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Simple Symbolic Dynamic of Heart Rate Variability Identify Patient with Congestive Heart Failure

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Abstract

Symbolic dynamics allows representing the heart rate variability signal into a common symbol that has been determined to ease the calculation process. The application of existing symbolic analysis can eliminate the information contained in those signals. This paper proposes a method of symbolic analysis by taking into account the size of symbolic signal changes. Symbols are divided into two groups: that for the increasing signal and decreasing one. To store the signal amplitude information, three groups of divisions are proposed i.e., amplitude less than one times standard deviation, that is more than or equal to one times standard deviation to less than two times standard deviation and more than two times standard deviation. The probability of each symbol in a series of data is calculated. Besides, Shannon entropy of all the data on each sample was also calculated. The result suggests that the probability of each symbol has a significant difference between the normal subject and patients with congestive heart failure.

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Keywords: Symbolic dynamic; heart rate variability; congestive heart failure

1. Introduction

Heart failure is a medical condition in which the heart can not pump enough blood throughout the body so that the body tissue needs of oxygen and nutrients are not met properly. The symptoms caused by this conditions are such as swelling of the legs ankles, shortness of breath and fatigue, and dry feeling in the chest. To diagnose heart failure,

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the medical doctor will perform several medical tests such as blood tests, chest X-rays, echocardiogram, and electrocardiogram. Treatment of patients with heart failure condition is done intensively by monitoring the condition of the heart and deliver drugs to alleviate the work of the heart.

Heart rate variability (HRV) is a non-invasive method to observe the effect of the autonomic system related to the heart on the activity of the sinus node through the cycle of change variation of R-R interval (interval-by-beat rate of the heart). The sinus node is the initial source of the heartbeat-controlled system from the central nervous system (brain). By looking at the changes in the central nervous control of the heart, the development of a condition that involves the heart organ and other organs can be known. Measurement of heart rate variability and its physiological correlation of the results have been proposed can be used to view the condition of the autonomic system of the human body [1]. However, recent studies mention that the available proposed method had may be adversely affected by variations in breathing patterns that are not associated with the autonomic system [2-5].

Autonomic system related to the heart is a complex system and regulate organ systems in a non-linear manner or regulation can not be estimated in a linear pattern [6]. A method is required to formulate these complex patterns to be easily known on how the autonomic system regulate the heart organ. Analysis of heart rate variability was also able to identify patients who have arrhythmias in heart rate patterns [7,8], identifying patients with diabetes [9,10], renal failure [11], myocardial infarction [12] and subarachnoid hemorrhage [13].

Symbolic Analysis (symbolic dynamics) allows the provision of a description of a symbol on a system with a certain amount. This analysis is suitable for describing the dynamics of a short vulnerable period in time series of heart rate variability. The number of symbols that appear in the time series will be calculated and noted the entropy of the distribution and frequency of occurrence of the symbol. This method in addition to the available heart rate variability analysis method, are also able to identify certain patient conditions such as seeing the success factors for the installation of an intensive respiratory [14] and the detection of the signal pattern of cardiac arrhythmias [15].

The assigning symbol on the variation of the dynamics of the time series eliminates the critical information of the time series that is the size of the variations. This research proposes improvements of existing symbolic dynamic method to accommodate the size of variation in the dynamics of the time series.

2. Research method

Data was obtained from the collection data already available in the repository of Physionet [16]. The data taken is Congestive Heart Failure Database R-R interval, BIDMC Database Congestive Heart Failure, and Normal Sinus Rhythm R-R interval Database. Those data were then mentioned as Lower NYHA class CHF, Higher NYHA class CHF and normal data, respectively. Before being analyzed, the list of R-R interval is calculated from that database.

The improvement of the symbolic dynamic method is needed to fill gaps in the symbolic method that has been proposed previously by other researchers. At this stage, the development of certain symbolic methods that have been proposed can be used in the time series data of heart rate variability. Naming the symbols can be done in a simple way by marking with the numbers of 1 for increasing signal and 0 for decreasing signal [14]. Another method proposed a way to label the symbols according to the location of the R-R by dividing the area between the minimum and maximum values (in one series data) [15,17]. To see the patterns combination in the series, a window in the series was applied and shifted the window along to the series until it is ended [18]. In this study, the symbolic method was developed by considering the R-R distance (height changes/amplitude of R-R interval that can be seen in Fig. 1).

The proposed method consider the variation of the R-R value and symbolize each point with the symbol of how much it decreases and increases from the previous value.

Symbols used are:

1: if the rise is less than or equal to 1 times the standard deviation
2: if it rises more than 1 times the standard deviation but less than or equal to 2 times the standard deviation
3: if it rises more than 2 times the standard deviation
4: if it drops less than or equal to 1 times the standard deviation
5: if it fell more than 1 times the standard deviation but less than or equal to 2 times the standard deviation
6: if it fell more than 2 times the standard deviation