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Name: Firas Khasawneh
Organization: Michigan State University

Abstract Title: Dynamical System Parameter Path Optimization using Persistent Homology

Authors: Firas A. Khasawneh and Max M. Chumley

Dynamical System Parameter Path Optimization using Persistent Homology

Introduction: Persistent homology, the flagship tool from Topological Data Analysis (TDA), has been successfully utilized in many different domains despite the absence of a differentiation framework. Only recently, a differential calculus has been defined on the space of persistence diagrams, thus unlocking new possibilities for combining persistence with powerful solvers and optimizers.

Objective: This work explores harnessing persistence differentiation for navigating the parameter space of dynamical systems to achieve desired response characteristics based on the topological features of the signal.

Methods: This optimization problem results in the formation of a path in the system parameter space to optimally lead the system to a response with the specified properties.

Results: We show several examples by applying the methods to different dynamical systems and scenarios to demonstrate how to promote different features and how to choose the hyperparameters to achieve different outcomes.

Significance: We use these tools to develop loss functions that promote certain dynamic behavior transitions such as fixed point to periodic behavior, chaos to limit cycle, etc. In contrast to available tools, specifying these constrains is significantly facilitated using a newly defined, flexible language based on applied topology for specifying the desired system behavior.

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