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Automatic recognition of arrhythmia based on principal component analysis network and linear support vector machine

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ABSTRACT

Electrocardiogram (ECG) classification is an important process in identifying arrhythmia, and neural network models have been widely used in this field. However, these models are often disrupted by heartbeat noise and are negatively affected by skewed data. To address these problems, a novel heartbeat recognition method is presented. The aim of this study is to apply a principal component analysis network (PCANet) for feature extraction based on a noisy ECG signal. To improve the classification speed, a linear support vector machine (SVM) was applied.In our experiments, we identified five types of imbalanced original and noise-free ECGs in the MIT-BIH arrhythmia database to verify the effectiveness of our algorithm and achieved 97.77% and 97.08% accuracy, respectively. The results show that our method has high recognition accuracy in the classification of skewed and noisy heartbeats, indicating that our method is a practical ECG recognition method with suitable noise robustness and skewed data applicability.

Keywords: principal component analysis network; arrhythmia recognition; noise robustness; deep learning; cardiovascular diseases.

1. Introduction

In recent years, the mortality rate of cardiovascular diseases has continued to increase worldwide [1]. According to the World Health Organization (WHO), cardiovascular diseases, accounting for one-third of global deaths, take more than 10 million lives each year [2]. Furthermore, an American Heart Association (AHA) report stated that 80% of cardiovascular deaths occurred in low-income and middle-income countries with almost equal mortality rates in men and women in 2017 [3]. As a collective term for a heterogeneous group of conditions including abnormal cardiac electrical activity, arrhythmia comprises a set of important cardiovascular diseases. Since 1980, the American College of Cardiology (ACC) has made multiple recommendations to reduce the incidence of arrhythmia [4]. To predict the occurrence of arrhythmia, an electrocardiogram (ECG) is generally used by doctors to identify the condition of the patient. However, the early prevention of such diseases is challenging due to subtle ECG variations [5] and common occasional similarities in ECG changes [6]. Hence, to accurately detect the abnormalities of the heart in advance, computer-assisted detection and classification of arrhythmia are expected to play major roles.

At present, artificial intelligence and machine learning are widely used in this field, with features extracted from ECGs and used for classifier training and classification [7]. In general, the complete process of classification includes three primary steps: (i) pre-processing, (ii) feature extraction, and (iii) classification. Currently, most mainstream classifiers generally identify a heartbeat by means of