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Classification of ECG Signal Based on Mixture of Linear and Non-Linear Features

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Abstract : In recent years, the use of intelligent systems in biomedical engineering has increased dramatically, especially in the diagnosis of various diseases. Also, due to the relatively simple recording of the electrocardiogram signal (ECG), this signal is a good tool to show the function of the heart and diseases associated with it. The aim of this paper is to design an intelligent system for automatically detecting a normal electrocardiogram signal from abnormal one. Using this diagnostic system, it is possible to identify a person's heart condition in a very short time and with high accuracy. The data used in this article are from the Physionet database, available in 2016 for use by researchers to provide the best method for detecting normal signals from abnormalities. Data is of both genders and the data recording time varies between several seconds to several minutes. All data is also labeled normal or abnormal. Due to the low positional accuracy and ECG signal time limit and the similarity of the signal in some diseases with the normal signal, the heart rate variability (HRV) signal was used. Measuring and analyzing the heart rate variability with time to evaluate the activity of the heart and differentiating different types of heart failure from one another is of interest to the experts. In the preprocessing stage, after noise cancelation by the adaptive Kalman filter and extracting the R wave by the Pan and Tampkinz algorithm, R-R intervals were extracted and the HRV signal was generated. In the process of processing this paper, a new idea was presented that, in addition to using the statistical characteristics of the signal to create a return map and extraction of nonlinear characteristics of the HRV signal due to the nonlinear nature of the signal. Finally, the artificial neural networks widely used in the field of ECG signal processing as well as distinctive features were used to classify the normal signals from abnormal ones. To evaluate the efficiency of proposed classifiers in this paper, the area under curve ROC was used. The results of the simulation in the MATLAB environment showed that the AUC of the MLP and SVM neural network was 0.893 and 0.947, respectively. As well as, the results of the proposed algorithm in this paper indicated that the more use of nonlinear characteristics in normal signal classification of the patient showed better performance. Today, research is aimed at quantitatively analyzing the linear and non-linear or descriptive and random nature of the heart rate variability signal, because it has been shown that the amount of these properties can be used to indicate the health status of the individual's heart. The study of nonlinear behavior and dynamics of the heart's neural control system in the short and long-term provides new information on how the cardiovascular system functions, and has led to the development of research in this field. Given that the ECG signal contains important information and is one of the common tools used by physicians to diagnose heart disease, but due to the limited accuracy of time and the fact that some information about this signal is hidden from the viewpoint of physicians, the design of the intelligent system proposed in this paper can help physicians with greater speed and accuracy in the diagnosis of normal and patient individuals and can be used as a complementary system in the treatment centers.

Keywords : neart rate variability, signal processing, linear and non-linear features, classification methods, ROC Curve
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