A New Approach to Heart Sounds Biometric Recognition Based on Gram-PNN

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***Abstract*— In this paper we introduce a new approach to heart sounds biometric recognition based on Gram polynomials and probabilistic neural networks (PNN). The usage of heart sounds as physiological biometric traits was first introduced in [1], in which the authors proposed and started exploring this idea. Heart sound recognition is based on the analysis of PCG (PhonoCardioGram) sequences. The proposed system presents good performance obtaining an error rate of 13.70 % over a database of 50 people, containing multiple heart sequences per person, each lasting from 20 to 70 seconds.**

Keywords—heard sound biometry; PNN; PhonoCardioGram

I. INTRODUCTION

Identity recognition is an increasingly important process in our daily lives. Traditional authentication methods fall into two categories: proving that you know something (i.e., password-based authentication) and proving that you own something (i.e., token-based authentication).

Today, one of the most important research directions in the field of biometrics is the characterization of novel biometric traits that can be used in conjunction with other traits, to limit their shortcomings or to enhance their performance.

In this paper we introduce a new approach to heart sounds biometric recognition. Biometric recognition is the process of inferring the identity of a person via quantitative analysis of one or more traits, that can be derived either directly from a persons body (physiological traits) or from ones behaviour (behavioural traits).

The usage of heart sounds as physiological biometric traits was first introduced in [1], in which the authors proposed and started exploring this idea. Their system is based on the frequency analysis, by means of the Chirp z-Transform (CZT), of the sounds produced by the heart during the closure of the mitral tricuspid valve and during the closure of the aortic pulmonary valve. These sounds, called S1 and S2, are extracted from the input signal using a segmentation algorithm.

In this paper the authors propose a new approach based Gram polynomials and probabilistic neural network (PNN).

II. THE GRAM-PNN-BASED BIOMETRIC SYSTEM

The block diagram of the proposed system is depicted in Figure 1.

The PCG (PhonoCardioGram) input trace to be recognized is acquired by a low cost stethoscope.

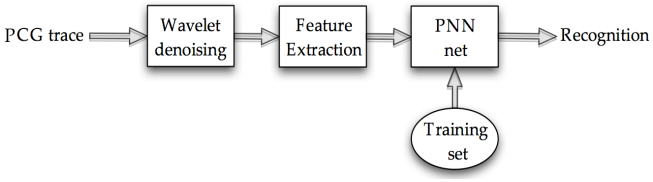

Figure 1. Block diagram of the proposed recognition system.

The database contains heart sounds acquired from 50 people. From each person, we acquired two recordings; each sequence includes 4 cardiac cycles. The two recordings were usually collected the same day, separated by a short break. The sensor used for the acquisition is a ThinkLabs Rhythm Digital Electronic Stethoscope; the files were acquired using a sampling frequency of 11025 Hz and 16 bits per sample, and are stored using the WAVE format.

The denoising algorithm is interval-dependent denoising of the signal that is based on performing a discrete wavelet transform (DWT) of the PCG trace in 12 levels, using the biorthogonal wavelet basis 6.8 then thresholds the wavelet (detail) coefficients down to level, and reconstructs a signal approximation using the modified detail coefficients. The signal is partitioned into intervals based on variance change points in the first level detail coefficients and thresholds each interval separately. The location and number of variance change points are automatically selected using a penalized contrast function [5]. The minimum delay between change points is 10 samples. Thresholds are obtained using a minimax threshold rule and soft thresholding is used to modify the wavelet coefficients [6].

The next block employs a novel feature extraction technique based on least squares approximation and Gram polynomials expansion. The thirty-two real numbers selected as features prove to be essentially non-correlated (which is crucial for a good recognition).

Finally, the feature set obtained from the wavelet denosing block is passed to the third block, a classifier based on Probabilistic Neural Networks (PNN) and structured in accordance with the OCON (One Class One Network) architecture. The PCG recognized should be that whose PNN outputs the maximum probability. Should however this value fall below a suitable threshold, the input PCG will be taken to belong to an “intruder”, i.e. an individual who is not in the database. In practice, a threshold of 0.8 has afforded a null intrusion error rate in all the experiments carried out.

The output of the DWT block is apt to represent a considerable burden for the classification block and to degrade its performance.

Our approach to overcome these difficulties is based on a representation of denoised PCG input trace as a linear combination of Gram polynomials. Coefficients of the combination are determined so that it represents the best approximation of the denoised PCG input trace in the least squares sense. We regard the lower order coefficients (thirty-two) as features extracted from the original PCG trace.

III. RESULT

We evaluated the systems in terms of recognition rate. Figure 3 shows the 32 features derived from the decomposition process for two replicates measured on the same person, as a function of four distinct people.

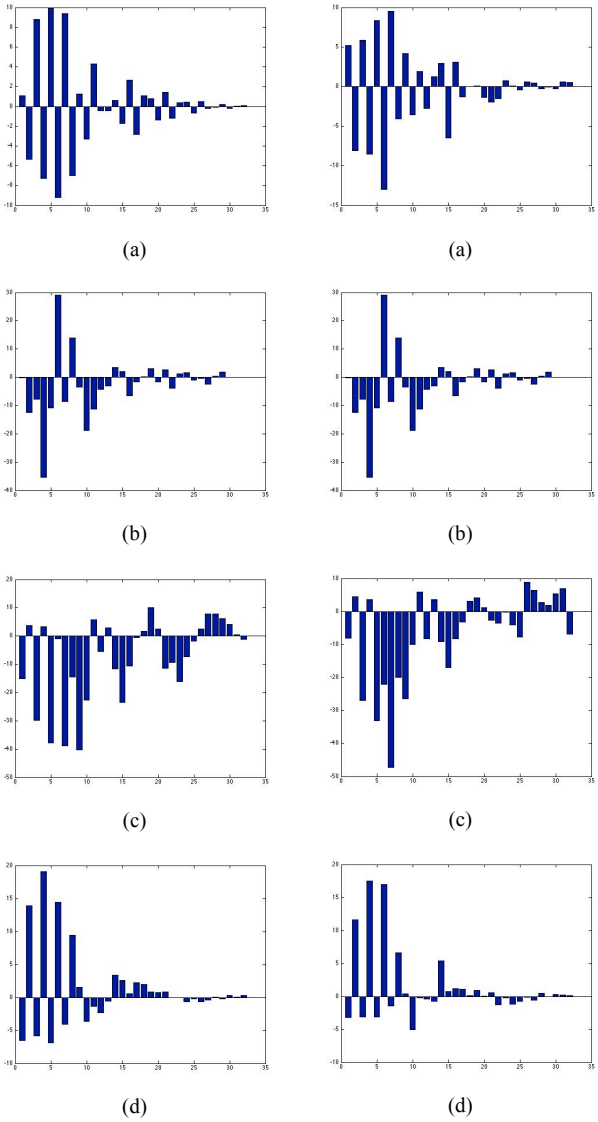

Figure 3. Excerpt of features from the database: plots labeled with the same letter indicate different instances of the same person, whilst different letters indicate different people.

The figures show a high similarity between the images taken on the same people and a marked difference between different subjects, obtaining an average error of about 14%. In conclusion, in this paper we proposed a new approach to human identity based on PCG. Compared to the methods proposed in the literature as to date, the technique proposed is very interesting from the point of view of performance

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