Lab 4 Report

Implicit Solids

CZ2003 Computer Graphics and Visualization

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FShape

The complex FShape (Fig 1) depicts a head consisting of 2 eyes and a nose, and a body. It is built using set theoretic operations applied to at least one each of the below shapes:

A. Ellipsoid
B. Halfspace
C. Cylinder
D. Cone

as per the lab manual's requirements
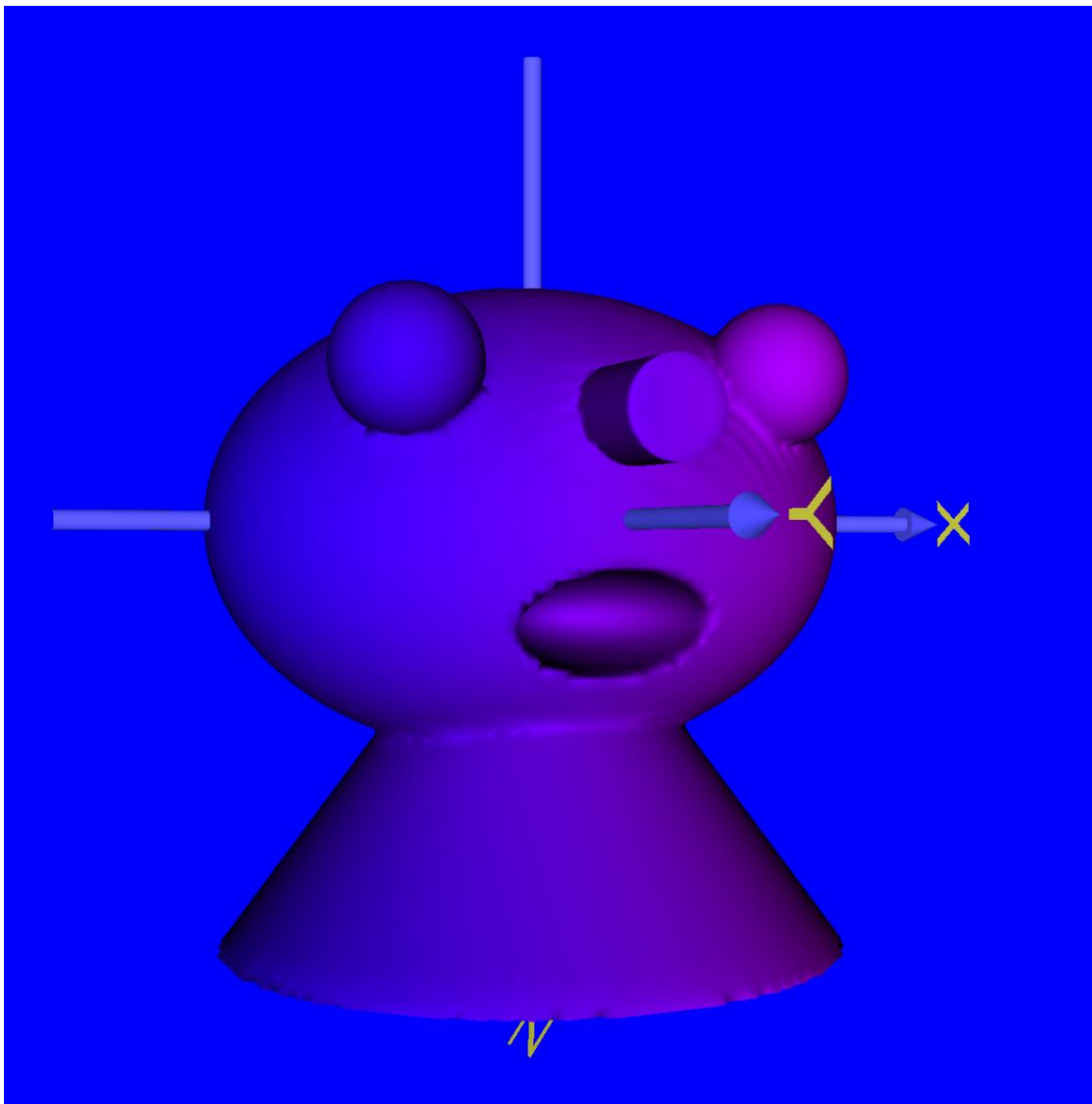
and an additional shape:

E. Sphere

Fig 1. Complex FShape

A. Ellipsoid

There is a total of 2 ellipsoids in the complex FShape. The ellipsoids forms the "head" and "mouth" of the solid object.

The "head" is an ellipsoid with a center at the origin and a radius along the x-axis of 0.7 units and along the y-axis and z-axis of 0.5 units. It is defined by the following implicit function.

$$\text{ellipsoid1: } 1 - \left(\frac{x}{0.7}\right)^2 - \left(\frac{y}{0.5}\right)^2 - \left(\frac{z}{0.5}\right)^2 \geq 0$$

The "mouth" is an ellipsoid with a center at (0, 0.4, 0.2) and a radius along the x-axis of 0.2 units and along the y-axis of 0.3 units and z-axis of 0.1 units. It is defined by the following implicit function.

$$\text{ellipsoid2: } 1 - \left(\frac{x}{0.2}\right)^2 - \left(\frac{(y-0.4)}{0.3}\right)^2 - \left(\frac{(z-0.2)}{0.1}\right)^2 \geq 0$$

B. Halfspace

There is a total of 4 halfspaces in the complex FShape.

Halfspace 1 has the following implicit function

$$\text{halfspace1: } y \geq 0$$

Halfspace 2 has the following implicit function

$$\text{halfspace2: } -y + 0.7 \geq 0$$

Halfspace 1 and 2 will be involved in the formation of a finite solid cylinder.

Halfspace 3 has the following implicit function

$$\text{halfspace3: } z \geq 0$$

Halfspace 4 has the following implicit function

$$\text{halfspace4: } -z + 0.9 \geq 0$$

Halfspace 3 and 4 will be involved in the formation of a finite solid cone.

C. Cylinder

The cylinder forms the "nose" of the solid object. It is a cylinder centered at (0, 0, -0.2) and has a radius of 0.10 units along axis y. It is defined by the following implicit function.

$$\text{shape2: } 0.10^2 - x^2 - (z + 0.2)^2 \geq 0$$

To form a solid finite cylinder, it needs to be intersected with 2 halfspaces, denoting the start and end of the cylinder. The solid cylinder has the following implicit function.

$$\text{cylinder} = \min (\min (\text{shape2, halfspace1}), \text{halfspace2}) \geq 0$$

D. Cone

The cone forms the "body" of the solid object. The following implicit function defines a double cone (i.e. two cones placed apex to apex) with a radius of 0.55 units, oriented along the z-axis.

$$\text{shape3: } z^2 - \left(\frac{x^2}{0.55}\right)^2 - \left(\frac{y^2}{0.55}\right)^2 \geq 0$$

To obtain a singular solid cone, it needs to be intersected with 2 halfspaces denoting the start and end of the cone. The solid cone has the following implicit function.

$$\text{cone: min (min (shape3, halfspace3), halfspace4)} \geq 0$$

E. Sphere

There is a total of 2 spheres in the complex FShape. They form the "eyes" of the solid object. They are both spheres of radius 0.15 units and are centered at (0.4, 0.35, -0.3) and (-0.4, 0.35, -0.3) respectively. The two spheres have the following implicit functions.

$$\text{sphere1: } 0.15^2 - (x - 0.4)^2 - (y - 0.35)^2 - (z + 0.3)^2 \geq 0$$

$$\text{sphere2: } 0.15^2 - (x + 0.4)^2 - (y - 0.35)^2 - (z + 0.3)^2 \geq 0$$

Final Shape

The final shape is obtained by doing a union of all the shapes except ellipsoid 2, which is subtracted from the whole shape. The final shape has the following implicit function.

$$\text{final = min (max (max (max (max (ellipsoid1, cylinder), cone), sphere1), sphere2), - ellipsoid2)} \geq 0$$

Tight Bounding Box

The tight bounding box has been adjust to a size of

$$\text{bboxSize 2 2 2}$$

this allows the shape to be rendered in 3 seconds.

Variable Colour

The complex FShape has a variable colour of blue-to-purple gradient. It is obtained by setting the diffuseColor parameter to be

diffuseColor "r = (u + 1) / 2; g = 0; b = 1;"

Description of Files

1. FShape.wrl - Shows the above described complex shape.