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Detecting atrial fibrillation using statistical features of electrocardiographic interbeat interval

Nuryani Nuryani¹ and Anto Satriyo Nugroho²

¹Department of Physics, University of Sebelas Maret

²Center for Information & Communication Technology, Agency for Assessment and Application of Technology

E-mail: nuryani@mipa.uns.ac.id

Abstract. This article presents a technique for detecting atrial fibrillation (AF). The technique employs electrocardiographic interbeat interval (IBI) alteration. The IBI is the time interval between individual beats of electrocardiogram. Two statistical, mean and standard deviation of IBI are examined. For the classification a support vector machine (SVM) with RBF function is applied. We have examined this technique using clinical electrocardiogram of patients with AF. The examination shows that the detection which utilizes mean and standard deviation of two consecutive segments provide the performance of 95.17%.

1. Introduction

Atrial fibrillation is a serious disease in relation with the heart atrial. It is suggested in association with serious complications, including an increased risk of death [1]. A stroke is also as the complication of atrial fibrillation [2]. The problem of this disease is in relation with the heart atrial. The common indication of atrial fibrillation is irregular heart-beats. The heart atrial beats chaotically.

Various methods have been proposed and investigated to identify the occurrence of atrial fibrillation in the body. The approaches to predict the occurrence of atrial fibrillation are also explored and thus an atrial fibrillation episode could be identified beforehand. Early information of an atrial fibrillation episode is important to provide appropriate medical actions early. These actions might reduce healthcare costs and improve patient care [3]. Strategies have been investigated to find an accurate and sophisticated system for atrial fibrillation detection [4, 5]. Electrocardiogram, especially RR interval, is often used as important feature to identify atrial fibrillation.

Artificial intelligent utilizes neural network with wavelet features of electrocardiogram is studied to detect atrial fibrillation [6]. Another neural network algorithm for atrial fibrillation is also investigated by (Mateo et al., 2013). It applies radial basis function (RBF) neural network and utilizes electrocardiographic features by cancelling the electrocardiographic QRST complex.

This article presents atrial fibrillation detection applying interbeat interval (IBI) alteration. IBI is the time interval between two consecutive beats. IBIs of two consecutive segments are studied for atrial fibrillation. This article also presents the difference performances of the detection which utilize the statistical parameters of IBI. A support vector machine (SBM) is used for the classification.

¹ nuryani@mipa.uns.ac.id

We organise the rest of this article as follows. The second section describes the proposed method providing features extraction and classification. The experimental result and discussion are presented in the third section. Finally, the conclusion is presented in the fourth section.

2. Numerical Methods

Essentially, the proposed atrial fibrillation detection is with base of electrocardiographic features. General design of the detection system is presented in Figure 1. The main input of the detection system is *R*-peaks and the output is the decision of atrial fibrillation (AF) or non-atrial fibrillation (nAF).

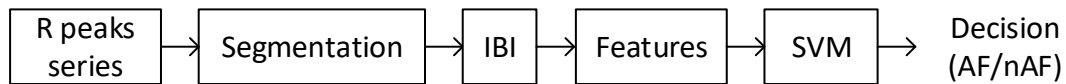


Figure 1. General design of the atrial fibrillation detection system

The electrocardiographic features are originally from *R*-peaks of electrocardiogram. An *R*-peak, or QRS peak, is the peak of electrocardiographic QRS. The *R*-peaks are obtained from the Physionet Database, which is atrial fibrillation Database (AFDB) [7]. The *R*-peaks are in the form of *R* series in sequential time. This series is then segmented in a certain time length. In each segment, interbeat interval (IBI) is calculated. IBI is defined as the time interval between two consecutive *R*-peaks. Thus, there are $n-1$ peaks in a segment with n *R*-peaks.

Two statistical parameters of n *R*-peaks in each segment are calculated. The two parameters are mean and standard deviation, and are called as f_1 and f_2 , respectively. Meanwhile, the mean and standard deviation of the previous segment are called f_3 and f_4 , respectively. The statistical parameters are utilized for features as presented in Table 1.

Table 1. Features of electrocardiography for atrial fibrillation detection

Features	Definition
f_1	The mean of IBI of a segment
f_2	The standard deviation of IBI of a segment
f_3	The mean of IBI of the previous segment
f_4	The standard deviation of IBI of the previous segment

The features are then classified using SVM, as described in [8]. The SVM applies radial basis function (RBF) for the kernel function. The C parameter of SVM is set to 100. The RBF parameter is set to 10. Five-fold cross-validation is conducted. In each validation, the data set is arranged to training set and testing set. The training and testing set are of 80% and 20%, respectively, of the total data set.

3. Results and Discussion

We have developed a system to detect atrial fibrillation using SVM and with base of electrocardiographic features. We have evaluated the system using clinical data of patients with atrial fibrillation, mostly paroxysmal. The clinical data is the database provided by Physionet [7]. It includes electrocardiographic recordings of human subjects with atrial fibrillation (mostly paroxysmal). The duration of each recording is 10 hours, with 250 samples per second.

The performances of the atrial fibrillation detection with different electrocardiographic features are presented in Table 2. The performance of the detection applying the mean of IBI is the worst. In term of accuracy, it finds 74.47% for f_1 (the mean of a segment) and 74.70% for f_3 (the mean of the previous segment). The higher performance is found by which utilizes standard deviation, 87.51% for f_2 (the standard deviation of a segment) and 88.49% for f_4 (the standard deviation of the previous segment).

Combining mean and standard deviation provides higher performance. The detection which applies both mean and standard deviation of segment provides performance of 92.67%, in term of accuracy. The two

statistics parameters in the previous segment provide slightly higher performance, which is 93.75%. By combining mean and standard deviation for both segment and the previous segment, the detection find the highest performance, which is 95.17%.

Table 2. The performance of the detection with different features

Features	Performances		
	Sensitivity (%)	Specificity (%)	Accuracy (%)
f1	72.21	76.09	74.47
f2	90.79	85.15	87.51
f3	72.49	76.29	74.70
f4	92.96	85.28	88.49
f1 f2	96.67	89.79	92.67
f3 f4	98.07	90.65	93.75
f1 f2 f3 f4	97.67	93.37	95.17

For the detection, RBF function is used for the SVM. It is considered to the previous studies which show that SVM utilizes RBF provide higher performance than which applies other functions, such as polynomial, linier and sigmoid [9]. However, other functions could be evaluated for this detection. Furthermore, C value or 100 is used for SVM. It is considered that the SVMs which utilizes C of 50 to 1000 provide nearly same performance [10].

4. Conclusion

A detection system for atrial fibrillation which utilizes interbeat interval (IBI) of electrocardiogram is presented in this article. Statistical parameters of IBI are evaluated. The parameters include mean and standard deviation. These two parameters are estimated from two consecutive segments. The performances of one segment and two consecutive segments are compared. For the classification, a support vector machine (SVM) is utilized. Using electrocardiographic clinical data of patients with atrial fibrillation, the detection system is evaluated. The detection system which applies both mean and standard deviation of two consecutive segments performs higher performance compared to other features. The performance is 95.17% in terms of accuracy.

5. References

- [1] J. S. Healey, J. Oldgren, M. Ezekowitz, J. Zhu, P. Pais, J. Wang, *et al.*, "Occurrence of death and stroke in patients in 47 countries 1 year after presenting with atrial fibrillation: a cohort study," *The Lancet*, vol. 388, pp. 1161-1169, 2016.
- [2] J. S. Healey, S. J. Connolly, M. R. Gold, C. W. Israel, I. C. Van Gelder, A. Capucci, *et al.*, "Subclinical atrial fibrillation and the risk of stroke," *New England Journal of Medicine*, vol. 366, pp. 120-129, 2012.
- [3] G. D. Clifford, I. Silva, B. Moody, Q. Li, D. Kella, A. Shahin, *et al.*, "The PhysioNet/Computing in Cardiology Challenge 2015: Reducing false arrhythmia alarms in the ICU," in *2015 Computing in Cardiology Conference (CinC)*, 2015, pp. 273-276.
- [4] M. Sardana, J. Saczynski, N. Esa, K. Floyd, K. Chon, J. W. Chong, *et al.*, "Performance and usability of a novel smartphone application for atrial fibrillation detection in an ambulatory population referred for cardiac monitoring," *Journal of the American College of Cardiology*, vol. 67, pp. 844-844, 2016.
- [5] T. Koivisto, T. Hurnanen, T. Vasankari, T. Kiviniemi, A. Saraste, and J. Airaksinen, "Automatic detection of atrial fibrillation using MEMS accelerometer," in *2015 Computing in Cardiology Conference (CinC)*, 2015, pp. 829-832.

- [6] K. Daqrouq, A. Alkhateeb, M. Ajour, and A. Morfeq, "Neural network and wavelet average framing percentage energy for atrial fibrillation classification," *Computer methods and programs in biomedicine*, vol. 113, pp. 919-926, 2014.
- [7] A. L. Goldberger, L. A. Amaral, L. Glass, J. M. Hausdorff, P. C. Ivanov, R. G. Mark, *et al.*, "Physiobank, physiotoolkit, and physionet components of a new research resource for complex physiologic signals," *Circulation*, vol. 101, pp. e215-e220, 2000.
- [8] N. Nuryani, I. Yahya, and A. Lestari, "Premature ventricular contraction detection using swarm-based support vector machine and QRS wave features," *International Journal of Biomedical Engineering and Technology*, vol. 16, pp. 306-316, 2014.
- [9] N. Nuryani, S. S. Ling, and H. Nguyen, "Electrocardiographic signals and swarm-based support vector machine for hypoglycemia detection," *Annals of biomedical engineering*, vol. 40, pp. 934-945, 2012.
- [10] N. Nuryani, B. Harjito, I. Yahya, M. Solikhah, R. Chai, and A. Lestari, "Atrial fibrillation detection using support vector machine and electrocardiographic descriptive statistics," *International Journal of Biomedical Engineering and Technology*, vol. 24, pp. 225-236, 2017.