**Classification of Arrhythmia by Using Deep Learning with 2-D ECG Spectral Image Representation**

**Amin Ullah, Syed M. Anwar, Muhammad Bilal, Raja M Mehmood**

**In the year of 2020**

**Abstract**

The electrocardiogram (ECG) is one of the most extensively employed signals used in the diagnosis and prediction of cardiovascular diseases (CVDs). The ECG signals can capture the heart’s rhythmic irregularities, commonly known as arrhythmias. A careful study of ECG signals is crucial for precise diagnoses of patients’ acute and chronic heart conditions. In this study, we propose a two-dimensional (2-D) convolutional neural network (CNN) model for the classification of ECG signals into eight classes; namely, normal beat, premature ventricular contraction beat, paced beat, right bundle branch block beat, left bundle branch block beat, atrial premature contraction beat, ventricular flutter wave beat, and ventricular escape beat. The one-dimensional ECG time series signals are transformed into 2-D spectrograms through short-time Fourier transform. The 2-D CNN model consisting of four convolutional layers and four pooling layers is designed for extracting robust features from the input spectrograms. Our proposed methodology is evaluated on a publicly available MIT-BIH arrhythmia dataset. We achieved a state-of-the-art average classification accuracy of 99.11%, which is better than those of recently reported results in classifying similar types of arrhythmias. The performance is significant in other indices as well, including sensitivity and specificity, which indicates the success of the proposed method.

**Conclusions**

In this study, we proposed a 2-D CNN-based classification model for automatic classification of cardiac arrhythmias using ECG signals. An accurate taxonomy of ECG signals is extremely helpful in the prevention and diagnosis of CVDs. Deep CNN has proven useful in enhancing the accuracy of diagnosis algorithms in the fusion of medicine and modern machine learning technologies. The proposed CNN-based classification algorithm, using 2-D images, can classify eight kinds of arrhythmia, namely, NOR, VFW, PVC, VEB, RBB, LBB, PAB, and APC, and it achieved 97.91% average sensitivity, 99.61% specificity, 99.11% average accuracy, and 98.59% positive predictive value (precision). These results indicate that the prediction and classification of arrhythmia with 2-D ECG representation as spectrograms and the CNN model is a reliable operative technique in the diagnosis of CVDs. The proposed scheme can help experts diagnose CVDs by referring to the automated classification of ECG signals. The present research uses only a single-lead ECG signal. The effect of multiple lead ECG data to further improve experimental cases will be studied in future work

# A review on deep learning methods for ECG arrhythmia classification

# Zahra Ebrahimi, Mohammad Loni, Masoud Daneshtalab, Arash Gharehbhagi

# In the year 2020

# Abstract

Deep Learning (DL) has recently become a topic of study in different applications including healthcare, in which timely detection of anomalies on Electrocardiogram (ECG) can play a vital role in patient monitoring. This paper presents a comprehensive review study on the recent [DL methods](https://www.sciencedirect.com/topics/computer-science/deep-learning-method) applied to the ECG signal for the [classification](https://www.sciencedirect.com/topics/computer-science/classification) purposes. This study considers various types of the DL methods such as Convolutional Neural Network (CNN), Deep Belief Network (DBN), [Recurrent Neural Network](https://www.sciencedirect.com/topics/computer-science/recurrent-neural-network) (RNN), Long Short-Term Memory (LSTM), and Gated Recurrent Unit (GRU). From the 75 studies reported within 2017 and 2018, CNN is dominantly observed as the suitable technique for feature extraction, seen in 52% of the studies. DL methods showed high accuracy in correct classification of Atrial Fibrillation (AF) (100%), Supraventricular Ectopic Beats (SVEB) (99.8%), and Ventricular Ectopic Beats (VEB) (99.7%) using the GRU/LSTM, CNN, and LSTM, respectively.

**Conclusions**

The study presented results of a review on different methods for classifying arrhythmia on ECG signals. The objective of the review method was to investigate the most powerful Deep Learning methods detecting various types of arrhythmia. Technical details of the common methods were discussed. The GRU/LSTM, CNN, and LSTM, showed outstanding results for correct classification of Atrial Fibrillation, Supraventricular Ectopic Beats, and Ventricular Ectopic Beats, respectively. It is also concluded that the use of a proper type of Deep Learning method can considerably improve the classification performance for the corresponding application.

# A Novel Deep-Learning-Based Framework for the Classification of Cardiac Arrhythmia

# In the year 2020

# Sonain Jamil, MuhibUr Rahman

# Abstract

Cardiovascular diseases (CVDs) are the primary cause of death. Every year, many people die due to heart attacks. The electrocardiogram (ECG) signal plays a vital role in diagnosing CVDs. ECG signals provide us with information about the heartbeat. ECGs can detect cardiac arrhythmia. In this article, a novel deep-learning-based approach is proposed to classify ECG signals as normal and into sixteen arrhythmia classes. The ECG signal is preprocessed and converted into a 2D signal using continuous wavelet transform (CWT). The time–frequency domain representation of the CWT is given to the deep convolutional neural network (D-CNN) with an attention block to extract the spatial features vector (SFV). The attention block is proposed to capture global features. For dimensionality reduction in SFV, a novel clump of features (CoF) framework is proposed. The k-fold cross-validation is applied to obtain the reduced feature vector (RFV), and the RFV is given to the classifier to classify the arrhythmia class. The proposed framework achieves 99.84% accuracy with 100% sensitivity and 99.6% specificity. The proposed algorithm outperforms the state-of-the-art accuracy, F1-score, and sensitivity techniques.

**Conclusions**

Cardiovascular diseases are the primary cause of death. Most deaths are due to heart attacks. An irregular heartbeat causes a heart attack. A normal heartbeat has rhythm in the ECG plot, whereas an abnormal heartbeat shows an irregular ECG plot. These irregular ECGs are called cardiac arrhythmia. The timely classification of these cardiac arrhythmias can avoid potential damage. In this article, we propose the novel attention-based ArrhythmiaNet with a CoF module to categorize seventeen classes of heartbeats. The proposed method achieved 99.84% accuracy with an SVM classifier. The sensitivity of the proposed technique was 100%, and the F1-score was 99%. The classification accuracy of ArrhythmiaNet with a kNN classifier was 98.64%, which is inferior to SVM. We have also compared the proposed framework with existing methods, and the experimental results verify that ArrhythmiaNet outperforms all the existing techniques in terms of accuracy.

# Classify arrhythmia by using 2D spectral images and deep neural network

# Tran Anh Vu, Hoang Quang Huy, Pham Duy Khanh, Nguyen Thi Minh Huyen, Trinh Thi Thu Uyen, Pham Thi Viet Huong

# In the year 2021

# Abstract

# Electrocardiogram (ECG) is the most common method for monitoring the working of the heart. ECG signal is the basis to determine normal or abnormal rhythm, thereby helping to accurately diagnose cardiovascular diseases. Therefore, an automatic algorithm to detect and diagnose abnormal heart rhythms is essential. There are many methods of classifying arrhythmias using machine learning algorithms such as k-nearest neighbors (KNN), support vector machines (SVM), based on the features extracted from the record of ECG signal. Actually, deep learning algorithms are evolving and highly effective in image analysis and processing. In this research, a dense neural network model is proposed to classify normal and abnormal beats. Input ECG signal presenting a time series is converted into 2-D spectral image by applying wavelet transform. Our research is evaluated based on using the Massachusetts Institute of Technology-Beth Israel Hospital (MIT-BIH) arrhythmia database. The accuracy of the classification algorithm we employ is 99.8%, demonstrating the model's validity when compared to other reports' findings. This is the foundation for our algorithm to prove it can be utilized as an efficient model for categorizing arrhythmia using ECG signals.

# Conclusions

# In this paper, we show how to use a dense neural network model to detect arrhythmias from ECG data recordings. An accurate taxonomy of ECG signals provides an excellent foundation for cardiovascular disease diagnosis and prognosis. Our approach is unique in that it uses the Wavelet transform to turn a onedimensional ECG signal into two-dimensional spectral pictures, which are then used as input to a classification model. When compared to methods that integrate feature extraction and current machine learning technologies, the neural network model has shown beneficial in enhancing the accuracy of heartbeat diagnoses.

# Two-dimensional ECG-based cardiac arrhythmia classification using DSE-ResNet

# Jiahao Li, Shao-peng Pang, Fangzhuo Xu, Shuwang Zhou, Minglei Shu

# In the year 2022

# Abstract

# Electrocardiogram (ECG) is mostly used for the clinical diagnosis of cardiac arrhythmia due to its simplicity, non-invasiveness, and reliability. Recently, many models based on the deep neural networks have been applied to the automatic classification of cardiac arrhythmia with great success. However, most models independently extract the internal features of each lead in the 12-lead ECG during the training phase, resulting in a lack of inter-lead features. Here, we propose a general model based on the two-dimensional ECG and ResNet with detached squeeze-and-excitation modules (DSE-ResNet) to realize the automatic classification of normal rhythm and 8 cardiac arrhythmias. The original 12-lead ECG is spliced into a two-dimensional plane like a grayscale picture. DSE-ResNet is used to simultaneously extract the internal and inter-lead features of the two-dimensional ECG. Furthermore, an orthogonal experiment method is used to optimize the hyper-parameters of DSE-ResNet and a multi-model voting strategy is used to improve classification performance. Experimental results based on the test set of China Physiological Signal Challenge 2018 (CPSC2018) show that our model has average F1=0.817F1=0.817 for classifying normal rhythm and 8 cardiac arrhythmias. Meanwhile, compared with the state-of-art model in CPSC2018, our model achieved the best F1F1 in 2 sub-abnormal types. This shows that the model based on the two-dimensional ECG and DSE-ResNet has advantage in detecting some cardiac arrhythmias and has the potential to be used as an auxiliary tool to help doctors perform cardiac arrhythmias analysis.

**Conclusion**

In this paper, we propose a general model based on the two-dimensional ECG and DSE-ResNet to realize the automatic classification of normal rhythm and 8 cardiac arrhythmias. The two-dimensional processing method combines the original 12-lead ECG into the same two-dimensional space, so that DSE-ResNet can simultaneously extract the internal and inter-lead features of the 12-lead ECG. Orthogonal experiment instead of grid search to select hyper-parameters reduces the computational complexity. Furthermore, the ensemble learning model based on voting strategy is used to improve classification and generalization performance. Experiments based on the small number of test set show that the classification performance of the ensemble learning model is much better than that of single models. Then we submitted our model to the competition official of CPSC2018 and got the test results based on the hidden test set. The comparison with the results of the top 5 models in the CPSC2018 shows that our model is reasonable in the average F1F1 value, and achieved the best test results in 2 sub-abnormal types.

This suggests that automatic classification of AF and Block may depend on the relationship between leads. This also means that the use of DSE-ResNet to process multi-channel ECG signals to capture internal lead and inter-lead features is effective for automatic identification of cardiac arrhythmias.

Our results not only provide a new perspective on the automatic classification of cardiac arrhythmia based on the 12-lead ECG, but also raise several questions. Based on the two-dimensional ECG, future research directions include exploring how to further improve the accuracy of prediction, how to reduce the prediction time, how to find redundant leads in the 12-lead ECG, and so on.

# Classification of cardiac arrhythmia using a convolutional neural network and bi-directional long short-term memory

# Shahab UI Hassan, Mohd S Mohd Zahid, Talal AA Abdullah, Khaleel Hussain

# In the year 2022

# Abstract

# Cardiac arrhythmia is a leading cause of cardiovascular disease, with a high fatality rate worldwide. The timely diagnosis of cardiac arrhythmias, determined by irregular and fast heart rate, may help lower the risk of strokes. Electrocardiogram signals have been widely used to identify arrhythmias due to their non-invasive approach. However, the manual process is error-prone and time-consuming. A better alternative is to utilize deep learning models for early automatic identification of cardiac arrhythmia, thereby enhancing diagnosis and treatment. In this article, a novel deep learning model, combining convolutional neural network and bi-directional long short-term memory, is proposed for arrhythmia classification. Specifically, the classification comprises five different classes: non-ectopic (N), supraventricular ectopic (S), ventricular ectopic (V), fusion (F), and unknown (Q) beats. The proposed model is trained, validated, and tested using MIT-BIH and St-Petersburg data sets separately. Also, the performance was measured in terms of precision, accuracy, recall, specificity, and f1-score. The results show that the proposed model achieves training, validation, and testing accuracies of 100%, 98%, and 98%, respectively with the MIT-BIH data set. Lower accuracies were shown for the St-Petersburg data set. The performance of the proposed model based on the MIT-BIH data set is also compared with the performance of existing models based on the MIT-BIH data set.

## **Conclusion**

## Arrhythmia is a severe CVD that can be predicted via ECG segment processing. Arrhythmia must be accurately diagnosed and prevented early to reduce cardiac disease. Our proposed system model met the study’s primary goal of assisting doctors in swiftly determining the kind of ECG or verifying their diagnostics in a medical context while maintaining a high level of precision and cost. In this work, a CNN-Bi-LSTM model is proposed to categorize five categories of ECG fragments to construct an effective and resilient autonomous computer-aided diagnosis system. The developed network achieved maximum accuracies of 100%, 98.0%, and 98.0% of training, validation, and testing using MIT-BIH data set. In comparison, the St-Petersburg data set achieved 98.0%, 95.0%, and 95.0% accuracies of training, validation, and testing in identifying arrhythmia.

This research showed many advantages, including its ability to help clinicians reliably make ECG recording-related clinical decisions. Moreover, it was intended to be as simple as possible while delivering the most significant performance. The described method is straightforward for health professionals and does not involve signal modification or feature extraction. Additionally, this research focused only on one kind of CVD, namely, arrhythmia, whereas the manifestations of cardiac disease are often complex and varied. As a result, more types of ECG data will need to be added to broaden the scope of the planned network.

# Electrocardiogram Based Arrhythmia Classification Using Wavelet Transform with Deep Learning Model

# Shadhon C. Mohonta, Mohammad Abdul Motin, Dinesh Kant Kumar

# In the year 2022

# Abstract

# High-risk patients of cardiovascular disease can be provided with computerised electrocardiogram (ECG) devices to detect Arrhythmia. These require long segments of quality ECG which however can lead to missing the episode. To overcome this, we have proposed a deep-learning approach, where the scalogram obtained by continuous wavelet transform (CWT) is classified by the network based on the signature corresponding to arrhythmia. The CWT of the recordings is obtained and used to train the 2D convolutional neural network (CNN) for automatic arrhythmia detection. The proposed model is trained and tested to identify five types of heartbeats such as normal, left bundle branch block, right bundle branch block, atrial premature, and premature ventricular contraction. The model shows an average sensitivity, specificity, and accuracy to be 98.87%, 99.85%, and 99.65%, respectively. The result shows that the proposed model can detect arrhythmia effectively from short segments of ECG and has the potential for being used for personalised and digital healthcare.

# Conclusion

# This paper proposes a deep learning model with different time-frequency representations of short length (0.225 seconds) ECG segment to identify arrhythmia accurately. CWT-RGB with proposed 2D-CNN model shows the highest classification performance in terms of average sensitivity, specificity and accuracy of 98.87%, 99.85% and 99.65%, respectively. Moreover, the use of smaller segments makes the model computationally simpler and faster without compromising the model performance. These findings can be a template for the automated detection of arrhythmias for future personalised and digital cardiac health monitoring.

# Multi-module Recurrent Convolutional Neural Network with Transformer Encoder for ECG Arrhythmia Classification

# Minh Duc Le, Vidhiwar Singh Rathour, Quang Sang Truong, Quan Mai, Patel Brijesh, Ngan Le

# In the year

# Abstract

# The automatic classification of electrocardiogram (ECG) signals has played an important role in cardiovascular diseases diagnosis and prediction. Deep neural networks (DNNs), particularly Convolutional Neural Networks (CNNs), have excelled in a variety of intelligent tasks including biomedical and health informatics. Most the existing approaches either partition the ECG time series into a set of segments and apply 1D-CNNs or divide the ECG signal into a set of spectrogram images and apply 2D-CNNs. These studies, however, suffer from the limitation that temporal dependencies between 1D segments or 2D spectrograms are not considered during network construction. Furthermore, meta-data including gender and age has not been well studied in these researches. To address those limitations, we propose a multi-module Recurrent Convolutional Neural Networks (RCNNs) consisting of both CNNs to learn spatial representation and Recurrent Neural Networks (RNNs) to model the temporal relationship. Our multi-module RCNNs architecture is designed as an end-to-end deep framework with four modules: (i) timeseries module by 1D RCNNs which extracts spatio-temporal information of ECG time series; (ii) spectrogram module by 2D RCNNs which learns visual-temporal representation of ECG spectrogram ; (iii) metadata module which vectorizes age and gender information; (iv) fusion module which semantically fuses the information from three above modules by a transformer encoder. Ten-fold cross validation was used to evaluate the approach on the MIT-BIH arrhythmia database (MIT-BIH) under different network configurations. The experimental results have proved that our proposed multi-module RCNNs with transformer encoder achieves the state-of-the-art with 99.14% F1 score and 98.29% accuracy

# Conclusion

# In this paper, we proposed an ECG arrhythmia classification method based multi-module Recurrent Convolutional Neural Networks (RCNNs). The experiment has been conducted on six classes (five most common classes and the other classes) from MIT-BIH arrhythmia database. Our network takes all time-series, spectrogram and metadata into consideration. The proposed multi-module RCNNs is able to model both spatial information through CNNs and temporal information through LSTM. Our experiments have shown that metadata plays an important role to improve the classification performance. Our multi-module network outperforms most SOTA approach on the same dataset, with F1-score = 99.14%, and accuracy = 98.29%.

# Arrhythmia Classification Algorithm Based on a Two-Dimensional Image and Modified EfficientNet

# Cui-fang Zhao, Wan-yun Yao, Mei-juan Yi, Chao Wan, Yong-Le Tian

# In the year 2022

# Abstract

# The classification and identification of arrhythmias using electrocardiogram (ECG) signals are of great practical significance in the early prevention and diagnosis of cardiovascular diseases. In this study, we propose an arrhythmia classification algorithm based on two-dimensional (2D) images and modified EfficientNet. First, we developed a method for converting original one-dimensional (1D) ECG signals into 2D image signals. In contrast with the existing classification method that uses only the time-domain features of a 1D ECG signal, the classification of 2D images can consider the spatiotemporal characteristics of the signal. Then, to better assign feature weights, we introduced an attention feature fusion module (AFF) into the EfficientNet network to replace the addition operation in the mobile inverted bottleneck convolution (MBConv) structure of the network. We selected EfficientNet for modification because, compared with most convolutional neural networks (CNNs), EfficientNet does not require manual adjustment of parameters, which improves the accuracy and speed of the network. Finally, we combined the 2D images and the improved EfficientNet network and tested its performance as an arrhythmia classification method. Our experimental results show that the network training of the proposed method requires less equipment and training time, and this method can effectively distinguish eight types of heartbeats in the MIT-BIH arrhythmia database, with a classification accuracy of 99.54%. Thus, the model has a good classification effect.

# Conclusion

# In this study, we developed a method for converting original 1D ECG signals into 2D image signals. To better assign feature weights, we introduced AFF to replace the addition operation in the MBConv structure of the EfficientNet network.

# The main limitation of the proposed arrhythmia classification algorithm is the low positive prediction accuracy for identifying APC beats. This is caused by data imbalance: specifically, there are many more NOR beats than other beats. The ratio of APC beats is only 2.3% in the data set. Moreover, multiple ECG samples from the same patient will generally exhibit the greatest similarity in heartbeats. The study results of the data augmentation show that the positive prediction accuracy for identifying VEB is substantially increased and ranges from 97.9% to 99.1%.

# Given the influence of available laboratory equipment, we converted 1D ECG signals into 2D image signals and used spatiotemporal characteristics to perform classification experiments on eight ECG signal types in the MIT-BIH arrhythmia database, achieving relatively high accuracy of 99.54% based on the improved EfficientNet-B0 network. Most medical data sets have sample imbalance problems, which are generally mitigated by increasing a few types of samples or decreasing most types of samples. In this study, we applied the preprocessing method of 1D to 2D ECG signal conversion, which increased the amount of data, and selected the best length. Additionally, we performed data augmentation for two categories, VEB and VFW, and we added four similar groups of different-length images to this data set, which alleviated the data imbalance problem to some extent. Finally, we employed three evaluation indices, namely, sensitivity, specificity, and precision rate ground, to evaluate the model’s effect, all of which were found to be high, indicating that the model has a good classification effect.

# To extend the sample, the next step will be to identify relevant volunteers for sample collection. Validation of more ECG signal databases will be considered in the future to improve the practicality and robustness of the classification method for eventual application on medical robots or ECG signal monitoring devices. This approach can help doctors more accurately and quickly diagnose cardiovascular diseases from ECG signals

# Cardiac Arrhythmia Detection using Deep Learning

# Monali Choudhary, Anisha Patnaik, Dipali Phatak, Dhanashri Deokar, Dilip Hingorani

# Abstract

# An electrocardiogram (ECG) is a significant indicative device for the appraisal of cardiovascular arrhythmias in clinical daily practice. In this study, a profound learning system beforehand prepared on an overall picture informational index is moved to do programmed ECG arrhythmia diagnostics by arranging patient ECG's into comparing heart conditions. Arrhythmias are more normal in individuals who are 60 years and more established. A convolutional neural organization (in particular AlexNet) is utilized for feature extraction and the removed highlights are taken care of into a basic back spread neural organization to complete the last classification. Fundamental focal point of this investigation is to execute a basic, solid and effectively pertinent learning method for the grouping of the chosen three diverse heart conditions (heart arrhythmia, Congestive Heart Failure, Normal sinus rhythm) so that diagnosis can be done for the same. The results exhibited that the moved profound learning highlight extractor fell with a traditional back proliferation neural organization had the option to get exceptionally elite rates. A comparison study was done where validation accuracy is 100% in GoogleNet, 94% in Squeezenet while it was near 97.33% in AlexNet.

# Conclusion

# In this study, ECG Data obtained from the hospital are digitized, pre-processed, converted into scalogram images for classification , feature extraction is done using deep learning and training and validation of data is done. The overall images were classified as heart arrhythmia, Congestive Heart Failure and Normal sinus rhythm. A detailed performance comparison among three networks is done and validation accuracy is checked in all the three cases i.e. 97.33% in AlexNet, 94% in Squeezenet and 100% using googlenet. With the confusion matrix, we analysed how many images were incorrectly classified. This investigation was started because of the reality individuals in our nation influenced via cardiovascular illnesses are expanding step by step. Arrhythmias are more normal in individuals who are 60 years and more established. It's to some extent because of mileage of a more established heart. In country regions because of absence of offices individuals can't analyze their infirmities. The task expects to track down the fundamental kind of coronary illness a patient is enduring with the goal that he can identify early the sickness assuming any. Whenever improved the undertaking can additionally discover the more issues related with the patient identified with heart. An application can be grown so a patient can become more acquainted with what sort of infection he is experiencing sitting at home. A straightforward gui is utilized for something similar. It very well may be made accessible to far off regions where there is exceptionally less openness to nearly everything. Additionally in the improvement of this venture, we can add the arrangements of kinds of Cardiac arrhythmias. The Hardware part can likewise be added to it for the estimations of different factors, for example, pulse, Pulse rate, oximeter we can transform it into a complete medical services framework. By utilizing the gsm module, the message can likewise be sent straightforwardly to the patients' mobile phone. We can likewise show it on LCD.

# Arrhythmia and Disease Classification Based on Deep Learning Techniques

**Ramya G. Franklin**[**1**](https://www.techscience.com/iasc/v31n2/44530/html#raut-1)**,**[**\***](https://www.techscience.com/iasc/v31n2/44530/html#rast-1)**and B. Muthukumar**[**2**](https://www.techscience.com/iasc/v31n2/44530/html#raut-2)

**In the year 2021**

**Abstract**

Electrocardiography (ECG) is a method for monitoring the human heart’s electrical activity. ECG signal is often used by clinical experts in the collected time arrangement for the evaluation of any rhythmic circumstances of a topic. The research was carried to make the assignment computerized by displaying the problem with encoder-decoder methods, by using misfortune appropriation to predict standard or anomalous information. The two Convolutional Neural Networks (CNNs) and the Long Short-Term Memory (LSTM) fully connected layer (FCL) have shown improved levels over deep learning networks (DLNs) across a wide range of applications such as speech recognition, prediction etc., As CNNs are suitable to reduce recurrence types, LSTMs are reasonable for temporary displays and DNNs are appropriate for preparing highlights for a more divisible area. CNN, LSTM, and DNNs are appropriate to view. The complementarity of CNNs, LSTMs, and DNNs was explored in this paper by consolidating them through a single architecture firm. Our findings show that the methodology suggested can expressively explain ECG series and of detection of anomalies through scores that beat other techniques supervised as well as unsupervised technique. The LSTM-Network and FL also showed that the imbalanced data sets of the ECG beat detection issue have been consistently solved and that they have not been prone to the accuracy of ECG-Signals. The novel approach should be used to assist cardiologists in their accurate and unbiased analysis of ECG signals in telemedicine scenarios.

**Conclusions**

The early diagnosis of cardiovascular infection is focused on exploration and distinction signs of arrhythmia. Throughout this analysis we proposed the interaction between CNN-LSTM and FCL to improve the preparedness influence, limiting the effects on the model training of an enormous amount of basic specific ECG beat information. The proposed architecture utilizes CNNs to decrease each spectral variation in the input feature but instead moves it on to LSTM layers while providing outputs to DNN layers, which have a more effective feature representation. The findings indicate that CNN-LSTM and FCL have obtained 99.33%, 96.06%, 94.36%, and 92.65%, individually, with the results being accuracy, *F*1 score, precision, and recall. The adequacy and intensity of the proposed architecture were seen by the MIT-BIH arrhythmic test results. The methodology proposed could be used to help cardiologists in diagnosing ECGs with a better level of accuracy and impartiality in telemedicine scenarios. In conclusion, in future examinations, various kinds and specific beats will be included. In addition, to analyze the appearance of the CNN LSTM using the FCL pattern, we intend also to introduce specific rates of noise to ECG signals.

# Convolutional neural network for classification of eight types of arrhythmia using 2D time-frequency feature map from standard 12-lead electrocardiogram.

# Jeong DU, Lim KM

**In the year 2021**

**Abstract**

Electrocardiograms (ECGs) are widely used for diagnosing cardiac arrhythmia based on the deformation of signal shapes due to changes in various heart diseases. However, these abnormal signs may not be observed in some 12 ECG channels, depending on the location, the heart shape, and the type of cardiac arrhythmia. Therefore, it is necessary to closely and comprehensively observe ECG records acquired from 12 channel electrodes to diagnose cardiac arrhythmias accurately. In this study, we proposed a clustering algorithm that can classify persistent cardiac arrhythmia as well as episodic cardiac arrhythmias using the standard 12-lead ECG records and the 2D CNN model using the time-frequency feature maps to classify the eight types of arrhythmias and normal sinus rhythm. The standard 12-lead ECG records were provided by China Physiological Signal Challenge 2018 and consisted of 6877 patients. The proposed algorithm showed high performance in classifying persistent cardiac arrhythmias; however, its accuracy was somewhat low in classifying episodic arrhythmias. If our proposed model is trained and verified using more clinical data, we believe it can be used as an auxiliary device for diagnosing cardiac arrhythmias.

**Conclusions**

The results of classifying eight cardiac arrhythmias using the proposed algorithm are shown. The F1 scores of the proposed model were over 0.8 during the classification of persistent cardiac arrhythmias such as AF, I-AVB, LBBB, and RBBB. The highest F1 score was observed for LBBB prediction at 0.89, and the classified F1 scores for AF, RBBB, and I-AVB were 0.86, 0.85, and 0.80, respectively. On the other hand, the classification performance of episodic cardiac arrhythmias such as PAC, PVC, and STE was relatively low compared to persistent cardiac arrhythmias. The lowest F1 score (0.52) was observed during the classification of STE, which had the smallest number of data classes. The F1 scores for PAC and PVC were 0.53 and 0.64, respectively. In addition, the F1 scores for NSR and STD were moderate as scores of 0.77 and 0.76, respectively. There was a difference in the number of data classes used for training and testing. Accordingly, the final macro F1 score of the proposed model was 0.74; however, the weighted F1 score, considering the difference in the number of data classes, was 0.78.