ABSTRACT

Cardiac arrhythmia is a heart rhythm disorder that can lead to serious consequences, including sudden cardiac arrest or even death, if not detected promptly and accurately. In clinical practice, arrhythmia detection is typically performed through manual interpretation of electrocardiogram (ECG) signals by medical professionals. However, this method is time-consuming, highly dependent on expertise, and prone to errors, especially when dealing with large volumes of data. With the rising demand for health monitoring systems based on the Internet of Things (IoT) and wearable devices, automated ECG-based arrhythmia detection has become a crucial solution for faster, more accurate, and real-time diagnosis support.

This study proposes an automated ECG beat classification system to distinguish between normal and arrhythmic beats using a combination of signal processing and machine learning. The pipeline involves ECG filtering, beat segmentation based on R-peak detection, and beat labeling using annotations from the MIT-BIH Arrhythmia Database. The labeled signals are then decomposed using Discrete Wavelet Transform (DWT) up to the fourth level. Features are extracted in the form of Rényi Entropy and statistical measures (mean, standard deviation, minimum, maximum) from each decomposition level, and then used to train an XGBoost classifier.

Experimental results show that the proposed approach achieves high classification performance. Using only Rényi Entropy features, the model achieves 88.21% accuracy and 94.11% AUC-ROC. When statistical features are added, the accuracy improves to 97.90%, with an F1-score of 97% and an AUC-ROC of 99.56%. SHAP analysis reveals that features from levels A3 and A4 contribute the most to classification. With an inference time of 0.15 seconds per beat, the model meets real-time monitoring requirements. This research contributes to the development of intelligent, adaptive, and accurate decision support systems for early detection of cardiac arrhythmia.

***Keywords**: ECG, cardiac arrhythmia, Discrete Wavelet Transform, Rényi Entropy, XGBoost, classification.*