CS6491 Fall 2009 Project P4

Individual project. The purpose of the project is to investigate the reconstruction of a blobby 3D shape from its contour and from the terminator for a known direction. We assume that the images are generated using orthographic projection (no perspective distortion).

Students may find the following examples useful:

http://www.gvu.gatech.edu/~jarek/demos/caplet/

http://www.gvu.gatech.edu/~jarek/demos/isosurface/

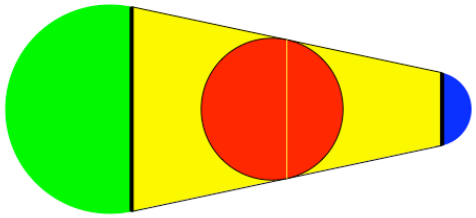
http://www.gvu.gatech.edu/~jarek/demos/bulge/

http://www.gvu.gatech.edu/~jarek/demos/roads/

The project has two phases. You need to provide an interactive applet and a PDF with the write up for each phase.

Phase 1 (due Oct 27): Consider a caplet (the convex hull of two balls (B(C0,r0) and B(C1,r1)). When the two centers, C1 and C2, have the same z coordinates, the image of the caplet looks like the on shown below (ignore the coloring).

Given a fixed circle (C,r) on the image (different from the circles of the caplet), your program should let the user specify the direction of the light source (at infinity) by clicking in that circle to specify a point L. The user should also be able to specify the position of the centers C0 and C1 of the caplet disks and their radii.

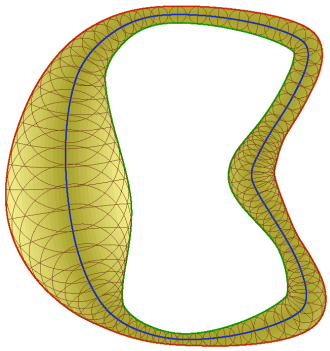


Part 1-A: Assume that the depth of C1 and C2 are identical (i.e., the two disks are on the same plane that is parallel to the screen). Write a program that will draw the terminator, which bounds the portion of the front of the caplet that sees the light, as a curve on top of the caplet. You may compute this curve in 2D or in 3D, but you should draw it as a 2D curve. Provide equations or construction process for computing the terminator and indicate/justify what kind of a curve it is (it may be composed of several curves, if so, discuss whether the terminator is smooth).

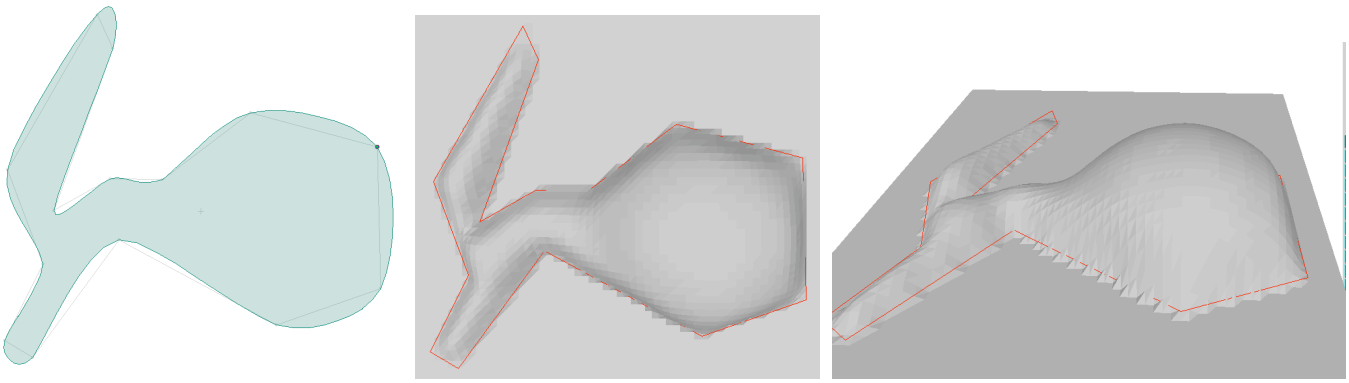
Part 1-B: Now C1 and C2 no longer have the same depth. For example, the center of the small blue ball in the image below is closer to the viewer than the center of the green ball. Let the user edit the depth of the C2 center of the blue ball. Compute and draw the terminator and show how it varies as the depth of C2 is changed. Provide equations or construction process for computing the terminator and indicate/justify what kind of a curve it is (it may be composed of several curves, if so, discuss whether the terminator is smooth). To illustrate the depth difference, use a shaded 3D rendering of the green and red balls and of the yellow cone that is tangent to both. Hence, you should see more that the half blue disk if its center is closer and less of the green disk. Furthermore, the lines that separate green and yellow will not be a straight line but an ellipse.

Part 1-C: Now, assume that the depth (z-coordinate) of C0 is 0 but that you do not know the depth z1 of C1. However, the user provides a point T (somewhere in the yellow or red region below) through which the terminator must pass. Are there positions of T from which you can unambiguously determine the value of z1? If so, explain the constraints on where T must lie and the equation or construction process for computing z1 from the other values (C.x,C.y,L.x,L.y,C0.x,C0,y,C0,z,r0,C1.x,C1.y,r1,T.x,T.y). Show several images for different positions of L (which specifies the light direction) and of T.

Phase 2(due Nov 17, no extensions!!!): Now, instead of the caplet, the user draws, edits or loads a closed-loop curve (such as the one on the left below). Your job is to compute the medial axis transform of the region R bounded by the curve. The medial axis transform expresses R as the union of disks whose center is on the medial axis. The figure below shows the medial axis and the disks for a region that is bounded by 2 loops. In this project, we only have one loop.



Replace each disk by a ball of the same center and radius. The union of these balls is a solid S, which we call the "bulge" of R. The figure below shows an approximation of that bulge (more precisely, the top half), from the z direction (center) and from an oblique perspective view (right).



Part 2-A: Using the same interface for specifying the direction to the light source at infinity, draw the terminator for the bulge S on top of the original loop. Explain the equations of its construction. Then, compute loops that bound the visible portion of S that faces the light and the visible portion of S that does not. Render them using different light and dark fill colors to produce the two-tone rendering of S. The figure above (center) shows a smooth (not a two-tone rendering of the shading) with the light behind the viewer. Your code should produce a different image with only 3 colors: white background, yellow part of S that faces the light, and orange part of S that does not. You may draw the border of these yellow and orange regions in brown. This is with the view from the z-direction. Produce different images changing the direction of the light.

Part 2-B: Let the user change the 3D orientation of the bulged shape S. Then, redraw its image as a 2D projection with the 2 coloring separated by the terminator as before. Note that the object may now have self occlusions. The image above (right) shows such a perspective for the front half of S. Again, your program should only draw the visible projections of the two parts (the yellow part that faces the light and the orange part that does not). Produce several images showing the same bulge S in different orientations.

Part 2-C: So far, the medial axis of R (in the original position) was a planar curve parallel to the screen. Now, we want to alter the height of the medial axis of R. The goal is to try and specify this height be drawing a terminator. Note that this terminator will be different from the one generated by your program that was assuming a planar medial axis. Explain whether this is possible and if so under which assumptions. Justify your answer. Also note that the drawn terminator may be invalid. Propose an approach for altering the relative depth of points on the medial axis based on such a terminator. Then, to demonstrate the result, draw the correct terminator (the one that your program computes for this distorted bulge) and also show the distorted bulge rotated in 3D. Provide the mathematical derivations.