ABSTRACT

Coronary artery disease (CAD) is one of the leading causes of death worldwide and is often detected at an advanced stage. Therefore, there is a need for a rapid, non-invasive, and efficient method of early detection. One potential approach is the use of Heart Rate Variability (HRV) signals, as HRV reflects the activity of the autonomic nervous system and overall heart function. However, conventional HRV analysis methods based on linear approaches often fail to capture the complex nonlinear dynamics of the heart.

This study proposes a phase space reconstruction-based approach to uncover the nonlinear dynamic patterns of Heart Rate Variability (HRV) parameters, namely SDRR (Standard Deviation of RR intervals) and RMSSD (Root Mean Square of Successive Differences), in two electrocardiogram (ECG) signal leads (Lead II and V1). The results of Phase Space Reconstruction (PSR) are analyzed morphologically using the two-sample Kolmogorov–Smirnov test and classified using two Convolutional Neural Network (CNN) architectures, namely VGG-16 and LeNet. The dataset used consists of electrocardiogram (ECG) recordings. The normal dataset is from the MIT-BIH Arrhythmia Database, and the CAD dataset is from the St. Petersburg incart 12-lead Arrhythmia Database, which were then processed through pre-processing, HRV feature extraction using ultra-short term HRV, and PSR reconstruction with delay variations (+1, +5, and +10).

The results of the study show that the VGG-16-based CNN model is capable of achieving high accuracy in distinguishing PSR patterns between CAD patients and normal individuals, with good sensitivity and specificity values. Kolmogorov-Smirnov testing also supports significant differences in the distribution of geometric attractor sizes between the CAD and normal class.

Keywords: Coronary Artery Disease, Heart Rate Variability, LeNet, Phase Space Reconstruction, VGG-16.