COBEM-2017-5901
COMPARISON BETWEEN ATRIAL FIBRILLATION DETECTION ALGORITHMS BASED ON RR INTERVALS

Miriam Ferraz de Paulo
Eduardo Guy Perpétuo Bock
Federal Institute of Education, Science and Technology of São Paulo, 625 Pedro Vicente Street - Canindé, São Paulo - SP, Brazil
ferraz.miriam@gmail.com, eduardo_bock@yahoo.com.br

Abstract. *This paper aims to study and compare two algorithms developing in MATLAB R2016b that make detection of atrial fibrillation from electrocardiogram signals. Atril fibrillation is a common cardiac arrhythmia where uncontrolled impulses in atria are observed. These impulses generate multiple wavefronts wandering in atrial region with different propagation patterns. The idea is to compare the disease detection using two methods that analyse irregularity in RR intervals. One of the methods uses coefficients of variation of RR intervals and ΔRR intervals and the other uses statistical indexes. Methods were analysed with MIT-BIH Atrial Fibrillation Database from Physionet site. The percentage of correct answers for RR intervals was 72.2% and in ΔRR intervals of 71.4%. In future, statistical indexes for evaluation will be calculated.*

Keywords: *Atrial Fibrillation, Detection, RR intervals, Coefficient of variation, Statistical methods.*

1. INTRODUCTION

Atrial Fibrillation (AF) is the most common arrhythmia in clinical practice and it affects between 0.5% and 1% of general population (Magalhães, *et al*., 2016). AF occurs when multiple uncontrolled impulses appear where small parts of atrial muscle contract simultaneously (Tateno and Glass, 2001). During AF, an erratic baseline of P wave is observed on Electrocardiogram (ECG) with irregular RR intervals. Although symptoms such as palpitations, dizziness, discomfort in breathing, patients may live with disease. But after years, it can lead to complications such as systemic thromboembolism and it can cause a stroke or a thrombosis accident. The objective of this work is to compare two detection methods based on RR intervals irregularity to be evaluated with same protocol to study their performance. One of the methods uses coefficients of variation (CVs) of RR intervals and ΔRR intervals (Tateno and Glass, 2001). Other method uses statistical indexes for detection, randomness, variability and complexity of RR intervals (Dash, *et al*., 2009) (McManus, *et al*., 2013). A MATLAB R2016b application was developed for AF detection using CVs of RR intervals and ΔRR intervals. The statistical method is undergoing development. To evaluate the algorithm, it has been used ECG signals from Physionet (Goldberger, *et al*., 2000) examining sensitivity and specificity of the two algorithms.

2. COMPUTATIONAL PROCEDURE

The MIT-BIH Atrial Fibrillation Database (Goldberger, *et al*., 2000) was used with 12 ECG recordings by 30 minutes of human patients, sampled at 250 Hz. The R peaks obtained through the *rdann* function of Physionet WFDB Toolbox for MATLAB and Octave, which reads the annotation files prepared using an automated R detector. The CVs are calculated by Eq. (1) and (2):

$$CV_{RR} = \frac{\sigma(RR\ intervals)}{\bar{x}(RR\ intervals)} \tag{1}$$

$$CV_{\Delta RR} = \frac{\sigma(\Delta RR\ intervals)}{\bar{x}(RR\ intervals)} \tag{2}$$

Where RR intervals are interbeat intervals and ΔRR is difference between two successive RR intervals.

If the CVs of the portion of the analyzed signal is within the range of the standard CVs (calculated from ECGs with AF) it is labeled as AF, as show Fig. 1.
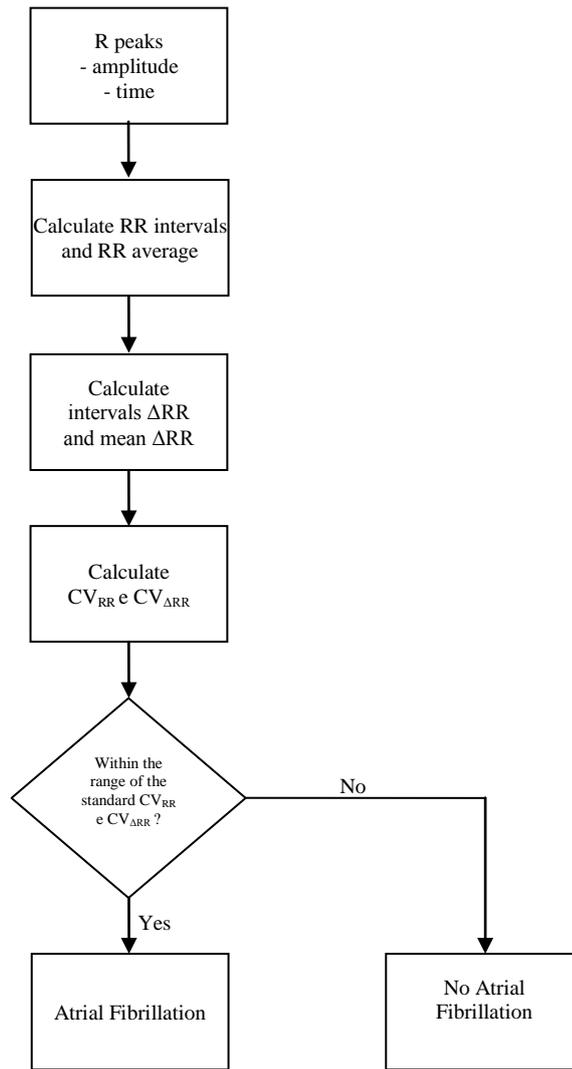
Figure 1. Flowchart - CVs of RR and ΔRR intervals.

The approach combines a Root Mean Square of Successive Difference (RMSSD) for RR intervals used to quantify RR variability. Shannon entropy (ShE) is used to characterize its complexity by Eq.(3) and Eq. (4) (Dash, *et al.*, 2009) (McManus, *et al.*, 2013).

$$Normalized\ RMSSD = \sqrt{\frac{1}{l-1}\sum_{j=1}^{l-1}[a(j+1)-a(j)]^2}\ \frac{1}{\sum_{j=1}^{l}a(j)} \tag{3}$$

Where l is the length of RR intervals and a(j) is the jth RR interval in the segment with length l, where j = 1, 2,..., l.

$$ShE = -\sum_{i-1}^{N}p(i)\frac{log(p(i))}{log\left(\frac{1}{N}\right)}, \quad p(i) = \frac{N(i)}{l} \tag{4}$$

Where N is the number of bins and N(i) is the number of beats in the i-th bin.
A simple logical AND condition is used:

If(Normalized RMSSD > TH_{RMSSD}) and (She > TH_{ShE})
the classify the segment as irregular,
else classify the statement as regular.
TH_{RMSSD} − threshold values of RMSSD/mean
TH_{ShE} − threshold values of ShE

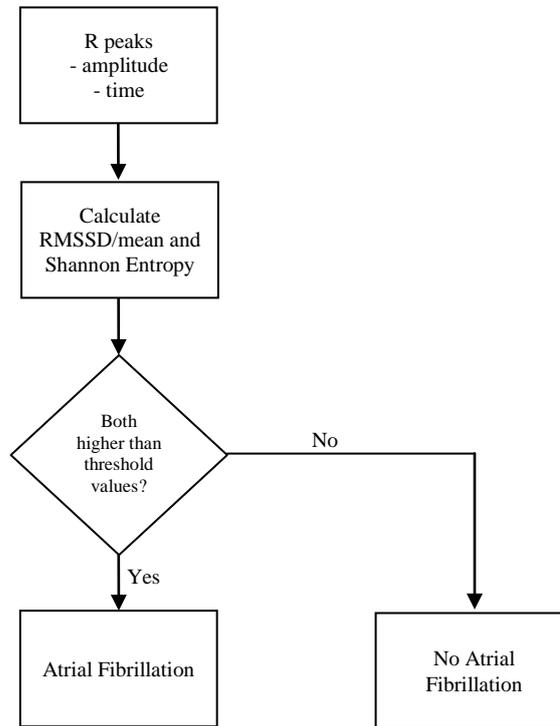The Figure 2 presents the flowchart that combines RMSSD and ShE.

Figure 2. Flowchart - RMSSD/ mean and ShE.

Using the established threshold values of 0.115 for RMSSD/mean and 0.55 for ShE (Dash, *et al*., 2009). After obtaining these statistical indexes, the intention is to evaluate this algorithm with the same database through sensitivity, specificity and errors.

3. RESULTS AND DISCUSSION

The results are being obtained from MIT-BIH Atrial Fibrillation Database. The CV test was applied in RR and ΔRR intervals. In order to obtain indexes of Table 1, annotations presented in the studied database were considered if passages contained FA or not. It considered values of CV test for RR intervals containing FA varying between 0.156 and 0.324. It was set for ΔRR intervals a range from 0.221 to 0.459 (Tateno and Glass, 2001).

Table 1. Accuracy of CV test for MIT-BIH Atrial Fibrillation Database

	RR	*ΔRR*
Sensitivity	54.8	49.5
Specificity	81.6	83.1

The percentage of correct answers for RR intervals was 72.2% and in ΔRR intervals of 71.4%. In future, statistical indexes for evaluation will be calculated.

4. CONCLUSIONS

The results were promising comparing with the values of CV obtained in the literature, but the ideal one would be to increase the rate of correct answers and to reduce the errors of the detector of peaks R. Depending on the results obtained with the statistical indexes the idea would be to use the two methods combined to detect AF more accurately.

5. REFERENCES

Dash, S., Chon, K.H., Lu, S. and Raeder, E.A., 2009. "Automatic real time detection of atrial fibrillation". *Annals of Biomedical Engineering*, Vol. 3, Issue 9, p. 1701-1709.

Goldberger, A.L., Amaral, LA.N., Glass, L., Hausdorff, J.M., Ivanov, P.C.H., Mark, R.G., Mietus, J.E., Moody, G.B., Peng, C.K. and Stanley, H.E, 2000. "PhysioBank, PhysioToolkit, and PhysioNet: Components of a New Research Resource for Complex Physiologic Signals". *Circulation*. Vol. 101, Issue 2, p. 215-220.

McManus, D.D., and *et al*., 2013"A novel application for the detection of an irregular pulse using an iPhone 4S in patients with atrial fibrillation". *Heart Rhythm Society*, Vol. 10 , Issue 3 , p. 315 - 319.

Magalhães, L.P., Figueiredo, M.J.O, Cintra, F.D., Saad, E.B., Kuniyishi, R.R., Teixeira, R.A. and *et al.,* 2016. "II Diretrizes Brasileiras de Fibrilação Atrial". *Arquivos Brasileiros de Cardiologia*, Vol. 106, nº4, Supl.2, p. 1-22.

Tateno, K. and Glass, L., 2001. "Automatic detection of atrial fibrillation using the coefficient of variation and density histograms of RR and ΔRR intervals". *Medical & Biological Engineering & Computing*, Vol. 39, p. 664-671.

6. RESPONSIBILITY NOTICE