Computational topology - group project

Detecting Shapes

Introduction: Data often contains geometric information, that is hard to extract without the use of topology. Imagine parts of a cell, or of a human body, different shapes of animals, molecules, any visual data in two-, three- or higher dimensional space.

Goal: Develop topologically motivated techniques for distinguishing various shapes.

Detailed description:

1. Choose a collection of shapes in $\mathbb{R}^3$ that are to be recognized: a line segment (long and thin), a flat disc (circular and thin), a perturbed 3-disc (potatoe-like shape), ellipsoid, circle, sphere, torus, ...

2. Approximate these shapes: you can use cubical complexes or simplicial complexes. You can sample some model of these shapes or just take pixels corresponding to them...

3. Develop topological techniques that can distinguish the shapes above. Note that many of them are homotopy equivalent.

    - One way would be to combine homology of the point-cloud, possibly after removing an open ball from the center, etc.
    - Another option would be to compute persistence diagrams and try to classify them using, for example, persistent silhuette.

4. Test techniques: rotate and translate your shapes. Do you still recognize the shape?

5. What happens if you test your approach in $\mathbb{R}^4$?

Results: The report should include a description and justification of techniques, pseudocodes, methods of computation, results of experiments, and division of work.

Students are encouraged to take the initiative and possibly implement their own ideas on the theme of the project: perhaps thinking of new shapes that can be recognized, etc.