

3D Polyhedron Analysis System Documentation

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1 Overview

The 3D Polyhedron Analysis System is a comprehensive software tool designed for analyzing and manipulating three-dimensional polyhedra. This system offers a wide range of functionalities including:

- 3D reconstruction from 2D projections
- Geometric calculations (surface area, volume, center of mass)
- Moment of inertia calculations
- Geometric transformations (rotation, translation, scaling, reflection)
- Orthographic projections (onto standard planes and custom planes)
- Visualization of projections using SDL2

This software is ideal for engineers, mathematicians, and researchers working with 3D geometric shapes, providing both analytical tools and visual representations.

2 How to Use the System

2.1 Compilation

To compile the system, ensure you have a C++ compiler (supporting C++11 or later) and the SDL2 library installed. Use the following command:

```
g++ -std=c++11 -o polyhedron_analyzer main.cpp polyhedron.cpp input.cpp transformations.cpp
```

Replace `/path/to/eigen3` and `/path/to/sdl2` with the actual paths on your system.

2.2 Running the Program

After compilation, run the program using:

```
./polyhedron_analyzer
```

2.3 User Interface

The program uses a command-line interface. Follow the on-screen prompts to:

1. Input polyhedron data
2. Choose analysis or transformation operations
3. View results or projections

3 Sample Inputs and Outputs

3.1 Example 1: Calculating Surface Area and Volume

Input:

```
Enter the number of vertices: 4
Enter the number of faces: 4
Enter vertex coordinates (x y z):
0 0 0
1 0 0
0 1 0
0 0 1
Enter face data:
3 0 1 2
3 0 1 3
3 0 2 3
3 1 2 3
Choose operation: 1 (Surface Area)
Choose operation: 2 (Volume)
```

Output:

```
Surface Area: 1.732051
Volume: 0.166667
```

3.2 Example 2: Orthographic Projection

Input:

```
[Previous polyhedron input]
Choose operation: 6 (Orthographic Projection)
Select axis: z
```

Output: An SDL2 window will open showing the orthographic projection of the polyhedron onto the XY plane.

3.3 Example 3: Geometric Transformation

Input:

```
[Previous polyhedron input]
Choose operation: 4 (Transform Polyhedron)
Select transformation: 1 (Rotate)
Enter rotation angle (degrees): 45
Enter rotation axis: 1 1 1
```

Output: The program will display the new coordinates of the rotated polyhedron.

4 Known Limitations

- **Input Size:** The system may experience performance issues with polyhedra containing more than 1000 vertices or faces.
- **Precision:** Calculations are subject to floating-point precision limitations.
- **Visualization:** The SDL2 visualization is basic and may not accurately represent complex polyhedra.
- **File Input:** The current version does not support reading polyhedron data from files.
- **Error Handling:** While basic input validation is implemented, the system may not gracefully handle all types of invalid inputs.