Hidden-Markov-Model for Esophageal ECG Wave Detection

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Subject: Electronic Implants
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Long-term electrocardiogram (ECG) signals derived from the esophageal mucosa (eECG) are used to detect heart rhythm disorders. An automatic classifier using Hidden-Markov-Models (HMM) is investigated to classify the atrial and ventricular waves. To annotate eECGs, annotations from simultaneously recorded surface ECGs are used. Hence, these recordings have to be synchronized. By means of the annotated eECGs, different feature vectors for the HMM can be evaluated statistically.

Signal Synchronization and Annotation

To evaluate such a HMM classification, adequate data sets have to be defined. Since no annotated eECGs are available, an own patient database containing annotations from simultaneously recorded surface ECGs (sECG) are used. However, the sECG and eECG recorders used in this database feature different oscillators with different sampling frequencies that alter with temperature. Consequently, the two signals need to be synchronized in segments individually. To align the signals and to calculate an initial resampling factor, two manually labeled arrhythmias are used. By minimization of the mean square error of the two filtered signals, the optimal resampling factor for each segment is found. In this way the signals divided into segments of 3 min duration were synchronized with an accuracy of below ±10 ms (example: see Fig. 1). Thus, the annotations can be taken over without confusion of P and R waves.

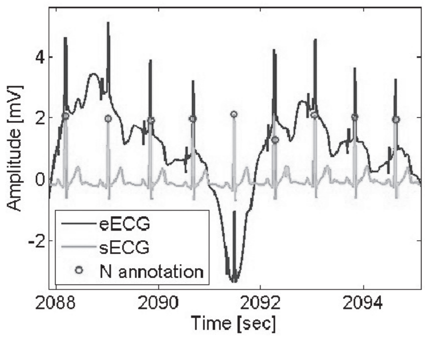

Fig. 1 Synchronized eECG and sECG signals.

HMM Classification

With sECG data derived from the MIT-BIH arrhythmia database a multidimensional HMM classifier for normal (N) and VES beats was designed and statistically quantified. For this purpose, different feature vectors for the HMM were investigated and evaluated. Most dedicated feature vector used the normalized slopes and normalized areas calculated from signal slices. These feature vectors, extracted from the whole signal, are fed to multiple HMM's to calculate the probability curves for each beat type (Fig. 2). While both beat types were classified with a sensitivity of 95.3%, positive predictive values of 96.4% for N beats, and 87.1% for VES beats, respectively, have been achieved.

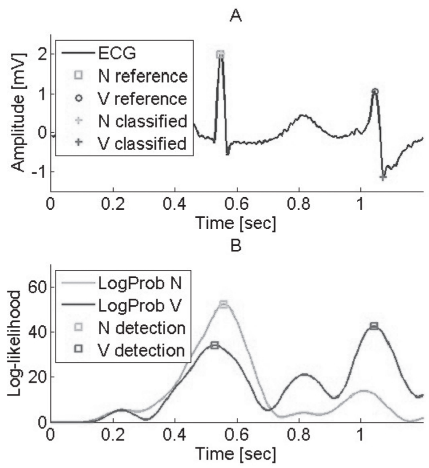

Fig. 2 Classified beats (A) resulting from the higher probability of the particular beat types (B).

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Conclusion

The HMM approach achieved promising results with respect to N and VES classification in sECGs. To classify P and R waves, however, the HMM classification process have to be improved further.

References

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