This course plans to cover the following topics. Extensive experimental projects are conducted.

 I. Geometric Data Analysis

(1) Dual Geometry of Principal Component Analysis (PCA) and Multidimensional Scaling (MDS):

(2) Robust PCA: PCA with outliers

(3) Sparse PCA: PCA with variable selection

(4) Manifold Learning:

Locally Linear Embedding (LLE) from PCA

Laplacian LLE, Diffusion map, LTSA etc.

ISOMAP from MDS

Graph Realization as manifold local MDS

(5) Supervised PCA:

Ridge Regression and PCA

Slice Inverse Regression (SIR)

Classification and Linear Discriminant Analysis (LDA)

(6) Further representation learning

tSNE

Steerable PCA

Dictionary Learning and matrix factorization

Deep learning

II. Topological data analysis

(1) clustering

k-center

k-means

hierarchical linkage

(2) Morse theory and Topological data analysis

Reeb graph and mapper

Persistent homology and discrete Morse theory

\*Critical nodes and graphs

(3) \*Euler Calculus and signal processing

(4) Connecting geometry and topology: Hodge Theory

Spectral clustering and graph Laplacian

Statistical Ranking and graph Helmholtzian

Game Theory