New Information from Old Signals: Attractor Reconstruction Analysis of the Electrocardiogram

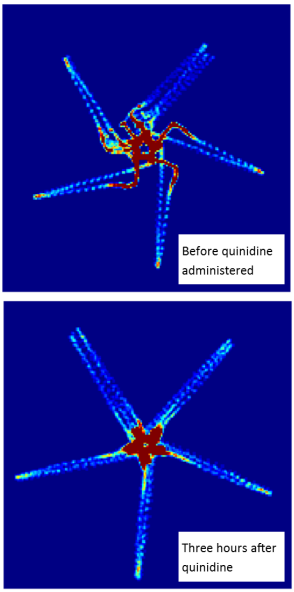
Jane V Lyle*, Esther Bonet-Luz, Manasi Nandi, Philip J Aston

University of Surrey
Guildford, UK

Proactive electrocardiogram (ECG) monitoring is increasingly common, but requires the derivation of diagnostic and predictive information. Heart rate variability (HRV) and the identification of particular points on the ECG wave remain the mainstay of analysis. However, both techniques exclude the wealth of information in the waveform profile, and any subsequent categorisation of nonlinear features does not provide specific morphological detail. Our method of attractor reconstruction uses all of the available waveform data and can be applied to any approximately periodic waveform. We show here its clinical relevance in the challenging analysis of ECG.

Method: We use the method of time delay embedding to reconstruct attractors from a single lead ECG measurement. We show that reconstructions can be undertaken in various dimensions, but we then project our n-dimensional attractor onto a two-dimensional plane providing a simple visualisation with reduced baseline wander, whilst retaining the information about the underlying waveform shape.

Results: Using the Physionet ecgrdvq data, we generate attractors in multiple dimensions. We have previously demonstrated that the attractor method highlights significant gender differences in the human ECG. Building on this, we show that the effect of ion channel blocking drugs on an individual's ECG can be quantified through the attractor. This novel analysis of ECG signals uses the attractor properties to derive useful clinical information in a simple manner, and supports a personalised approach to early detection, diagnosis and treatment of a range of diseases.



Five dimensional attractor projection of ECG before and after the administration of quinidine