DHAWAN, SAHIL, M.A. Analyzing the Topological Properties of 3D STL Files. (2024)
Directed by Dr. Thomas Weighill. 10 pp.

ABSTRACT TEXT

ANALYZING THE TOPOLOGICAL PROPERTIES OF 3D STL FILES

by

Sahil Dhawan

A Thesis Submitted to
the Faculty of The Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Greensboro
2024

Approved by

Committee Chair

Dedicated to my cats, Piccolo and Gohan, and my dogs, Bebe and Tilly.

APPROVAL PAGE

This thesis written by Sahil Dhawan has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair _____
Thomas Weighill

Committee Members _____
Michael Hull

_____
Thomas Lewis

_____
MEMBER 3

_____
Date of Acceptance by Committee

_____
Date of Final Oral Examination

ACKNOWLEDGMENTS

It is customary to recognize the assistance of the advisor and/or committee chair, all other members of the committee, and only those organizations and/or persons who actually aided the research. If financial support was provided to make the study possible, credit for such assistance should be given.

PREFACE

A preface is a statement that either explains the author's reasons for pursuing this subject matter or provides a personal comment about the subject that would not otherwise be included in the document.

Contents

List of Tables

List of Figures

Chapter 1: Homology

1.1 Simplicial Homology

Information in this topic is from [1]

A simplex is the convex hull of (n+1) points in $\mathbb{R}^m$ in general position.

- 0-simplex: a point
- 1-simplex: an edge
- 2-sipmlex: a "filled-in" triangle, or a triangle containing all points within the boundaries of its edges.
- 3-simplex: a "filled-in/solid" tetrahedron, or a tetrahedron containing all points within the boundaries of its "filled-in" triangles.

1.2 Persistent Homology

Cech Complexes

$Cech_r(X) = \{\sigma \subseteq X \mid \cap_{x \in \sigma} B_r(X) \neq \emptyset\}$

- Balls grow around points of metric space, every time k+1 balls intersect, add a k-dimensional simplex to complex.

Vietoris-Rips Complexes

$VR_r(X) = \{\sigma \subseteq X \mid diam\sigma \leq 2r\}$

- if subsets of metric space have diameter less than or equal to 2*r, add simplex

Delaunay Complexes

$Del(X) = \{\sigma \subseteq X \mid \cap_{x \in \sigma} V_x \neq \emptyset\}$
$V_x = \{y \in \mathbb{R}^2 \mid ||y - x|| \leq ||y - z||, z \in X\}$

- Do not depend on a parameter or intersecting balls (no "time")
- Intersecting voronoi cells determine simplices in complex

Alpha Complexes

$Alpha_r(X) = \{\sigma \subseteq X \mid \cap_{x \in \sigma} (B_r(X) \cap V_x) \neq \emptyset\}$

- in-between cech and delauney complexes: to construct, take into account both voronoi cell-associated points in metric spce and growing balls around these points

Chapter 2: Methods

2.1 What is an STL File?

An STL file is

2.1.1 Converting the .ast File to a Data Structure

The .ast file was parsed for four strings which are used to denote the beginning and end of the description of faces and vertices: "facet normal", "end facet", "outer loop", and "end loop", respectively. The data was then converted into tuple with python.

```
solid Mesh
  facet normal 0.000000 0.000000 -1.000000
    outer loop
      vertex 4.500000 -0.288675 0.000000
      vertex 5.000000 0.577350 0.000000
      vertex 5.500000 -0.288675 0.000000
    endloop
  endfacet
  facet normal -0.816497 0.471405 0.333333
    outer loop
      vertex 5.000000 0.000000 0.816497
      vertex 5.000000 0.577350 0.000000
      vertex 4.500000 -0.288675 0.000000
    endloop
  endfacet
  facet normal 0.000000 -0.942809 0.333333
    outer loop
      vertex 5.000000 0.000000 0.816497
      vertex 4.500000 -0.288675 0.000000
      vertex 5.500000 -0.288675 0.000000
    endloop
  endfacet
  facet normal 0.816497 0.471405 0.333333
    outer loop
      vertex 5.000000 0.000000 0.816497
      vertex 5.500000 -0.288675 0.000000
      vertex 5.000000 0.577350 0.000000
    endloop
  endfacet
endsolid Mesh
```

Figure 2.1. The contents of an ASCII STL file representing a tetrahedron.

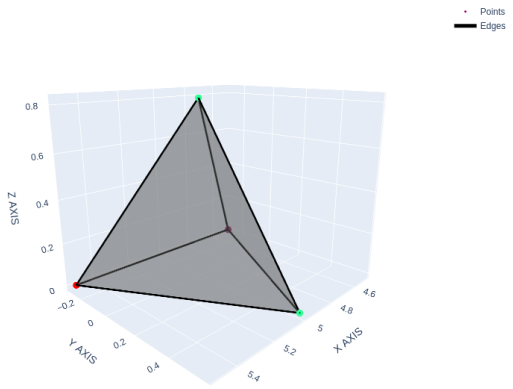

Figure 2.2. An ASCII STL file representing a tetrahedron plotted with Plotly.

2.2 Python Libraries

2.3 Meshing

2.4 Filtration Construction

2.5 Persistence Diagram Construction

Chapter 3: Results

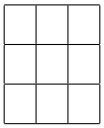

Figure 3.1. Persistence Diagrams of a rectangular prism ring with a cut that decreases to the original shape.

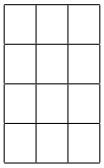

Figure 3.2. Persistence Diagrams of a rectangular prism ring with a cut that decreases to the original shape.

Chapter 4: Discussion

Bibliography

[1] Allen Hatcher. *Algebraic topology*. Cambridge University Press, 2001.

Chapter A: Appendix