Investigating Phase Transitions in a Cardiac System through Informational Properties of Renewal Process Models

Konstantinos N. Aronis, MD,[1,2] Ariadna Venegas-Li,[3,4] Anastasiya Salova,[4] and Andrea Santoro[5]
[1)] *Division of Cardiology, Jonhs Hopkins Hospital, Johns Hopkins University, School of Medicine, Baltimore, MD, USA.*
[2)] *Institute of Computational Medicine, Department of Biomedical Engineering, Johns Hopkins University, Whiting School of Engineering, Baltimore, MD, USA.*[a)]
[3)] *Complexity Sciences Center, University of California at Davis, Davis, CA, USA.*
[4)] *Department of Physics, University of California at Davis, Davis, CA, USA.*
[5)] *School of Mathematical Sciences, Queen Mary, University of London, London, UK.*

(Dated: 1 December 2018)

Development of ventricular tachycardia and degeneration of it into ventricular fibrillation can be considered a phase transition in cardiac dynamics. Characterization of the underlying physical mechanisms may lead to better prediction of the onset of this phase transition and enable efficient treatment of patients at risk. Aiming to contribute to this characterization we study time series of activity in simulated heart tissue. We use Bayesian structural inference to find the best fit models in a set of hidden Markov models representing renewal processes. We compute the entropy rate and statistical complexity of these models and compare between results for healthy heart activity, heart activity at the onset of the phase transition and heart activity after the phase transition. We discuss the advantages and shortcomings of this approach, as well as alternative improvements.

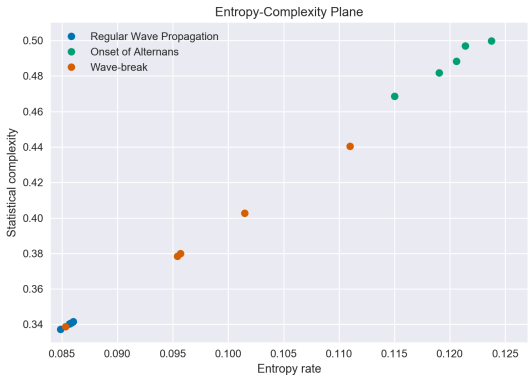

FIG. 1. Points in the plot represent estimated values of entropy rate and statistical complexity for time series of voltage activity recorded in five different sites of a cardiac dynamic simulation. Each of the sites is simulated in three different regimes: regular wave propagation (representing healthy heart tissue), near the onset of alternans (representing a phase transition into ventricular fibrilation), and after the wave-break (representing heart tissue undergoing ventricular fibrilation).

[a)] Electronic mail: karonis1@jhmi.edu