Design of an artificial neural network and feature extraction to identify arrhythmias from ECG

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Válber César Cavalcanti Roza ; Ana Maria de Almeida ; Octavian Adrian Postolache **All Authors**

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Abstract:
This paper presents a design of an artificial neural network (ANN) and feature extraction methods to identify two types of arrhythmias in datasets obtained through electrocardiography (ECG) signals, namely arrhythmia dataset (AD) and supraventricular arrhythmia dataset (SAD). No special ANN toolkit was used; instead, each neuron and necessary calculus were modeled and individually programmed. Thus, four temporal-based features are used: heart rate (HR), R-peaks root mean square (R-RMS), RR-peaks variance (RR-VAR), and QSR-complex standard deviation (QSR-SD). The network architecture presents four neurons in the input layer, eight in hidden layer and an output layer with two neurons. The proposed classification method uses the MIT-BIH Dataset (Massachusetts Institute of Technology-Beth Israel Hospital) for training, validation and execution or test phases. Preliminary results show the high efficiency of the proposed ANN design and its classification method, reaching accuracies between 98.76% and 98.91%, when in the identification of NSRD and arrhythmic ECG; and accuracies of 86.37% (AD) and 76.35% (SAD), when analyzing only classifications between both arrhythmias.

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Contents

Electrocardiography (ECG) is an important non-invasive technique used in medicine to observe the heart variation and abnormalities over a period of time. Continuous and typical ECG signal consists of P-waves, QRS-complexes and T-waves [1], and provides fundamental information about the electrical activity of the heart. Abnormalities in this electrical activity may represent heart diseases defined by the absence of any structural cardiac defects and are responsible for a large number of sudden, unexpected deaths, including those of young individuals [2]. Thus, several diseases may be detected through ECG analysis such as, atrial fibrillation (AF) [3], [4], long QT syndrome, Brugada syndrome, catecholaminergic polymorphic ventricular tachycardia and the short QT syndrome [2] and arrhythmia [5]. Some of these diseases cannot be visually distinguished easily by a medical specialist due to its similar appearance with other signals [6]. However, a deep computational analysis may be used to detect small differences and possible diseases. To allow for such automatic detection, several features may be extracted from ECG signals such as, heart rate variability (HRV) triangular index [7], morphological features [8] through the temporal-domain analysis [7], [9] and frequency-domain [1], [7], [10], and wavelet transform coefficients [11]–[14]. Furthermore, automatic methods to correctively identify diseases or patterns from these signals may be reached through statistical Markov models [15], artificial neural networks (ANN) [1], [3], [6], [16], linear discriminant analysis [17], and support vector machine (SVM) [18].