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Towards Understanding Complex Spatio-Temporal Systems

Abstract

Nonlinear dynamical systems play an important role in modelling of various processes in fields ranging from physics, chemistry and biology to many other natural and social sciences. Despite the importance of nonlinear models and intense efforts of many researchers, the global dynamics of many of these systems is still far from being properly understood. Our comprehension of the dynamics becomes even more tentative if the governing equations are not known. In this case the study of the system is based on data collected from experiments. In this talk I will introduce rigorous mathematical methods for analysing the dynamics of a system from time series and demonstrate these methods on a variety of different problems which exhibit an intricate pattern formation. In the first part I will explain how to describe these patterns using persistent homology. Persistent homology allows us to transform experimental or numerical data into a point cloud in the space of persistence diagrams. There are a variety of metrics that can be imposed on the space of persistence diagrams. By choosing different metrics one can interrogate the pattern locally or globally, which provides deeper insight into the dynamics of the process of pattern formation. In the second part of this talk I will discuss topological methods for identifying robust dynamical structures that act as organising block of the dynamics.