

Topological Data Analysis

Tentative Schedule

Part I: Computational Topology

1. Basics in topology

- Topological space, maps, homeomorphisms, homotopy
- Manifolds and Morse function

2. Complexes

- Simplicial complexes, Cubical complexes and CW complexes
- Commonly Choices of simplicial complexes from point cloud data

3. Homology

- Chains, cycles, boundaries, and homology groups
- Example homology calculations, simplicial maps and functoriality
- Algorithms for computing homology
- Funtoriality of Homology

Part II: Persistent Homology

4. Persistent Homology I

- Filtrations, VR and Cech filtrations
- Persistent modules and decomposition
- Persistent homology and barcodes
- Matrix view and reduction-based algorithm

5: Persistent Homology II

- Bottleneck distance, interleaving distance
- Gromov-Hausdorff distance and stability

6. Analyzing Point Cloud Data via PH

- analyzing PCDs, homology inference
- Data sparsification for PCDs

7. Persistence in Applications

- PH pipeline/framework; Various Applications in biology, neural science
- Takens embedding and time series

Part III: Advanced Topics

8. TDA and Machine Learning

- Different vectorizations of persistence diagrams
- topological constraints and priors

9. Analysis of Functions on Data

- Reeb graph and contour tree
- Intro to Mapper: Covers and nerve theorem
- Mapper and applications

10. Discrete Morse Theory and Applications

- Review of Morse theory and discrete Morse theory
- Application to data analysis