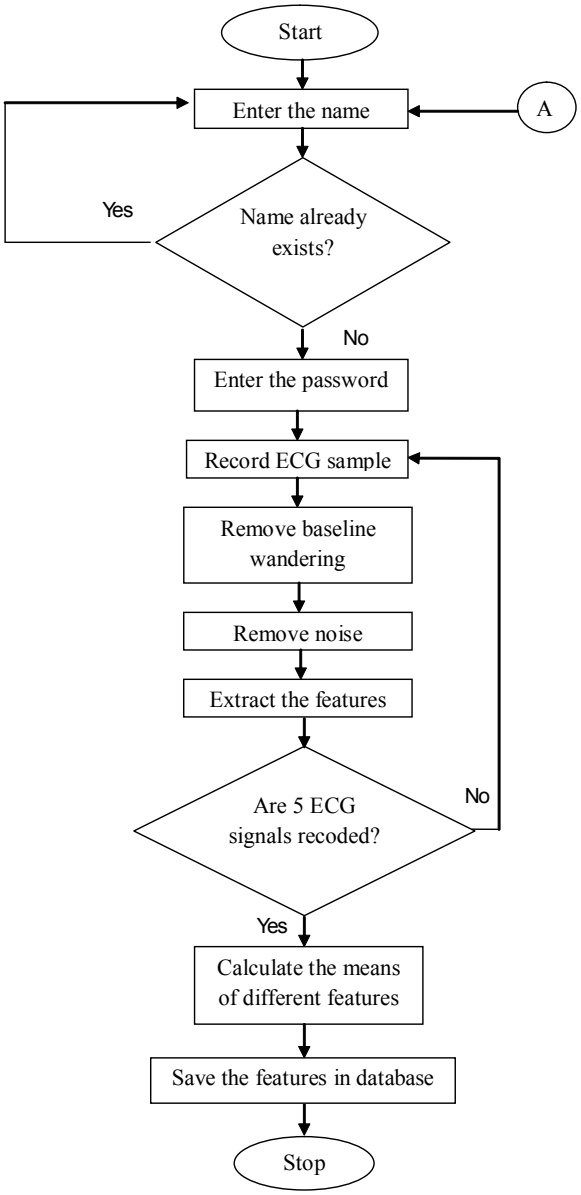

Figure 2. Flow Chart for Enrollment of a Person

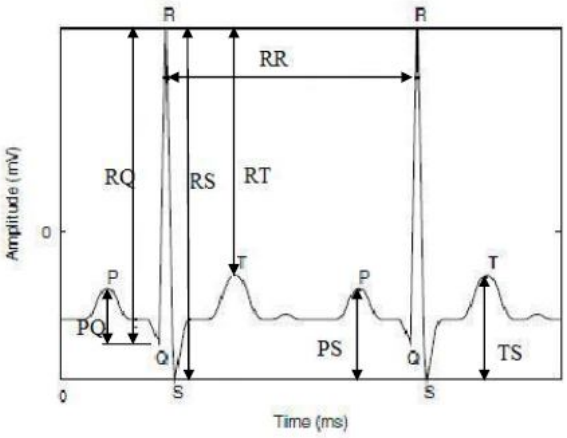

Figure 3. Selected Features from ECG

machine and selecting lead II bipolar for ECG recording.

4. Storing data of 5 seconds in a text file.

From the recorded ECG signal the various features are extracted. For feature extraction, the ECG signal is pre-processed to remove baseline wandering (which usually comes from respiration at frequencies wandering between 0.15 to 0.3 Hz) and noise with the help of a digital filter (http://zone.ni.com/devzone/cda/tut/p/id/6349). The features are extracted from the preprocessed ECG signal. In this work, the seven ECG features, PR amplitude, QR amplitude, RS amplitude, RT amplitude, RR interval, PS amplitude and TS amplitude, were selected for verification as shown in Figure 3.

The above features were selected because it has been observed that heart beat of a person changes from infant to

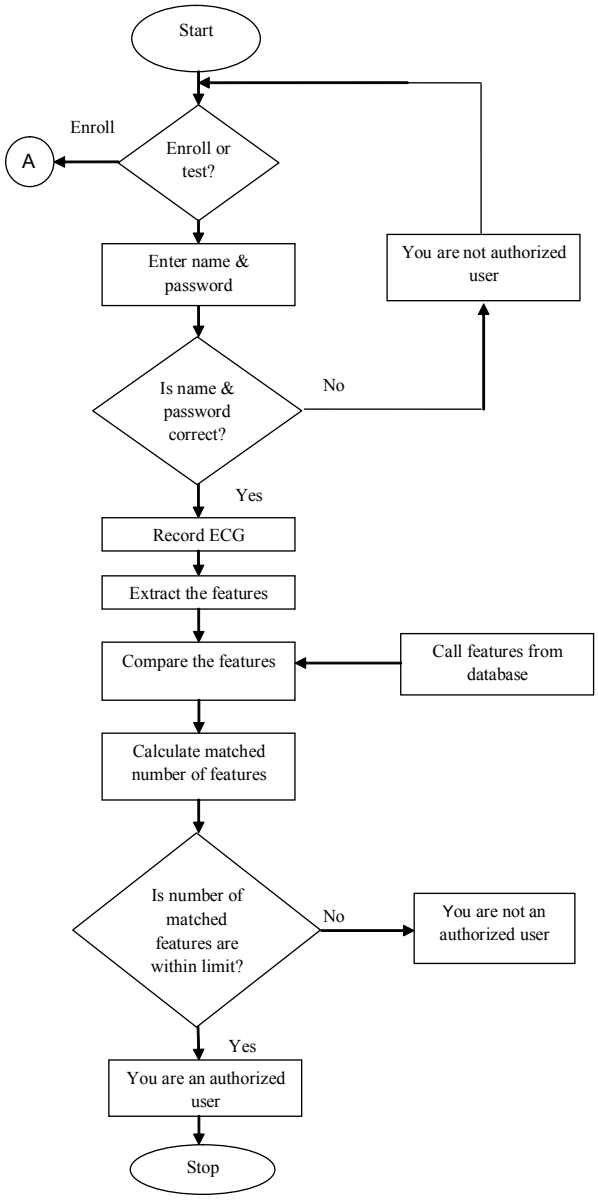

Figure 4. Flow chart for Testing the Authenticity of the User

adult person, so the time duration between various peaks and valleys changes. Also amplitude features have minimum changes with age so mostly amplitude features were selected.

For feature extraction, the R peak in the waveform was detected using a peak detector. The peak before the R peak is the P peak and peak after the R peak is the T peak. The distance of two R peaks was measured by using index of array. The valley between the P and R peaks is Q and valley between the R and T peaks is S.

The system was designed in such a manner that each user had to provide five samples of ECG signals during the enrollment step. The features were extracted from all the samples and the mean of each feature was stored in the database.

In the verification process, first of all name and password of the user were checked. If the first stage was passed then the ECG signal of the subject was recorded. The extracted features from the ECG signal were compared one by one with the features of the person already stored during the enrollment process. If any specific feature and its corresponding feature stored in the database lies within the limits of deviation (which had been taken ±10% from the stored features) then it was assumed that the two features matched with each other. In this way all the seven features were tested for matching. The decision was taken in favor of the claimant if a minimum 5 out of 7 features of the subject were matched, access was then provided to the subject, otherwise access was denied. The flow chart of the ECG-based biometrics verification system is shown in Figure 4.

3. Results

Values of extracted features of all 20 subjects are shown in Table 1 and the results of the verification system are shown in Table 2. In Table 2 the diagonal reading in bold presents the number of matched samples of a subject with itself which shows the true accept cases i.e. the accuracy of the system, the off diagonal readings show the number of matched samples with other subjects i.e. false accepts of the system.

As shown in Table 2 the experiments were conducted on the collected database in the laboratory of 20 persons of different ages having 10 samples from each person. From Table 2 it has been concluded that

a) 122 false verifications were accepted out of 3800
b) 6 true verifications were rejected out of 200

Tables 3 and 4 show the FRR and FAR of the system.

4. Conclusion

The work presented in this paper represents one type of biometric-based security system. The use of ECG as a biometric not only provides superiority over the traditional methods but also overcomes the problem of presence and living condition of the authorized user. In other words the use of ECG as a biometric enhances the security of the system.

The system has been developed and implemented on LabVIEW 7.1 platform. The developed system provides an

Table 1. Extracted features of different subjects

Subject	Features						
	PR	QR	RS	RT	RR	PS	TS
Subject1	1.86317	3.34588	2.71037	1.83380	798.907	0.847203	0.876489
Subject2	2.32498	4.04857	3.44104	2.33037	701.577	1.116060	1.110660
Subject3	1.81446	2.86525	2.42702	1.78187	682.084	0.612563	0.645150
Subject4	1.28027	1.95856	2.04706	1.17829	703.183	0.766782	0.868763
Subject5	2.10934	3.69789	3.12540	2.09417	791.458	1.016060	1.031230
Subject6	1.39743	2.07143	1.89451	1.27138	1135.09	0.497089	0.623130
Subject7	1.45911	2.30484	1.88505	1.38883	691.137	0.425940	0.496224
Subject8	2.75310	4.38531	4.02811	2.77792	789.235	1.275010	1.250190
Subject9	1.35744	2.04539	2.02366	1.32184	920.174	0.666222	0.701816
Subject10	1.02837	1.47654	1.59480	1.02762	825.656	0.566434	0.567179
Subject11	1.78449	3.21430	3.07183	1.79239	932.190	1.287340	1.279440
Subject12	1.71369	2.26694	2.88027	1.57601	718.303	1.166580	1.304260
Subject13	1.39975	1.94104	2.05747	1.33238	787.171	0.657727	0.725090
Subject14	1.70610	2.76527	2.62869	1.64658	871.155	0.922590	0.982109
Subject15	1.06010	1.41805	2.44731	0.90526	923.083	1.387210	1.542050
Subject16	1.50971	2.49336	2.12827	1.44788	782.072	0.618566	0.680394
Subject17	1.48516	2.42080	2.22353	1.48078	787.528	0.738375	0.742754
Subject18	1.24325	2.24022	1.78881	1.21024	812.367	0.545561	0.578571
Subject19	1.90889	3.03207	2.84017	1.93515	822.969	0.931281	0.905027
Subject20	1.41820	2.24748	2.22200	1.25683	768.693	0.803807	0.965172

Table 2. The result of verification process

	Subject1	Subject2	Subject3	Subject4	Subject5	Subject6	Subject7	Subject8	Subject9	Subject10	Subject11	Subject12	Subject13	Subject14	Subject15	Subject16	Subject17	Subject18	Subject19	Subject20
Subject1	10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0
Subject2	0	9	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subject3	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Subject4	0	0	0	10	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2
Subject5	0	2	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Subject6	0	0	0	0	0	10	0	0	5	0	0	0	0	0	0	0	0	1	0	0
Subject7	0	0	0	0	0	4	9	0	0	0	0	0	0	0	0	0	0	2	0	0
Subject8	0	1	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
Subject9	0	0	0	1	0	3	0	0	9	0	0	0	4	0	0	4	4	1	0	1
Subject10	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	1	0	0
Subject11	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0
Subject12	0	0	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0	0	0
Subject13	4	0	0	3	0	3	0	0	3	0	0	0	10	0	0	4	4	0	0	0
Subject14	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	4	0
Subject15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Subject16	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	10	3	1	0	4
Subject17	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	3	10	0	0	5
Subject18	0	0	0	0	0	4	0	0	1	0	0	0	0	0	0	0	0	9	0	0
Subject19	4	0	0	0	2	0	0	0	2	0	2	0	0	2	0	0	0	0	10	0
Subject20	0	0	0	4	0	0	0	0	0	0	0	0	2	0	0	1	1	0	0	9

Table 3. True test result

Total number of persons	True test per person	Total true tests	Total false rejects	% False rejects
20	10	200	6	3

Table 4. Imposter test result

Total number of persons	Imposter test per person	Total imposter tests	Total false accepts	% False accepts
20	190	3800	122	3.21

accuracy of almost 97%. The false rejection rate of the system has been observed to be 3% while a 3.21% false acceptance rate has been achieved. Also the system detects the user in almost real time.

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