CS499/554 Geometric Modeling

Project 2

Due May 4, 2025

In this assignment, we will write a computer-generated program that creates cross-hatching results given 3D meshes and a viewpoint. Below are the components of this work. You will also write a report that summarizes your work, the results you have, and the analysis as required below. Feel free to explore and have fun!

1. (**Silhouette drawing**) Incorporate silhouette drawing into **learnply**.
    a. Classify each face as being either forward or backward using the ray-normal dot product test. Then find all the edges that are part of silhouette. Draw the silhouette edges each time the viewpoint has changed. What problem do you encounter when you switch viewpoints?
    b. Implement a face-based silhouette depiction method. This time, perform the ray-normal dot product test at each vertex and extract silhouette inside each face that correspond to the zero levelset of the ray-normal dot product function. Compare this technique to the one in 3(a). Which one is more preferred, and why? Justify your answers both in words and figures. Be comprehensive and thorough in your reasoning.
    c. Do the methods in (a) and (b) capture all the important features in the model? In what way can these methods be improved? Provide at least three aspects to this.

2. **(Curvature estimation)** Implement the discrete curvature estimation algorithm by Meyer et al. http://www.multires.caltech.edu/pubs/diffGeoOps.pdf. You will need to estimate and visualize the mean curvature, Gaussian curvature, and the curvature tensor. For the mean and Gaussian curvatures, design appropriate color coding schemes and explain them in the report. For the curvature tensor, use crosses to show the principal curvature directions. For a stable estimation of the curvature tensor, you will need to smooth the initial estimation through the Laplacian smoothing process described in the class.
    a. Compare the uniform, cord, mean curvature, and mean values weights for curvature tensor smoothing. Which scheme is more preferred? Justify your answers with theoretical and/or visual analysis.
    b. Are you satisfied with the curvature estimation algorithm you have implemented even after smoothing? Did you find cases where it is not working well? Which parts of the algorithm do you think can be improved, and how do you propose to improve them? Make sure to draw conclusions only after having carefully examined all the test models from various viewpoints and tried different smoothing parameters.

3. **(Pen-and-ink)** Apply your curvature estimation algorithm to pen-and-ink sketching of a 3D model according to the algorithm described in the class. There will be a streamline starting from the center of each triangle and moving in either direction for five more triangles (11

triangles total per streamline). When crossing an edge, you need to compute the direction of the streamline in the new triangle T. Implement the following two ways and compare them.

a. Use the major or minor eigenvector direction based on the curvature tensor in T.
b. Unfold the triangle T to be in the same plane as T', then continue using the direction from the major or eigenvector direction from T.

Do the two methods give you comparable results? Are you satisfied with either approach? Discuss their relative strengths and weaknesses. What is a common problem with both approaches, and how would you fix the problem? In addition, are you satisfied with the final sketching results? If not, which parts of the pen-and-ink sketching pipeline do you plan to improve and how?