From ECG Signals to Intelligent Diagnosis: A Survey on Deep Learning-Based Arrhythmia Classification and Deployment

Neha Saravanan

Student, Electronics and Communication

RV Institute of Technology and Management, Bangalore, India

saravanan.neha3@gmail.com

Abstract: *Electrocardiogram (ECG) analysis is a fundamental tool for diagnosing cardiac arrhythmias and enabling continuous heart monitoring. Recent advancements in machine learning, particularly deep learning, have significantly improved the accuracy and automation of ECG-based arrhythmia classification. This survey presents a comprehensive review of recent research focusing on ECG signal preprocessing, deep learning architectures, hybrid and ensemble models, data imbalance mitigation techniquesand deployment-oriented solutions for wearable and edge devices. Emphasis is placed on comparing convolutional neural networks (CNNs), recurrent neural networks (RNNs), CNN–LSTM hybrids, generative data augmentation strategies and lightweight models suitable for real-time applications. A detailed comparative analysis of representative studies highlights current trends, performance metrics and deployment feasibility. The survey also identifies challenges and future research directions for robust and clinically reliable ECG arrhythmia detection systems*

Keywords: *ECG signal processing, Arrhythmia classification, Deep learning, CNN-LSTM, Data imbalance, Wearable healthcare*