Hidden Markov Tree-based Arrhythmia Classification

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The electrocardiogram (ECG) is the recording of the electrical property of the heartbeats. Several approaches that automatically classify heartbeats have been proposed in the literature using a variety of features to represent the ECG. This paper aims at providing new insights on the electrocardiogram classification problem through an original concept of combining Hidden Markov Tree (HMT) model with the (HTK) recognition toolkit. This HMT recognition framework is based on different parameters like Morphological Descriptors (MD), Higher Order Cumulants (HOC) and Synchronous Wavelet Transform Energy (SWTE) which is a new parameterisation technique. The assessment of performances is achieved using the benchmark public QT database from Physionet that makes a cross validation method: the training stage (10mn) about 2/3 of the data and the test stage (5mn) about the last 1/3.

The recognition results of 8 arrhythmia classes extracted from QT database, while varying each time the states (5 to 7) and the gaussian numbers by state (2 to 5) of the HMT model are presented and discussed. For morphological descriptors (MD), every heart beat is characterized by 10-elements vector representing information of the amplitude, the area, specific interval durations and slopes. For (HOC) descriptors, every heart beat is characterized by 15-elements vector, five for each cumulant (the second, the third and the fourth order cumulants) and finally 8-elements vector for the (SWTE) descriptors in the fourth scale with a first derivative gaussian wavelet having a standard deviation =0,25. To evaluate the performance of the classifier, a comparative study of recognition rates in terms of average sensitivity (SE) and average specificity (SP) and other statistical indices are used. These indices obtained with morphological descriptors for our recognition system having 6 states and 4 gaussians per state were a sensitivity (SE) of 94,95%, a specificity (SP) about 98,65%. By using higher order cumulants, we obtained a sensitivity (SE) of 97,22% and a specificity (SP) about 99,12% with the same model having 5 states and 3 gaussians per state. Synchronous wavelet transform energy allows a sensitivity (SE) of 95,20% and a specificity (SP) of 99,03% for a HMT model having 6 states and 3 gaussians per state.