

Automatic Detection of Atrial Fibrillation Using Basic Shannon Entropy of RR Interval Feature

Adfal Afdala¹, Nuryani Nuryani² and Anto Satriyo Nugroho³

¹Physics Department of Post Graduate Program SebelasMaret University

²Informatics Department of Under Graduate Program SebelasMaret University
Jl. Ir. Sutami 36A KetinganJebres Surakarta 57126, INDONESIA.

E-mail: afdala17@gmail.com

Abstract. Atrial Fibrillation is one of heart disease, that common characterized by irregularity heart beat. Atrial fibrillation leads to severe complications such as cardiac failure with the subsequent risk of a stroke. A method to detect atrial fibrillation is needed to prevent a risk of atrial fibrillation. This research uses data from physionet in atrial fibrillation database category. The performance of Shannon entropy has the highest accuracy if a threshold is 0.5 with accuracy 89.79%, sensitivity 91.04% and specificity 89.01%. Based on the result we get a conclusion, the ability of Shannon entropy to detect atrial fibrillation is good.

1. Introduction

Atrial fibrillation (AF) is the most common cardiac arrhythmia, whose prevalence is 0.4%–1% of the general population and increases with age. The prevalence in individual over the age of 80 is about 8% in a developed country [1]. This caused by food and a lifestyle of prevalence. The another factor is atrial fibrillation difficult to detect. Atrial fibrillation can occur in a range a few seconds to hours, that means the short term ECG can't give more information about atrial fibrillation [2], that purpose automatic detection is needed to detect atrial fibrillation.

One way to detect atrial fibrillation is to study the morphology of electrocardiogram. Atrial fibrillation has morphological characteristics in the electrocardiogram that was missed of P wave, and irregularity of heart rate which is represented by R peaks [3][4]. Atrial fibrillation can be detected by observing morphological ECG signal. They are R-R Interval and P waves [5]. R-R interval used as a feature in this research to characterized atrial fibrillation in a time interval.

2. Numerical Methods

Database of atrial fibrillation from physionet was used. Database consist of 23 patient with frequency sampling 250 Hz. A segment consist of 10^4 data, if we convert to the time domain, each segment equals to 40 s ECG measurement. Process on extraction features divided three parts, they are finding R peaks, calculate R-R Interval, and finding maximum entropy occur in each segment. Algorithm of Pan-Tomkins is one of a method to finding R peaks. The ability of this method to detect R peaks has accuracy 99.3% [6].



Pan-Tomkins algorithm consist of some process, they are:

1. Bandpass filter
2. Derivative
3. Squaring Function
4. Integration
5. Adjust threshold
6. Decision

R-R interval is a difference of position R(n) from position R(n-1), it is the main characteristic of atrial fibrillation.

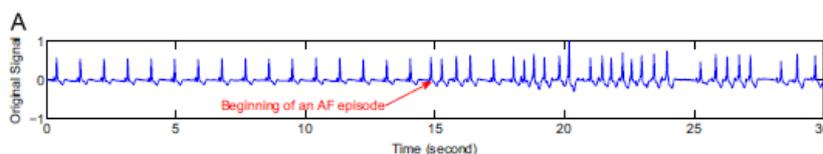


Figure 1. R peaks are characteristic of AF [6]

Figure 1 shows R-R interval as characteristic of atrial fibrillation. RR interval feature has been proposed and investigated by some researcher. Automatic detection of atrial fibrillation using stationary wavelettransform and support vector machine presented in [7]. A simple method for detection atrial fibrillation using RR interval presented in [8]. The next process is finding out the maximum beat in each segment in this process. Shannon entropy applied to get entropy of each segment. Shannon entropy calculates based on equation 1 [9][10].

$$S = -\sum_i^n P_i \log P_i \tag{1}$$

The next process classifies the feature data using artificial neural network backpropagation. This process divided two parts, they are training process and testing process. Each process using random technique sampling for data training and data testing. The ratio of data training and data testing is 10% and 90%. The flow chart of this article represents in figure 2.

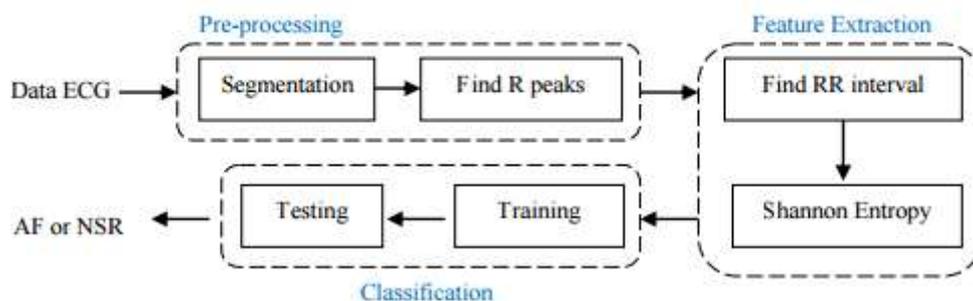


Figure 2. Procedure of the research

3. Results and Discussion

Each patient has different length of a segment where the dominant length is 921 segment. Each segment divided by nine intervals, that means one patient has 921 segments and each segment has ninefeature. To knows the performance of feature, the principal component analysis method applied to this research. The result of this process presented in figure 3.

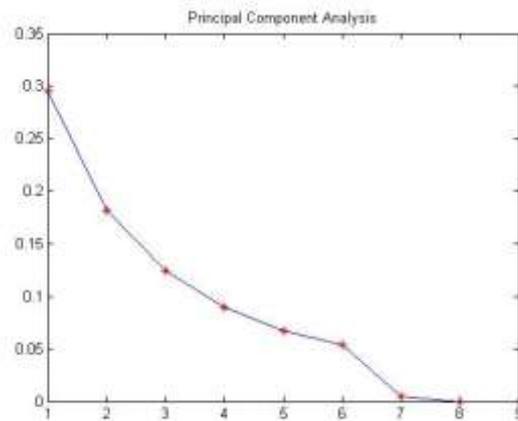


Figure 3. Eigenvector PCA of feature patient 5

Figure 3 shows the eigen vector of each feature, feature 7 to 9 has a lower value than a previous feature. Feature who has lower value reduced from data. That will be minimized computational weight process.

The important process in this research is feature extraction process. Shannon entropy of RR interval is one of feature which will be tested using artificial neural network backpropagation to detect atrial fibrillation. The result of Shannon entropy for each segment presented in table 1.

Table 1. Entropy

Segment	H(1)	H(2)	H(3)	H(4)	H(5)	H(6)	H(7)	H(8)	H(9)	Label
10	0	0	0	0	0	0	0	81.29	143.8	NonAF
15	0	0	0	0	0	0	1.255	316.7	214.1	NonAF
30	0	0	0	0	0	0	0	43.94	222.2	NonAF
400	0	0	0	158.3	28.14	47.74	59.64	9.053	0	AF
450	0	0	2.593	27.91	2.593	8.962	8.962	36.95	0.197	AF
550	0	0	2.78	9.536	106	21.4	49.56	9.536	0.213	AF

Table 1 shows the calculation of Shannon entropy in segment AF and nonAF. Based on table 1, each segment has maximum entropy. If we apply binarization for entropy, we set maximum entropy is 1 and else is zero. Entropy in table 1 becomes presented in table 2.

Table 2. Binarization of entropy

Segment	H(1)	H(2)	H(3)	H(4)	H(5)	H(6)	H(7)	H(8)	H(9)	Label
10	0	0	0	0	0	0	0	0	1	NonAF
15	0	0	0	0	0	0	0	1	0	NonAF
30	0	0	0	0	0	0	0	0	1	NonAF
400	0	0	0	1	0	0	0	0	0	AF
450	0	0	0	0	0	0	0	1	0	AF
550	0	0	0	0	1	0	0	0	0	AF

Table 2 shows segment AF and nonAF have characteristic a part of maximum entropy. Based on table 2 we get a feature to apply in artificial neural network backpropagation. Parameters in the artificial neural network are learning rate, epoch, and momentum. Learning rate is 0.05, epoch 5000, and momentum 0.9. The result of training process presented in figure 4.

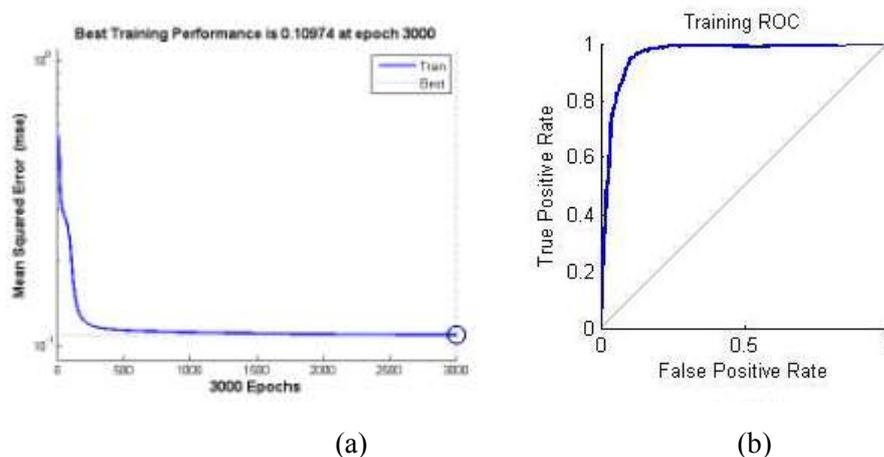


Figure 4.(a) Performance of MSE training process (b) ROC training process

Figure 4a shows a performance of mean square error in the training process. The smallest value of the mean square error is 0.109. The mean square error of training process decreases significantly between epoch 1 to 300. Training will be stopped if a mean square error has been convergent.

Figure 4b shows performance training process to know how well system training predicts AF and NonAF. Based on figure 4b the system has good performance, but the testing process in the difference data set is needed to detect how well the system performance in new data set. This process called testing process. We applied system on training process to detect AF or nonAF in a new data set. This is an output of this research. The result of this process presented in table 3.

Table 3. Performance training system in new data

Performance	Threshold										
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Accuracy	38.51	77.46	78.21	85.39	85.39	84.83	84.79	84.24	79.59	70.95	61.49
Sensitivity	100	95.86	95.22	85.45	85.31	73.68	72.56	70.79	54.43	28.57	0
Specificity	0	65.45	67.06	84.72	84.82	91.15	91.78	91.98	94.66	96.79	99.27

Table 3 shows the output of this system in some threshold to get the decision AF or NonAF. Accuracy, sensitivity, and specificity are 85.39%, 85.31%, and 84.82% respectively. The result has a good level to detect atrial fibrillation.

4. Conclusion

This article presents a new feature for detecting atrial fibrillation. This feature is Shannon entropy for RR interval and classifier by artificial neural network. The result of performance is good. Shannon entropy has the ability to detect atrial fibrillation with accuracy, sensitivity, and specificity. The best obtained accuracy, sensitivity, and specificity were 85.39%, 85.31%, and 84.82% respectively.

References

- [1] Sarath R .Dessertation.Atrial Fibrillation Signal Analysis. University of Florida,2011.
- [2] Dizon L.Thesis.Atrial Fibrillation Algorithm Evaluation and Implementation in Java. Royal Institute of Technology.Swaden.2014.
- [3] Camm A J 2012*Europen Society Of Cardiology*.**14**,1385-1413.
- [4] Babaeizadeh S *et al* 2009 *JournalElectrocardiology***42** 522.
- [5] Padmavathi K and Ramakrishna K 2015*Procedia Computer Science***46**53-59.
- [6] Pan J and Tomkins W 1985*IEEE Transactions on Biomedical Engineering***32** 230-235.
- [7] Shadnaz A, Alireza M, & Maryam M 2015 *Computers in biology and medicine***60** 132-142.
- [8] Lian J, Wang L and Muessig D 2014 *Journal Cardiology***107** 1494-1497.
- [9] Bromiley P A and Tachker N.A.Shannon Entropy,Renyi Entropy and Information.Biomedical Engineering.University of Manchester.2010.
- [10] Zhou X *et al* 2015 *Journal Pone***10** 1371.