A Quantitative Method for Analyzing Dynamical Systems Using Topological Data Analysis Tools

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In this presentation, I will discuss preliminary results from the analysis of both sampled and continuous dynamical systems using topological data analysis techniques. The core method employed is the Euler Characteristic Profile (ECP) [1], which is applied to vector fields sampled from the phase space. This robust characteristic of vector fields allows us to establish a distance metric between different types of dynamics, whether continuous or discrete, even when only finite samples are available. The proposed suite of methods serves as an alternative to traditional Conley index theory, with the added benefit of stability under small perturbations of the vector field.

Our initial research is focused on examining two- and three-dimensional dynamics, including features like fixed points, saddle points, periodic orbits, multistability, and chaotic behaviors. The goal is to explore their organization within the space defined by the corresponding Euler profiles. This work holds the potential to offer a novel perspective on the qualitative analysis of dynamical systems.

[1] P. Dłotko, D. Gurnari. Euler characteristic curves and profiles: a stable shape invariant for big data problems. *GigaScience* (2023). https://doi.org/10.1093/gigascience/giad094