ABSTRACT

Cardiac arrhythmia is a heart rhythm disturbance that can lead to serious cardiovascular conditions, especially if not detected early. The complexity of electrocardiogram (ECG) signal morphology, high data dimensionality, and imbalanced class distribution within the dataset make arrhythmia detection a significant challenge in the development of artificial intelligence-based diagnostic systems. Therefore, a systematic approach capable of handling nonlinear signal characteristics and imbalanced distribution with high accuracy is needed to support precise and efficient clinical decision-making.

This study develops an arrhythmia classification system based on ECG signals from the MIT-BIH Arrhythmia Database by combining Discrete Wavelet Transform (DWT) and Kullback–Leibler Divergence (KL Divergence) for feature extraction. Prior to extraction, the data is balanced using random undersampling. Four distribution approaches are used in KL Divergence, namely Uniform, Exponential, Gaussian, and Combined. All features are classified using Support Vector Machine (SVM) based on RBF kernel, and evaluated through various metrics such as accuracy, F1-score, ROC AUC, log loss, average precision (AP), computational efficiency, and model stability (CV).

The test results show that KL Combined provides the best performance with an accuracy of 0.8895, F1-score of 0.9039, AUC of 0.9406, and test log loss of 0.3012. KL Combined is the most balanced method with the best performance in all aspects. KL Uniform offers stability, KL Gaussian excels in prediction speed, and KL Exponential despite having moderate calibration, cannot match the time efficiency and efficiency of the KL Combined model, which makes it an optimal choice for arrhythmia detection systems that prioritize accuracy and clinical consistency.

Keywords: *cardiac arrhytmia, Kullback-Leibler Divergence, Discrate Wavelet Transform, ECG, MIT-IBH, Support Vector Machine*