

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

## **Abstract:**

The majority of heart illnesses can be diagnosed by analysing the ECG signal for arrhythmias. The P-QRS-T waves in an ECG signal represent one cardiac cycle. This suggested study addresses several methods and transformations that have been previously described in the literature for analysing an ECG signal and extracting features from an arrhythmia analysis.

Cardiologists must manually identify different ECG heart-beat classes, which takes time and effort. On computer-based techniques for classifying these heart diseases. A proposed taxonomy based on dichotomies involving full time series-based versus feature-based, AAMI versus Non-AAMI, and inter-patient versus intra-patient based distinctions is used in this work to organise the current research. This work's primary contributions are a comprehensive evaluation of the literature on the detection of irregular heartbeats and the identification of relevant research.

## **INTRODUCTION:**

An electrocardiogram (ECG) reports the electrical activity of the heart as obtained by a skin electrode.

Heartbeat shape and rate are indicators of cardiac health in humans. This signal, which is used to identify heart problems, is detected on the surface of the human body using a non-invasive approach.

Any disorder of heart rate or rhythm, or change in the morphological pattern, is an indication of cardiac arrhythmia, which could be detected by analysis of the recorded ECG waveform. The amplitude and duration of the P-QRS-T wave contains useful information about the nature of disease afflicting the heart. The electrical wave is due to depolarization and re polarization of  $\text{Na}^+$  and  $\text{K}^+$  ions in

The ECG signal gives the following details about a person's heart:

- 1] The position of the heart and the size of its chambers in relation to one another
- 2] Origin and spread of impulses
- 3] Disturbances in heart rhythm and conduction
- 4] Extent and location of myocardial ischemia
- 5] Changes in the concentrations of electrolytes
- 6] Drug effects on the heart.

### **Arrhythmias in ECG signal:**

The term "Normal sinus rhythm" refers to the heart's normal rhythm in the absence of disease or abnormalities in the ECG signal's shape (NSR). NSR typically have heart rates between 60 and 100 beats per minute. The breathing cycle has a small impact on how regularly the R-R interval occurs. Sinus tachycardia is the name for the cardiac rhythm that occurs when the heart rate rises above 100 beats per minute. This is not an arrhythmia, but rather the heart's normal response to a need for increased blood flow. Bradycardia, or an excessively slow heartbeat, can have a negative impact on important organs. When the heart rate is too fast, the ventricles are not completely filled before contraction for which pumping

## **RELATED WORK:**

It works by capturing any potential bio-electric change in the human heart, the ECG signal can identify abnormal circumstances and malfunctions. It can be difficult to accurately identify the clinical condition that an ECG signal indicates. Therefore, before recommending a specific treatment, cardiologists need to precisely forecast and identify the appropriate form of irregular cardiac ECG wave. This could necessitate hours-long observation and analysis of ECG recordings (patients in critical care).

Computer-aided diagnosis methods have been created to automatically recognise these signals in order to get around the difficulty of explaining the ECG signal visually and physically. The majority of this field's research has been done by utilising various machine learning (ML) strategies for the effective identification and precise analysis of ECG signals.

Frequency analysis, artificial neural networks (ANNs), Heuristic-based methods, statistical methods, support vector machines (SVMs), wavelet transform, filter banks, hidden Markov models, and a combination of expert methods are just a few of the methods used to classify ECG signals.

A approach based on artificial neural networks was able to classify ECG waves into six categories with an average accuracy of 90.6%. A feed-forward neural network was employed as a classifier, and it was able to detect four different types of arrhythmias with an average accuracy of 96.95%.

For the prediction and diagnosis of many disorders, advanced diagnostic techniques are utilised in conjunction with machine learning, a subset of artificial intelligence. As a subset of ML, deep learning has several uses in the diagnosis and treatment of deadly diseases, including CVDs.

For the analysis of bioinformatics signals, various deep learning techniques have been presented. For feature extraction, a recurrent neural network (RNN) identified four different forms of arrhythmia with an average accuracy of 98.06%. A 1-D convolutional neural network model was suggested for the classification and extraction of features from a 1-D ECG signal, and it produced a classification accuracy of 96.72%. For the classification of the ECG dataset, a deeper 1-D CNN model was proposed and achieved an average accuracy of 97.03%. Large ECG datasets were employed in both cases, however the ECG signals were displayed as 1-D time series. For the automatic classification of five different heartbeat arrhythmia categories, a nine-layer 2-D CNN model was used, with an accuracy of 94.03%.

## **EXISTING WORKS:**

### **1. Journal name: Deep Learning Model for Arrhythmia Classification with 2D Convolutional Neural Network**

**Authors: S. Nithya, Mary Shanthi Rani**

**In the year 2022**

Due to delays in identification and treatment, cardiac arrhythmia, an irregular heartbeat, causes a large proportion of untimely fatalities. Additionally, early automated arrhythmia detection could assist the doctor in determining the different forms of arrhythmia, enabling more accurate and individualised treatment. Since the artefacts in the 1D signal could interfere with accurate classification, the conventional 1D ECG signal is transformed to pictures. Arrhythmia diagnosis in ECG signals has expanded to include a dynamic new dimension of signal to picture conversion. In this paper, we present two convolutional neural network models, ARBC and AMBC, for binary and multi-class classification of ECG signals (CNN). According to experimental results,

the proposed models' accuracy for binary and multi-class classification was 96.88% and 98.98%, respectively. Keywords Arrhythmia 2D-CNN Classification ECG deep learning

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

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

**In the year 2020**

One of the most widely used signals for the detection and prognosis of cardiovascular disorders is the electrocardiogram (ECG) (CVDs). The abnormal heartbeats, or arrhythmias, can be seen in the ECG data. For accurate diagnoses of both acute and chronic heart problems in patients, a careful analysis of ECG signals is essential. For the classification of ECG signals into eight classes—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—we propose a two-dimensional (2-D) convolutional neural network (CNN) model in this study. Short-time Fourier transform is used to convert the one-dimensional ECG time series signals into two-dimensional spectrograms.

The 2-D CNN model is intended to extract reliable information from the input spectrograms and has four convolutional layers and four pooling layers. On an MIT-BIH arrhythmia dataset that is available to the public, our suggested methodology is assessed. We classified similar types of arrhythmias with a state-of-the-art average classification accuracy of 99.11%, which is higher than earlier published data. Performance is noteworthy in other indices as well, such as

sensitivity and specificity, which shows that the suggested strategy is effective.

### **3. Journal name: Arrhythmia and Disease Classification Based on Deep Learning Techniques**

**Authors: Ramya G. Franklin and B. Muthukumar**

**In the year 2021**

Monitoring the electrical activity of the human heart is done using electrocardiography (ECG). Clinical specialists frequently utilise an ECG signal in a collected time arrangement to assess any rhythmic conditions of a subject. By showing the issue with encoder-decoder techniques and employing misfortune appropriation to forecast normal or abnormal information, the research was done to automate the assignment. The LSTM-Network and FL additionally demonstrated that the issue of the ECG beat detection problem's unbalanced data sets had been consistently resolved and that they had not been vulnerable to the reliability of ECG-Signals. The innovative method should help cardiologists in telemedicine settings analyse ECG readings objectively and accurately.

The investigation and differentiation of arrhythmia signals are key components of the early identification of cardiovascular infection. In order to improve the readiness influence and reduce the effects of a large amount of basic specific ECG beat information on the model training, we proposed an interaction between CNN-LSTM and FCL throughout this investigation. The suggested design makes use of CNNs to reduce each spectral variation in the input feature, but then moves it to LSTM layers and sends the outputs to DNN layers, which have a more useful feature representation.

According to the results, CNN-LSTM and FCL have achieved accuracy, F1 score, precision, and recall rates of 99.33%, 96.06%, 94.36%, and 92.65%, respectively. The results of the MIT-BIH arrhythmic test demonstrated the sufficiency and intensity of the suggested architecture. Cardiologists may be able to diagnose ECGs more accurately and impartially using the suggested methods in telemedicine settings. In conclusion, numerous types and particular beats will be added in future exams. We also propose to add particular rates of noise to ECG signals in order to examine the CNN LSTM's appearance utilising the FCL pattern.

#### **4. Journal name: Arrhythmia Classification Algorithm Based on a Two-Dimensional Image and Modified EfficientNet**

**Authors: Cui-fang Zhao, Wan-yun Yao, Mei-juan Yi, Chao Wan, Yong-Le Tian**

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 chose EfficientNet for modification because it requires less manual parameter adjustment than the majority of convolutional neural

networks (CNNs), which increases the network's accuracy and speed. Finally, we assessed the effectiveness of the combined 2D pictures and upgraded EfficientNet network as an arrhythmia classification approach. Our experimental findings demonstrate that the suggested method can successfully discriminate eight different types of heartbeats in the MIT-BIH arrhythmia database with a classification accuracy of 99.54%, and the network training of the proposed method requires less hardware and training time. As a result, the model's categorization effect is effective

## **5. Journal name: A Novel Deep-Learning-Based Framework for the Classification of Cardiac Arrhythmia**

**Authors: Sonain Jamil, MuhibUr Rahman**

**In the year 2020**

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.



**6. Journal name: Deep Learning for Musculoskeletal Image Analysis**

**Authors: Ismail Irmakci, Syed Muhammad Anwar, Drew a Torigian, Ulas Bagci**

**In the year 2020**

Radiology imaging, including computed tomography, magnetic resonance imaging (MRI), and ultrasound, is necessary for the diagnosis, prognosis, and treatment of patients with musculoskeletal (MSK) problems. The assessment of metabolic health, ageing, and diabetes can also be assisted by radiology scans. In order to address an unmet clinical need in MSK radiology, this work shows how machine learning, specifically deep learning techniques, can be employed for quick and reliable image processing of MRI images. We examine machine learning categorization of various abnormalities, such as meniscus and anterior cruciate ligament injuries, and concentrate on automatic interpretation of knee images from MRI scans as a demanding case study. We compared single and multi-view imaging when classifying the abnormalities using widely used convolutional neural network (CNN) based architectures to evaluate the classification performances of various neural network architectures for knee abnormalities under the constraints of limited imaging data. Promising findings suggested the potential for classifying MSK abnormalities using multi-view deep learning in routine clinical evaluation.

**7. Journal name: Medical Image Analysis using Convolutional Neural Networks**

**Authors: Syed Muhammad Anwar , Muhammad Majid , Adnan Qayyum , Muhammad Awais , Majdi Alnowami , Muhammad Khurram Khan in the year 2018**

Medical image analysis is the science of resolving clinical issues using photographs produced in clinical practise. The objective is to effectively and efficiently extract information for better clinical diagnosis. Medical image analysis is one of the top research and development areas as a result of recent developments in the biomedical engineering industry.

The use of machine learning algorithms for the analysis of medical pictures is one of the factors contributing to this development. When a neural network is capable of autonomously learning features, deep learning is successfully employed as a technique for machine learning. In contrast, those procedures employ characteristics that are usually hand-crafted.

It can be difficult to choose and calculate these features. Deep convolutional networks are one of the deep learning methods that are frequently utilised for medical image analysis. Segmentation, abnormality detection, disease categorization, computer assisted diagnosis, and retrieval are a few examples of application areas that fall under this category. In this article, a thorough overview of the state-of-the-art in deep convolutional network-based medical picture processing is offered. These techniques difficulties and possibilities are also discussed.

## **8. Journal name: ECG Arrhythmia Classification Using Transfer Learning from 2-Dimensional Deep CNN Features**

**Authors: Milad Salem, Shayan Taheri, Jiann Shiun-Yuan**

**In the year 2018**

Due to the recent advances in the area of deep learning, it has been demonstrated that a deep neural network, trained on a huge amount of data, can recognize cardiac arrhythmias better than

cardiologists. Moreover, traditionally feature extraction was considered an integral part of ECG pattern recognition; however, recent findings have shown that deep neural networks can carry out the task of feature extraction directly from the data itself. In order to use deep neural networks for their accuracy and feature extraction, high volume of training data is required, which in the case of independent studies is not pragmatic.

To arise to this challenge, in this work, the identification and classification of four ECG patterns are studied from a transfer learning perspective, transferring knowledge learned from the image classification domain to the ECG signal classification domain. It is demonstrated that feature maps learned in a deep neural network trained on great amounts of generic input images can be used as general descriptors for the ECG signal spectrograms and result in features that enable classification of arrhythmias. Overall, an accuracy of 97.23 percent is achieved in classifying near 7000 instances by ten-fold cross validation

#### **9. Journal name: A statistical analysis based recommender model for heart disease patients**

**Authors: Anam Mustaqeem ,Syed Muhammad Anwar, Abdul Rashid Khan, Muhammad Majid In the year 2017**

The recommendations are generated by assessing the severity of clinical features of patients, estimating the risk associated with clinical features and disease, and calculating the probability of occurrence of disease. The purpose of this model is to build an intelligent and adaptive recommender system for heart disease patients. The experiments for the proposed recommender system are conducted on a clinical data set collected and labelled in consultation with medical experts from a known hospital.

The performance of the proposed prediction model is evaluated using accuracy and kappa statistics as evaluation measures. The medical recommendations are generated based on information collected from a knowledge base created with the help of physicians. The results of the recommendation model are evaluated using confusion matrix and gives an accuracy of 97.8%.

Thus the proposed system exhibits good prediction and recommendation accuracies and promises to be a useful contribution in the field of e-health and medical informatics.

**10. Journal name: Real-Time Patient-Specific ECG  
Classification by 1-D Convolutional Neural Networks**

**Authors: Serkan Kiranyaz, Turker Ince, Moncef Gabbouj**

**In the year 2015**

An adaptive implementation of 1-D convolutional neural networks (CNNs) is inherently used to fuse the two major blocks of the ECG classification into a single learning body: feature extraction and classification. Therefore, for each patient, an individual and simple CNN will be trained by using relatively small common and patient-specific training data, and thus, such patient-specific feature extraction ability can further improve the classification performance. Since this also negates the necessity to extract hand-crafted manual features, once a dedicated CNN is trained for a particular patient, it can solely be used to classify possibly long ECG data stream in a fast and accurate manner or alternatively, such a solution can conveniently be used for real-time ECG monitoring and early alert system on a light-weight wearable device.

The results over the MIT-BIH arrhythmia benchmark database demonstrate that the proposed solution achieves a superior

classification performance than most of the state-of-the-art methods for the detection of ventricular ectopic beats and supraventricular ectopic beats. Conclusion: Besides the speed and computational efficiency achieved, once a dedicated CNN is trained for an individual patient, it can solely be used to classify his/her long ECG records such as Holter registers in a fast and accurate manner.

## **Conclusion:**

The prior works are arranged into a taxonomy framework to highlight the potential gaps and unmet needs in the ECG heart-beat arrhythmia analysis problem. In the literature, a number of strategies for clustering and classification of ECG heart rhythm disorders has been examined. Researchers can find gaps and unresolved research topics by using such a well-organized literature survey. So that the researchers might consider methods for addressing them in this work, gaps and unmet needs have been compiled.

## **References:**

1. Amin Ullah- University of Engineering and Technology, Taxila, Syed Anwar- University of Engineering and Technology, Taxila, Muhammad Bilal-Hankuk University of Foreign Studies, Raja Majid Mehmood- Xiamen University Malaysia
2. S. Nithya, Mary Shanthi Rani Innovations in Information and Communication Technologies, Springer Nature Singapore
3. Ramya G. Franklin and B. Muthukumar School of Computing, Sathyabama Institute of Science and Technology, Chennai, 600119, India
4. Cui-fang Zhao, Wan-yun Yao, Mei-juan Yi, Chao Wan, Yong-Le Tian
5. Sonain Jamil MuhibUr Rahman, Affiliations expand, PMID: 35324625, PMCID: PMC8949672

6. Irmakci I, Anwar, S.M, Torigian, D.A, Bagci, U. Deep Learning for Musculoskeletal Image Analysis. arXiv2020, arXiv:2003.0054
7. Anwar, S.M, Majid, M, A.; Awais, M, Alnowami, M, Khan, M.K. Medical image analysis using convolutional neural networks: A review. J. Med. Syst. 2018,42, 226
8. Salem, M, Taheri, S, Yuan, J.S. ECG arrhythmia classification using transfer learning from 2-dimensional deep CNN features. In Proceedings of the 2018 IEEE Biomedical Circuits and Systems Conference (BioCAS), Cleveland, OH, USA, 17–19 October 2018; IEEE: Piscataway, NJ, USA, 2018; pp. 1–4
9. Mustaqeem, A, Anwar, S.M, Khan, A.R, Majid, M. A statistical analysis based recommender model for heart disease patients. Int. J. Med. Inform. 2017,108, 134–145
10. Serkan Kiranyaz-Qatar University, Muhammad Bilal-Hankuk University of Foreign Studies, Raja Majid Mehmood-Xiamen University Malaysia