

Long-Duration Ambulatory Holter ECG QRS Complex Geometrical Templates Extraction by Non-Parametric Clustering of the QRS Virtual Close-up Extracted Feature Space

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The presented study concentrates on description of the new feature extraction and clustering techniques for the QRS geometrical templates extraction. To meet this end, first the original holter ECG signal is segmented into QRS and non-QRS regions. Then, each QRS region and also its corresponding discrete wavelet transform are supposed as virtual images and each of them is divided into eight polar sectors. Next, the curve length and the polar area of each excerpted segment are calculated and are used as elements of the feature space, (therefore, for each detected QRS complex, 32 features are computed). Afterwards, applying the Principal Components Analysis (PCA), the dimension of the feature space is reduced to 2, and the joint probability density function (pdf) of the mapped features is estimated via Parzen approximation. Afterwards, using a n-dimensional adaptive smoothing method, the obtained joint pdf is smoothed as far as the number of its local maximums is reached to the desired user-defined template number. After assigning the detected peaks as the cluster centers, to estimate the border of each cluster, each center is assigned as a local search origin and in all directions, investigations are conducted to find the best minimum slope-height locations. For each boundary sample in the 2-D histogram, its corresponding QRS complex Kendall tau rank correlation coefficients with the QRS of all cluster centers are calculated and consequently each candidate border location is added to the cluster with the maximum correlation coefficient. After determination of borders, the median QRS waveform of each cluster is extracted and is assigned as the cluster template. The method was applied to DAY general hospital high resolution holter data (more than 1,500,000 beats including BBB, PVC and Junctional contractions) and average values of $Se=99.87\%$ and $P+=99.84\%$ are obtained for QRS waveshape classification.