Cardiac Arrhythmia, CHF, and NSR Classification With NCA-Based Feature Fusion and SVM Classifier

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ABSTRACT

An arrhythmia is an irregular heartbeat that causes abnormal heart rhythms. Manual analysis of electrocardiogram (ECG) signals is not sufficient to quickly detect cardiac arrhythmias. This study proposes a deep learning approach based on a convolutional neural network (CNN) architecture for the classification of cardiac arrhythmias (ARR), congestive heart failure (CHF), and normal sinus rhythm (NSR). First, the ECG signal is converted into a 2D image using time-frequency conversion. The scalogram is constructed using a continuous wavelet transform to extract dynamic features. With CNN, each ECG signal is broken down into heartbeats, and then each heartbeat is converted into a 2D grayscale image of the heartbeat. Morphological feature extraction was performed by segmenting the QRS complex and detecting P and T waves. A third approach to feature extraction is dual-tree complex wavelet transform (DT-CWT). In addition, all extracted features are combined using neighborhood component analysis (NCA), and features are selected to classify using a support vector machine (SVM) classifier.

KEYWORDS

CNN, CWT, DCWT, ECG, NCA, PCA, QRS, SVM

INTRODUCTION

The working principle of the tissues and organs in our body is based on the potential difference that occurs as a result of the electrochemical events of the cells. This potential difference produces electrical signals that can be measured from the body surface. The electrical activity of the heart is also measured and evaluated by the electrocardiography (ECG) method. ECG is the recording of the potential difference that occurs due to the contraction and relaxation of the heart during a heartbeat with the help of electrodes placed on the body surface. In a healthy person's ECG signal, there are P waves, QRS complexes, and T waves, each representing different phases of the heartbeat. Analysis and interpretation of ECG signals recorded for a certain period of time play an important role in the diagnosis of any heart-related disease. Abnormalities caused by the wave formation time, shape or the time difference between the waves cause arrhythmic heart rhythms (Xiong et al., 2018). Early and accurate diagnosis of arrhythmic signals is critical in preventing diseases that may result in sudden death.

Manual analysis of the ECG signal is not sufficient for rapid detection of abnormalities in heart rhythm. The analysis of the long-term ECG signal by the experts takes a lot of time and this analysis

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may not accurately identify the problem. Computer-aided decision systems are being developed in the examination of ECG signals due to its advantages such as increasing the accuracy of diagnosis, shortening the analysis time, and reducing the expert errors that may occur. In the literature, there are many different studies based on signal processing methods related to arrhythmia detection using ECG signals. These studies are based on the extraction of different features from the signals and the classification of these features.

Depending on the examination of the time or frequency domain, ECG morphology (Anwar et al., 2018), RR interval (Xiang et al., 2018), principal component analysis (PCA) (Manik et al., 2019), independent component analysis (ICA) (Desai et al., 2015), Fourier transform (Kurniawan et al., 2020), empirical mode decomposition (EMD) (Izci et al., 2018), The features are extracted by methods such as discrete wavelet transform (DWT) (Hamed & Owis, 2016; Chen & Maharatna, 2020). Different machine learning algorithms are used in the classification of feature vectors obtained from arrhythmic and normal signals. Support vector machines (SVM) (Li et al., 2020), k-nearest neighbor (k-NN) classifier (Qaisar et al., 2020), artificial neural networks (ANN) (Dewangan & Shukla, 2016; Subbiah & Subramanian, 2018) are among the classifiers used in the classification of ECG signals. In traditional machine learning algorithms, the signals go through the preprocessing stage in order to decompose the noise that may occur during signal recording. At this stage, the signal is cleared of noise by various filters. Deep learning algorithms are being developed as an alternative to machine learning algorithms consisting of preprocessing, feature extraction and classification stages. Deep learning can perform preprocessing, feature extraction and classification stages together, thanks to many hidden layers in its structure (Hatami et al., 2018).

In this paper contribution are as follows,

An Alexnet-NCA-SVM hybrid structure is suggested for Arrhythmia, CHF, and NSR ECG signal categorization. The proposed method is implemented with hybridization of time frequency scalogram images to get deep features, Morphological features, DTCWT and PCA features fused with NCA to demonstrate its superiority in classifier. This paper's contribution to the literature can be summarized as follows. ECG signals for arrhythmia, CHF, and NSR are grouped together. The Alexnet-NCA-SVM hybrid structure was used for classification.

The rest of this paper is structured as follows. The second section presents Literature review; third section represents proposed method for classifying the proposed ECG signals. Fourth section discusses the simulation results in the MATLAB environment. The fifth section contains a final commentary with instructions for further work.

LITERATURE REVIEW

In recent studies on the classification of arrhythmic signals, deep learning methods are preferred because of their high success (Ullah et al., 2020). These methods vary according to the training model they use. Recurrent neural networks (RNN) (Zhang et al., 2020; Pokaprakarn et al., 2022; Hannun et al., 2019), deep neural networks (DNN) (Nonaka & Seita, 2020; Jun et al., 2018), convolutional neural networks (CNN) (Kiranyaz et al., 2016) are examples of these models.

A model for diagnosing cardiac arrhythmias was proposed by Singh and Singh (2019) with filter-based feature selection approaches were applied to three separate machine learning algorithms applied to the Cardiac Arrhythmia data set, and the best features were picked. The performance of feature selection approaches was assessed using SVM, random forest. Isin and Ozdalili (2017) proposed a deep learning-based technique for classifying patient ECG's and automating ECG arrhythmia detection. AlexNet feature descriptor is used in the proposed method. To reach the final classification, the retrieved characteristics are fed into a simple back propagation neural network. To test the suggested approach, three class different ECG waveforms were chosen from the MIT-BIH Arrhythmia database. The results show that the deep learning feature can reach very high-performance

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