

# 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. Spectral Methods in TDA**

- Persistent Laplacian
- Theory and applications