SM 402: Basic Computational Topology
Implementation Project

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Contents

1 Problem Statement

Given any input simplicial complex (up to 3 -dimensional), compute β_3 using the boundary matrix method.

2 Algorithm

Formula used to calculate β_3:

$$\beta_3 = dim(Ker(\partial_3)) - dim(Im(\partial_4)) \tag{1}$$

In our python file, we take the filename (.gts file) as an input from the user and process the file.
We know that ∂_3 and ∂_4 are defined as:

$$\partial_3 : C_3(K) \to C_2(K)$$

$$\partial_4 : C_4(K) \to C_3(K)$$

∂_k boundary matrix row labels are basis for $C_{k-1}(X)$ and column labels are the basis for $C_k(X)$.
Kernel of a matrix is nullspace of the matrix and image is columnspace of a matrix.

3 Steps to run the code

Make sure you have `python3 and numpy and plotly` installed. Use the command `pip3 install numpy plotly` to install them.
For best results for tetrahedron, use `tetra.py`.Use `Tetrahedron.gts` as your input file.
For Torus and TangleCube, use the command `python3 only.py` to run it. Then enter the name of the of the `.gts` file.

4 Code

only.py

```
import time
import numpy as np
import os
import plotly.graph_objects as go
```

```
begin = time.time()


def convert_float(nested):
    return [[float(x) for x in lst] for lst in nested]


def convert_int(nested):
    return [[int(x) for x in lst] for lst in nested]


def open_file(file_name):
    try:
        with open(file_name, 'r') as f:
            line = f.readline()
            lst = line.split(' ')
            no_vertices = int(lst[0])
            no_edges = int(lst[1])
            no_faces = int(lst[2])
            print("Number of vertices:", no_vertices)
            print("Number of edges:", no_edges)
            print("Number of faces:", no_faces)

            vertices = []
            edges = []
            faces = []

            for i in range(no_vertices):
                line = f.readline()
                vertices.append(list(line.replace('\n', '').split(' ')))
```

```
        for i in range(no_edges):
            line = f.readline()
            edges.append(list(line.replace('\n', '').split(' ')))

        for i in range(no_faces):
            line = f.readline()
            faces.append(list(line.replace('\n', '').split(' ')))

except OSError as e:
    print(e.strerror)

print("vertices:", convert_float(vertices))
print("edges:", convert_int(edges))
print("faces:", convert_int(faces))

try:
    os.mknod('vertices.txt')

except FileExistsError as e:
    print(e.strerror)

with open("vertices.txt", "a") as f:
    for lst in vertices:
        f.write(lst[0] + ' '+lst[1] + ' ' + lst[2] + '\n')

pts = np.loadtxt(np.DataSource().open(
    'vertices.txt'))

x, y, z = pts.T

fig = go.Figure(
    data=[go.Mesh3d(x=x, y=y, z=z, color='cyan', opacity=0.5)])
```

```
    fig.show()


    os.remove('vertices.txt')



if __name__ == '__main__':
    file_name = input("Enter the name of the file: ")
    open_file(file_name)
    end = time.time()
    print("Time elapsed:", end - begin, 's')
```

4.1 Github Link

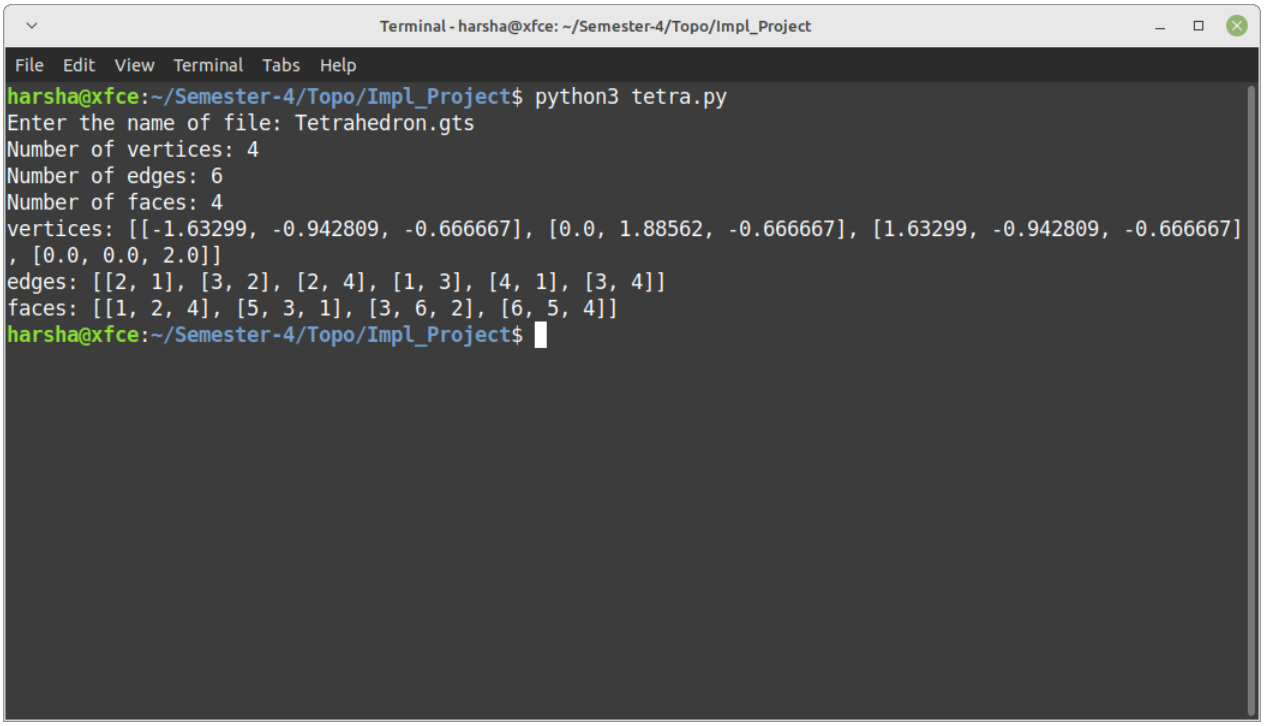
You can also visit the below link.

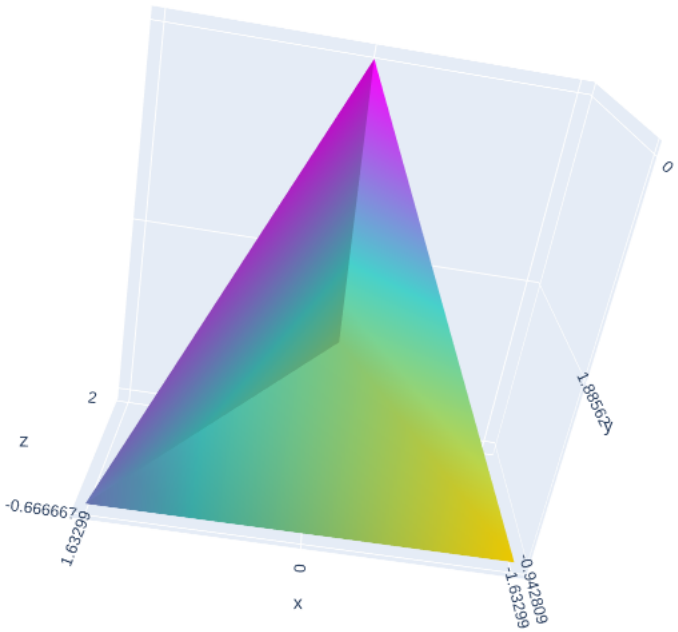
https://github.com/harsha-deep/BCTImplementationProject

5 Note

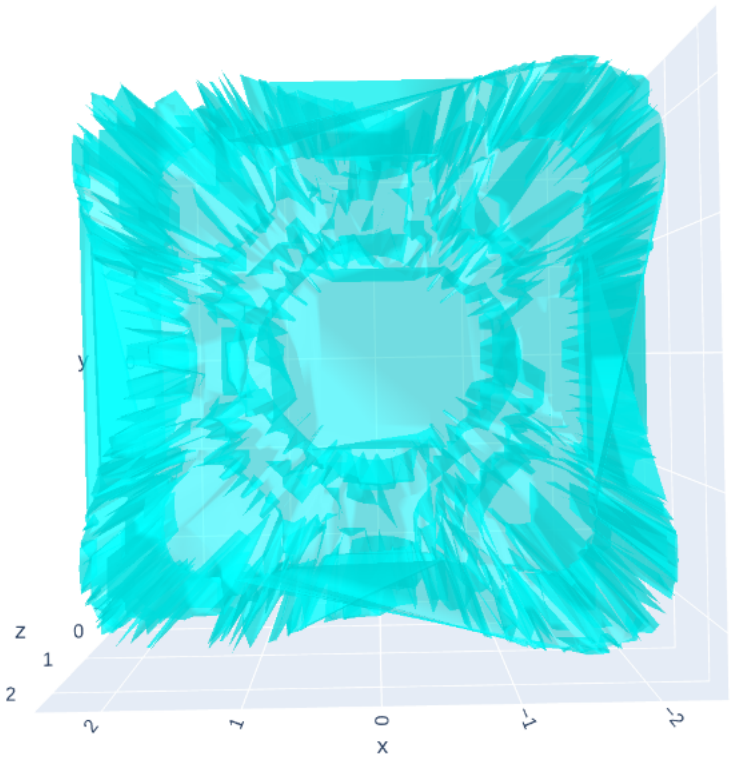
The code is not complete. We are unable to calculate ∂_3 and ∂_4.

6 Screenshots





Tetrahedron.



Tangle cube.

7 References

1 . https://en.wikipedia.org/wiki/Simplicial_complex

2. https://jeremykun.com/2013/04/10/computing-homology/

3. https://jeremykun.com/2014/01/23/fixing-bugs-in-computing-homology/

4. http://gts.sourceforge.net/samples.html

5. https://plotly.com/python/3d-mesh/