Support system for Apnea diagnosis using statistical analysis of ECG signals

Ludmila B. Meireles[1], Caio V. Barreto[1], Derick C. de Jesus[1], Lucas S. Cantanhêde[1], Jonathan A. Queiroz[1]

[1]*Departamento de Programação, Universidade Ceuma*
Rua Josué Montello, No. 1, Renascença II, 65075-120, São Luís - MA, Brasil
ludmilabmeireles@gmail.com, queirozjth@gmail.com

Abstract. The advancement of technology has given researchers and doctors the possibility to detect abnormalities in the human body, before they become serious and irreversible diseases. The Electrocardiogram (ECG), which is an exam whose output value reveals the behavior and heart rate of an individual, is of fundamental importance for the analysis not only of the health of the heart, but of the individual as a whole. This article proposes to do the classificatory analysis of ECG data, using healthy databases and apnea. The methods used to separate the two groups into healthy and apnea groups were the mean, variance and kurtosis. The results achieved by the proposed methods obtained accuracy greater than 90%. These results can be used in clinical practice to support the diagnosis, that is, the proposed method has the potential use as a screening method and aid to the diagnosis and monitoring of cardiac pathologies.

Keywords: Electrocardiogram, Data classification analysis, Apnea

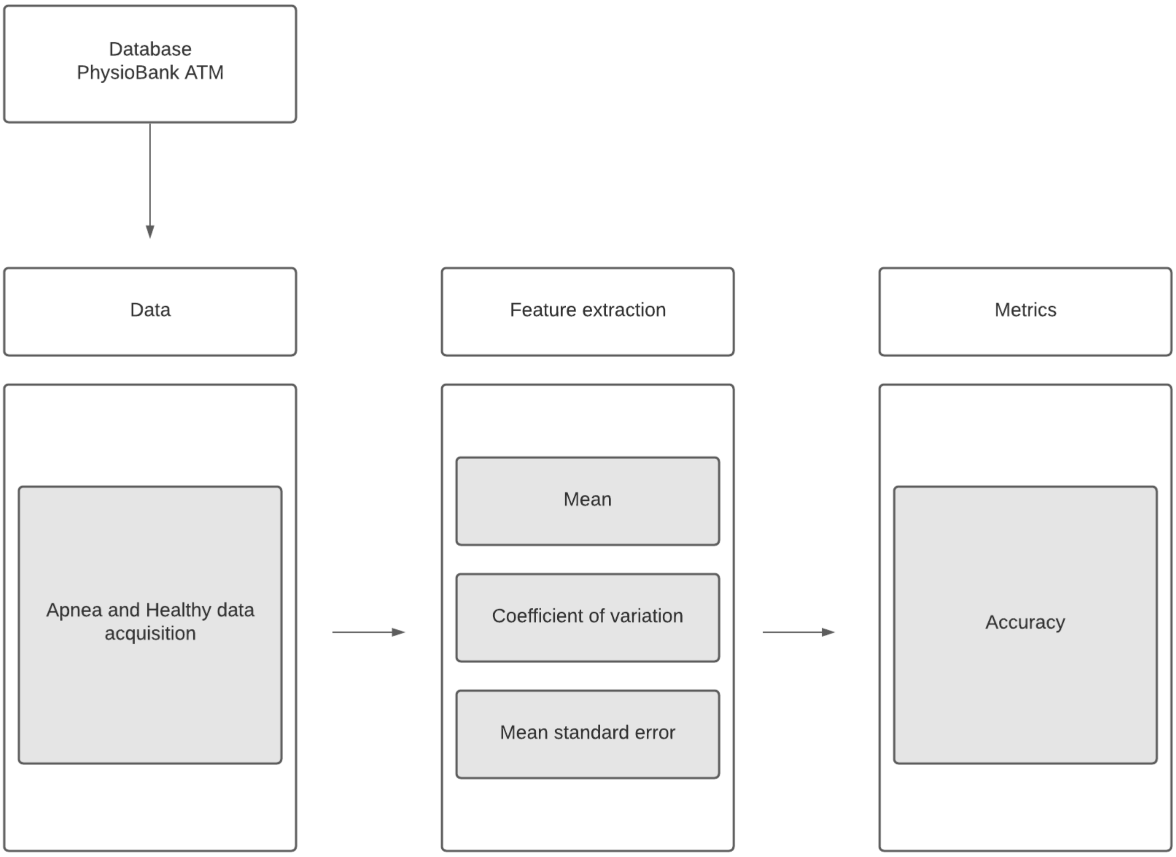
1 Introduction

The Obstructive Sleep Apnea Syndrome (OSAS) is a very frequent disorder during sleep, and is defined by the repetitive occurrence of upper airway obstruction, for a period equal to or greater than 10 seconds. It manifests itself through various symptoms, such as daytime sleepiness, snoring, restless sleep, fatigue and lack of focus[1]. According to the WHO - World Health Organization, about 1000 people in Brazil die daily due to this disorder. However, the advancement of technology has provided researchers and doctors with the possibility of detecting abnormalities in the human body, before they become serious and irreversible diseases. The diagnosis of OSAS is made through a battery of tests, which involve both questionnaires for sleep assessment and polysomnography. This includes several tests, such as the EEG (Electroencephalogram), the ECG (Electrocardiogram) and the EMG (Electromyography). Due to high costs and complexity of performing all these tests, this article proposes the use of the ECG for higher-order analysis, and thus identify OSAS with greater efficiency and feasibility for patients and professionals. Through cardiac signals, it is intended to show that is possible to classify these into 2 groups: one with patients with OSAS and the other with healthy patients, and thus help in the treatment of those in need.

2 Methodology

Two databases were used, namely: signals of healthy individuals and signals of individuals with Obstructive Sleep Apnea Syndrome (OSAS). With the data obtained, the mean, variance and kurtosis values were calculated, which can be seen in this topic. Figure 1 shows the process of building this paper.

Figure 1 – Proposed methodology to implement this work.



2.1 Database

The databases used were the MIT-BIH Normal Sinus Rhythm Database (nsrdb) and the Apnea-ECG Database (apnea-ecg). Data are available in [2][3]. The database with healthy patients, that is, with normal sinus rhythm, contains 18 records. As for patients with Apnea, 18 records were also removed. The first 10 minutes of all signs were excluded, later 2219 cardiac cycles were removed from each ECG sign for analysis.

2.2 Feature Extraction

In this step, equations with the following variables were used: mean, variance and kurtosis. The equations for each variable are described below:

$$\bar{x} = \frac{\sum xi}{n}$$

Where:

$\bar{x}$	-	Arithmetic Mean
$\sum xi$	-	Sum of x values of the sample
n	-	Sample size

$$CV = \frac{\sigma}{\bar{x}} \,.\, 100$$

Where:

CV	-	Coefficient of variation
σ	-	Standard deviation
$\bar{x}$	-	Arithmetic Mean

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$$

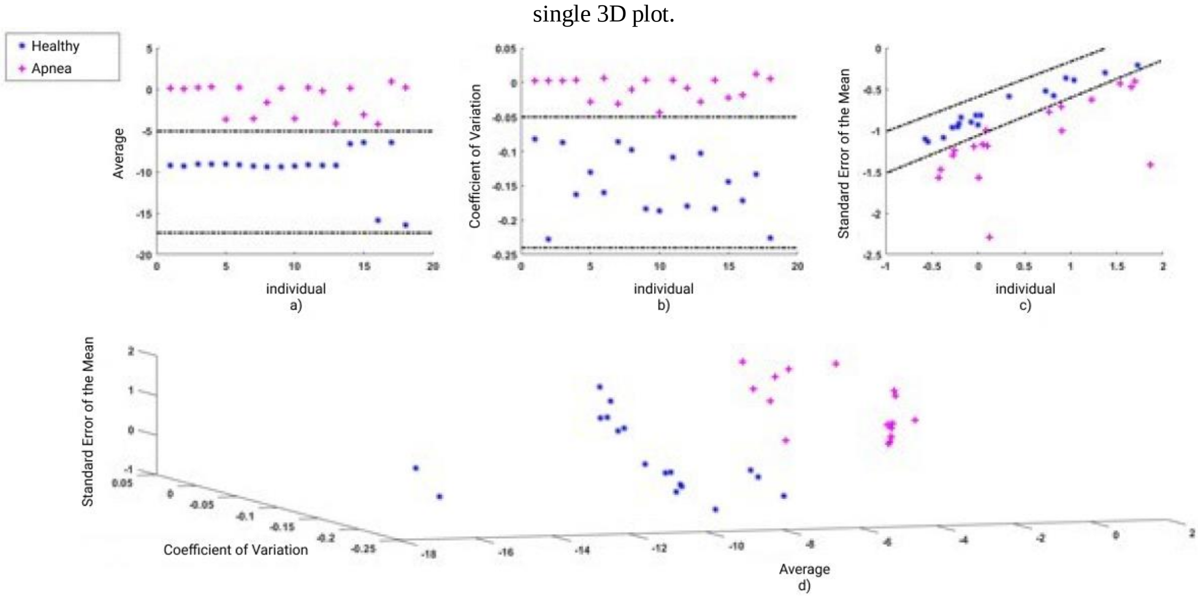
Where:

σ	-	Standard deviation
$\bar{x}$	-	Arithmetic Mean
$\sqrt{n}$	-	Square root of the number of sample values

3 Results and Discussion

Initially, we used 2219 cardiac cycles from 18 healthy individuals, totaling 39942 cardiac cycles of the pathology, we repeated the process and extracted using 2219 cardiac cycles from 18 individuals with Apnea. The next step was to extract the characteristics of the ECG Signals from healthy individuals and individuals with apnea. For this, we used the mean, coefficient of variation and standard error of the mean. Results are expressed in relation to the 99% range of acceptance region. Figure 2 illustrates the region of data acceptance when we use the mean (figure 2a), the coefficient of variation (figure 2b) and the standard error of the mean (figure 2c). Furthermore, we present the combination of the three characteristics in a single 3D plot (figure 2d).

Figure 2 - Scatter plot for the signs of healthy individuals and individuals with apnea. a) I the data acceptance region when using the mean, b) Illustrates the data acceptance region when using the coefficient of variation. c) Illustrates the region of data acceptance when used and the standard error of the mean. d) Illustrates the combination of the three features in a single 3D plot.



The results obtained accuracy greater than 99% for two classes and for three classes the hit rate was 100%, demonstrating that the proposed method can be used to support decision-making in clinical practice.

Other tests were performed using, in addition to the mean, coefficient of variation and standard error of the mean, statistics of variance, standard deviation, asymmetry and kurtosis. However, the results obtained by these metrics were lower than those presented in this article, ranging from 90% to 95% of the right rate in the classification of signs with apnea.

4 Conclusion

In this article, statistical analysis of healthy and apnea ECG signals enabled the extraction of characteristics and classification of different groups of patients. The results obtained from ECG signals, one of the polysomnographic study exams that is used as the gold standard in the follow-up of individuals with apnea, can be used for a diagnosis of individuals with OSAS, thus helping the medical team in making appropriate decisions. more practical and autonomous. When compared to polysomnography, the proposed method has an even greater diagnostic simplicity, becoming an alternative to aid in the diagnosis and follow-up of OSAS. For future work, other heart diseases can be studied and cataloged, as well as new techniques to extract these data. As well as using other classifiers besides the ones used in this article to evaluate the metrics. Further assisting decision-making for those seeking greater effectiveness in medical diagnoses.

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