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A computational framework based on behavioural modelling: Application to the matching of electrocardiogram (ECG) recordings

María Teresa Signes *, Higinio Mora, Juan Manuel García

Departamento de Tecnología Informática y Computación, University of Alicante, 03690, San Vicente del Raspeig, Alicante, Spain

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We present a computational framework to aid in cardiovascular disease diagnosis. Our method defines a set of standard behaviours obtained by the recursive calculation of a parameterized formula, and these behaviours are used to match the electrocardiogram (ECG) recording. The advantage of this proposal is the capability to extract from the huge set of numerical values of the ECGs a characteristic reduced pattern with behavioural meaning which allows more accurate and easy matching with unknown ECGs in order to diagnose the patients.

1. Introduction

The electrocardiogram (ECG) signal is an important and commonly used aid in cardiovascular disease diagnosis because it provides key information about the electrical activity of the heart. Many disturbances in the heart performance show variations in the waveform shapes and can be used to diagnose the disease. It is important to remember that the 12-lead ECG provides spatial information about the heart's electrical activity in three orthogonal directions: right/left, superior/inferior, anterior/posterior. To detect abnormal ECG signals, continuous monitoring is required by physicians. Several methods for automated arrhythmia detection have been developed to simplify the huge monitoring task due to the large number of patients in intensive care units as well as to reduce the diagnostic inefficiency caused by inaccuracies in visual inspection. Many well-known techniques are based on descriptive parameters of the wave shape, such as the segments and curves [1–3], and on frequency or time–frequency features, such as dynamic time warping [4,5] or wavelet transforms [6]. Other recent approaches can generate realistic synthetic ECG signals by means of ordinary differential equations (ODEs) and may be employed to assess biomedical signal processing techniques which are used to compute clinical statistics from the ECG [7,8]. Linear discriminant methods such as Karhunen–Loewe basis functions [9] or decomposition into Hermite basis functions [10] can be used to represent the QRS complex and part of the ST complex. These approaches may also involve artificial intelligence techniques such as artificial neural networks or fuzzy logics [10,11]. Proposals combining different techniques succeed in improving the classification results [5,12–19]. Polynomial fitting or spline interpolation is used to remove base line wander, i.e. a low-frequency activity in the ECG which may interfere with the signal analysis, rendering clinical interpretation inaccurate and misleading [20–23]. Usually, this method has a growing computational complexity as the order of the polynomials increases. Nevertheless, in [23], the polynomial distance measurement is used to implement an ECG-based biometric system. The authors claim their method is speedy, area saving and accurate compared with other well-known algorithms. Finally, we have to mention intelligent-agent-based techniques because they provide a structure that can combine not only data types but also a variety of reasoning methodologies in the same decision support system [24,25].

* Corresponding author. Tel.: +34 96 590 3400; fax: +34 96 590 3464.
E-mail addresses: teresa@dtic.ua.es (M.T. Signes), hmora@dtic.ua.es (H. Mora), juanma@dtic.ua.es (J.M. García).
URL: http://www.ua.es/i2rc/index2-eng.html (M.T. Signes, H. Mora, J.M. García).

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