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Early Diagnosis of Myocardial Ischemia Based on Support Vector Machine and Gaussian Mixture Model by Using Features of ECG Recordings

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Abstract : Acute myocardial infarction is a major cause of death in the world. Therefore, its fast and reliable diagnosis is a major clinical need. ECG is the most important diagnostic methodology which is used to make decisions about the management of the cardiovascular diseases. In patients with acute myocardial ischemia, temporary chest pains together with changes in ST segment and T wave of ECG occur shortly before the start of myocardial infarction. In this study, a technique which detects changes in ST/T sections of ECG is developed for the early diagnosis of acute myocardial ischemia. For this purpose, a database of real ECG recordings that contains a set of records from 75 patients presenting symptoms of chest pain who underwent elective percutaneous coronary intervention (PCI) is constituted. 12-lead ECG's of the patients were recorded before and during the PCI procedure. Two ECG epochs, which are the pre-inflation ECG which is acquired before any catheter insertion and the occlusion ECG which is acquired during balloon inflation, are analyzed for each patient. By using pre-inflation and occlusion recordings, ECG features that are critical in the detection of acute myocardial ischemia are identified and the most discriminative features for the detection of acute myocardial ischemia are extracted. A classification technique based on support vector machine (SVM) approach operating with linear and radial basis function (RBF) kernels to detect ischemic events by using ST-T derived joint features from non-ischemic and ischemic states of the patients is developed. The dataset is randomly divided into training and testing sets and the training set is used to optimize SVM hyperparameters by using grid-search method and 10fold cross-validation. SVMs are designed specifically for each patient by tuning the kernel parameters in order to obtain the optimal classification performance results. As a result of implementing the developed classification technique to real ECG recordings, it is shown that the proposed technique provides highly reliable detections of the anomalies in ECG signals. Furthermore, to develop a detection technique that can be used in the absence of ECG recording obtained during healthy stage, the detection of acute myocardial ischemia based on ECG recordings of the patients obtained during ischemia is also investigated. For this purpose, a Gaussian mixture model (GMM) is used to represent the joint pdf of the most discriminating ECG features of myocardial ischemia. Then, a Neyman-Pearson type of approach is developed to provide detection of outliers that would correspond to acute myocardial ischemia. Neyman – Pearson decision strategy is used by computing the average log likelihood values of ECG segments and comparing them with a range of different threshold values. For different discrimination threshold values and number of ECG segments, probability of detection and probability of false alarm values are computed, and the corresponding ROC curves are obtained. The results indicate that increasing number of ECG segments provide higher performance for GMM based classification. Moreover, the comparison between the performances of SVM and GMM based classification showed that SVM provides higher classification performance results over ECG recordings of considerable number of patients.

Keywords : ECG classification, Gaussian mixture model, Neyman–Pearson approach, support vector machine
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