VIPICS: **V**isualizing and **I**nteracting with **P**aths in **C**onfiguration **S**paces

Mathematics Computing Laboratory
Spring 2019 project

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Structure.

- There will be weekly meetings with assigned readings / problems / coding.
- You will recieve a letter grade based on your participation.

Checklist (non-math).

- how to use `git` and GitHub
- how to code in C#
- how to use Unity with the Oculus headset

Checklist (math). Undergraduate level understanding of sets and algebraic topology.

- Edelsbrunner, Harer: Chapter 3
- Carlsson: Sections 2.1, 2.3
- Aguilar, Gitler, Prieto: Pages xvii-xx
- Hatcher: Pages xii, 5-6, 25-27

Goals (non-math). Primary, secondary, and tertiary, all within a Unity scene.

P1. Create a scene where, with the Oculus controls, the user can

   (a) add and delete points in $\mathbf{R}^3$,

   (b) ajust the real parameter $r \in \mathbf{R}_{\geqslant 0}$ with one of the joysticks.

P2. Visualize the Vietoris–Rips complex from the points in the scene and the radius, which changes as the user moves the points and adjusts the radius.

P3. Create a poster describing the semester's work.

S1. Pair points together to describe straight-line paths in space, and let the user adjust position along the paths with the other joystick. The VR complex is visible and responds to user changes.

T1. Adjust the visualizations for the Čech complex instead. Allow the user to switch between them.

T2. Visualize the resulting stratified two-dimensional space.

Goals (math).

P1. Understand, work with, and compute

  (a) simplicial homology,

  (b) the topology of and distances in configuration space.

S1. Given $P \subseteq \mathbf{R}^N$ of size n, describe a formula that gives $r \in \mathbf{R}_{\geqslant 0}$ at which the $(n-1)$-simplex of the Čech construction is born.

T1. Understand, work with, and compute distances between persistence diagrams.

Sources. Some, not all.

- Aguilar, Gitler, Prieto (2002). *Algebraic Topology from a Homotopical Viewpoint.*
- Carlsson (2009). *Topology and data.*
- Chan, Carlsson, Rabadan (2013). *Topology of viral evolution.*
- Edelsbrunner, Harer (2009). *Computational Topology: An Introduction.*
- Hatcher (2015). *Algebraic Topology.*
- May (1999). *A Concise Course in Algebraic Topology.*
- Topaz, Ziegelmeier, Halverson (2015). *Topological Data Analysis of Biological Aggregation Models.*