

Electrocardiogram Presentation

Introduction of Human Electrocardiogram: The goal of this presentation is to model the human electrocardiogram and to study its dynamics through embedology. Before embedding we first need to get data from the MIT Polysomnographic database^[2] (Figure 1) which shows the amplitude of the signal with respect to time. The goal is to somehow try to represent this data into a graph, to describe the behavior of a heart beat.

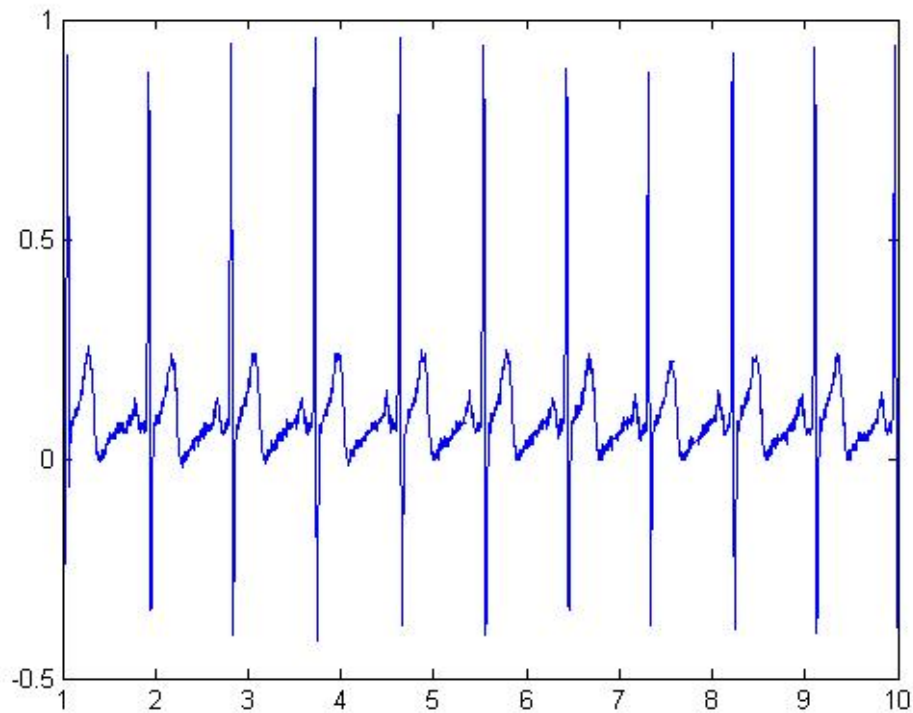


Figure 1: First 10 seconds of a heartbeat reproduced by MATLAB

Introduction to Embedology: Embedology is a useful tool in trying to model or predict a certain data set with 2 or more variables. Two theorems are key in order to embed the data acquired, one is the Fractal Whitney Embedding Theorem and the other is the Fractal Delay Embedding Prevalence Theorem. The Fractal Whitney Embedding Theorem lists different conditions necessary for a data to be embedded. The three conditions are that the data has to be a

one to one function and it has to be an immersion (Figure 2). A function is one to one when a data set can be transformed from one subset to another without losing its properties and a function is an immersion when all its derivatives are one to one. From there one can use it to fit delay coordinates, with the same conditions (Figure 3). This is important since the data we acquired is best modeled with delay coordinates.

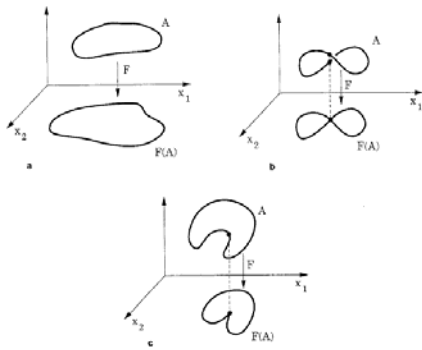


Fig. 1. (a) An embedding F of the smooth manifold A into R^2 . (b) An immersion that fails to be one-to-one. (c) A one-to-one map that fails to be an immersion.

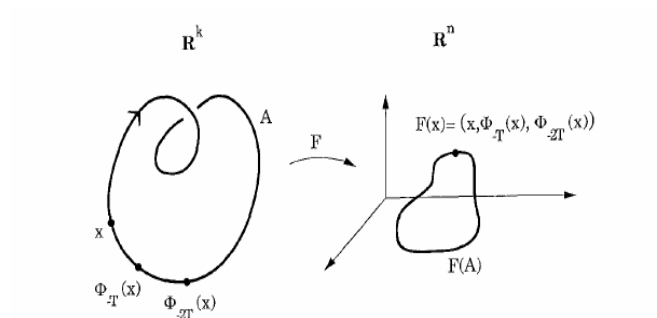


Fig. 2. The attractor on the left is mapped using delay coordinates into the reconstruction space on the right.

Figure 2: reproduced from reference [1], Page 583 (1991)

Figure 3: reproduced from reference [1], Page 588 (1991)

Applying Embedology to Human Electrocardiogram: Since the data acquired met the conditions posed by the Fractal Delay Embedding Prevalence Theorem, one can use the delay coordinates to model the behavior of the heartbeat (Figure 4). Embedology is a really useful tool in taking raw data and trying to gather information from the behavior observed. From the important theorems one can describe and understand the beat of the heart and to get more of an insight through this behavior.

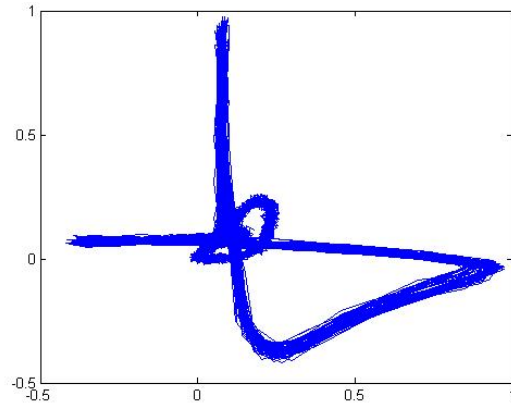


Figure 4: reproduced by MATLAB

Sources

1. Tim Sauer, James A. Yorke, and Martin Casdagli , *Embedology* J. Stat Phys **Vol 65**, 579-616 (1991)
2. M. Perc, *Nonlinear time series analysis of the human electrocardiogram*, Eur. J. Phys. **26**, 757-768 (2005).