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SCIENTIFIC PAPER

Proposing feature engineering method based on deep learning and K-NNs for ECG beat classification and arrhythmia detection

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Abstract

Arrhythmia is slow, fast or irregular heartbeat. Manual ECG assessment and disease classification is an error-prone task because of vast differences in ECG morphology and difficulty in accurate identifying ECG components. Moreover, proposing a computer-aided diagnosis system for heartbeat classification can be useful when access to medical care centers is difficult or impossible. Therefore, the main aim of this study is classifying ECG beats for arrhythmia detection (four beat classes are considered). Previous studies have proposed different methods based on traditional machine learning and/or deep learning. In this paper, a novel feature engineering method is proposed based on deep learning and K-NNs. The features extracted by our proposed method are classified with different classifiers such as decision trees, SVMs with different kernels and random forests. Our proposed method has reasonably good performance for beat classification and achieves the average Accuracy of 99.77%, AUC of 99.99%, Precision of 99.75% and Recall of 99.30% using fivefold Cross Validation strategy. The main advantage of the proposed method is its low computational time compared to training deep learning models from scratch and its high accuracy compared to the traditional machine learning models. The strength and suitability of the proposed method for feature extraction is shown by the high balance between sensitivity and specificity.

Keywords ECG beat classification · Arrhythmia detection · Deep learning · Feature engineering

Introduction

Arrhythmia is slow, fast or irregular heartbeat [1]. Manual ECG assessment and disease classification is an error-prone task because of vast differences in ECG morphology and difficulty in accurate identifying ECG components [1, 2].

Moreover, proposing a computer-aided diagnosis system for heartbeat classification can be useful when access to medical care centers is difficult or impossible. Many researches have been focused on heartbeat classification using traditional machine learning methods [3, 4]. In recent years, a few studies have proposed approaches for heartbeat arrhythmia detection based on deep learning methods [5], Huanhuan and Yue [6–8].

Table 1 illustrates a brief review of the previous studies on ECG beat classification with emphasis on deep learning methods. The most of the listed methods have been analyzed MITBIH database.

Traditional machine learning methods need to design methods for extracting features from heartbeat signals. The performance of the heartbeat classifiers depends strongly on the quality of the feature extraction methods. Handcrafted features are defined based on experts' opinions and determining the best suited features is a time-consuming and tedious work [8]. On the other hand, ECG signals have non-stationary nature and need more complex methods for feature extraction [5].

Deep learning provides models such as deep belief networks (DBN) and Restricted Boltzmann machines (RBM) for classifying data [5].

In the previous studies, among deep learning models, DBN have been used for extracting features from ECG signals [8], Huanhuan and Yue [6]. Moreover, convolutional neural networks (CNNs) can be used for extracting

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