Visualisation and Pattern Recognition of Heart Rate Variability

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Thesis submitted for the degree of
Doctor of Philosophy

March 1999

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Abstract

Analysis of heart rate variability (HRV) may be used as a noninvasive probe of autonomic nervous system activity. It has found application in many situations where autonomic function is of interest, such as diabetic autonomic neuropathy, hypertension, and recovery following myocardial infarction. This thesis considers various signal processing aspects of HRV analysis; in particular, those of data visualisation and classification.

Frequency domain techniques are popular for HRV processing since the oscillations in the signal are largely separable by frequency. The analysis of spectral HRV data is conventionally performed by considering the power contained in sub-bands within the spectrum. This approach is not ideal: the choice of the limits of the sub-bands can be difficult, and the band-power values do not have a convenient physiological interpretation.

In this thesis, data visualisation techniques - specifically the least-squares scaling and the generative topographic mapping - are applied to the analysis of spectral HRV data. These techniques take a high-dimensional data set and construct a two-dimensional representation in which the relationships between the data are preserved. This allows simple graphical depiction and visual exploration of the data by the user. With spectral data, this approach allows the physiological significance of the data to be ascertained without the need to perform sub-band analysis. The techniques are quite general and may be applied to the analysis of data from other processing methods, such as nonlinear HRV analysis and cardiovascular system modelling. The use of the least-squares scaling and the generative topographic mapping for the visualisation of spectral HRV data is demonstrated on data from two studies: one on sleep apnoea, and the other on the effects on propranolol and posture on heart rate variability.

The fusion of HRV with information from other sources is one method of improving the reliability of HRV analysis. The use of classification techniques for information fusion is investigated in the second part of this thesis. For the discrimination of heart rate data by posture and propranolol, the fusion of HRV information with mean heart rate is shown to yield better discrimination than the use of HRV alone. The use of HRV with other diagnostic information for the detection of sleep apnoea is also explored.

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