


Chapter 3

Automated Detection of Cardiovascular Arrhythmias Using Machine Learning and Deep Learning on ECG Signals

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ABSTRACT

This study explores various machine learning and deep learning approaches to classify normal and arrhythmic heartbeats using the MIT-BIH Arrhythmia dataset. Feature extraction techniques, including Discrete Fourier Transform, Discrete Wavelet Transform, and Continuous Wavelet Transform, were employed to enhance signal representation. Machine learning classifiers were tested, along with deep learning-based models and a custom Convolutional Neural Network (CNN) trained on CWT-generated scalograms. The results indicate that deep learning models significantly outperform traditional machine learning classifiers, with the custom CNN achieving the highest accuracy of 82.76% when trained on augmented CWT scalogram images. While KNN (97.76%) and SVM (98%) performed well, their dependency on feature engineering and computational limitations restricted their scalability. This study underscores the potential of AI-driven ECG classification to revolutionize automated arrhythmia detection, enabling real-time monitoring and early intervention in clinical settings.

1. INTRODUCTION

Arrhythmias, or irregular heartbeats, are a significant global health concern, with studies indicating that approximately 5% of the U.S. population experiences an arrhythmia each year (Scripps Health). Moreover, research suggests that 1 in 4 Americans over the age of 40 is at risk of developing an arrhythmia, underscoring the importance of early detection and intervention. Given that cardiovascular diseases remain among the leading causes of mortality worldwide, timely diagnosis and treatment of arrhythmias, particularly atrial fibrillation (AFib), can play a crucial role in preventing life-threatening complications such as strokes. Early detection methods can significantly reduce the burden on healthcare systems by enabling proactive treatment and management. Furthermore, emerging studies, such as the University of Pennsylvania research, suggest that COVID-19-positive patients are 10 times more likely to develop arrhythmias than healthy individuals, highlighting the impact of infections and systemic diseases on cardiac rhythm abnormalities. The rising prevalence of arrhythmias and their association with severe complications make it imperative to develop accurate, reliable, and cost-effective methods for arrhythmia detection and classification. In this project, we focus on distinguishing normal heartbeats from four different types of arrhythmias, leveraging advancements in deep learning and artificial intelligence to automate and enhance the detection process.

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