CPSC 314
Quiz 2 Solutions

December, 02 2004

1. Clipping

   (a) (10 points) Write an algorithm (pseudo-code) for clipping a line $L = P_1P_2$ ($P_1 = (P_1^x, P_1^y)$, $P_2 = (P_2^x, P_2^y)$) against a triangle $T = (T_1, T_2, T_3)$ with $T_1 = (T_1^x, T_1^y)$, $T_2 = (T_2^x, T_2^y)$, $T_3 = (T_3^x, T_3^y)$ (in 2D). Follow the framework of the Cohen-Sutherland algorithm for clipping a line against a window.

   Note: The algorithm is almost identical to the one shown in class. The only differences are the number of edges and the table.

   Assume the triangle edges are given in CCW order $T_1T_2 \;\; T_2T_3 \;\; T_3T_1$

   Calculate a 3 digit binary code for each of the line end points $d_j = d_j^1 d_j^2 d_j^2$, such that $d_j^i = 0$ if P_j is to the left of line T_iT_{i+1} and $d_i^j = 1$ if P_j is to the right of line T_iT_{i+1} for $j = 1, 2 \;\; i = 1, 2, 3$.

   If ($d_1 \;\; OR \;\; d_2 = 0$) then both end points are in the triangle, thus the line is inside. If ($d_1 \;\; AND \;\; d_2 \neq 0$) then both end points are to the right of the same edge, thus the line does not intersect the triangle, and the whole line is clipped.

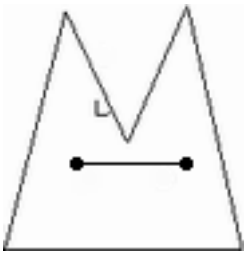
   otherwise, find $\min_{i,j} \;\; s.t. \;\; d_{j_i} \neq 0$ and find $\bar{P}_j =$ the intersection between P_1P_2 and the edge T_iT_{i+1}, recursively call the clipping algorithm with the new line $\bar{P}_jP_{j+1}$

   (b) (5 points) Explain how to extend your algorithm for clipping the line L against a convex polygon $T = (T_1, T_2, \ldots, T_n)$.

   Extend the binary code from 3 digits to n digits, each digit representing the end point position with respect to an edge.

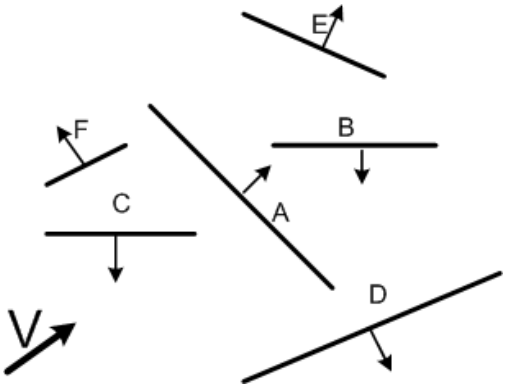
   (c) (3 points) Will your algorithm work for non-convex polygons? Explain.

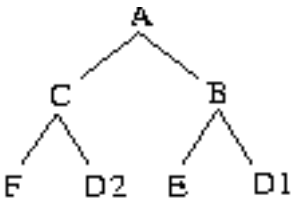
   No. The two points are on different sides of edge L, thus one of the binary codes

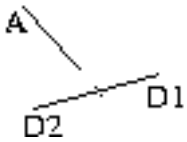
will not be zero. 

2. BSP Trees

   (a) (8 points) Construct the BSP tree for the segments shown below (use alphabetical insertion order for the segments, when possible). Use the convention where the right subtree (child) is located on the side that the normal points to. Show your work.







   (b) (8 points) Given the view direction V as shown above, describe the complete traversal order of your BSP tree during rendering.

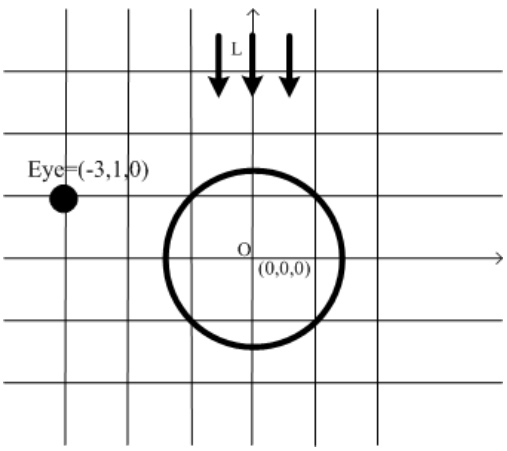
$$(A+)A(A-)$$
$$(B-)B(B+)A(C-)C(C+)$$
$$EBD_1AFCD_2$$

(c) (6 points) Depth sort: Given a set of polygons parallel to the XY plane, and an arbitrary view direction, is it always possible to sort the polygons for drawing, without splitting any of them? Explain.

Yes. Since all polygons are parallel to the XY plane, no polygon will intersect any other polygon plane. Therefore, constructing a BSP tree will not require splitting any polygons. Traversal of the BSP tree will then give the correct drawing order.

3. Lighting:

The scene below consists of: a sphere of radius $\sqrt{2}$ centered at origin with $k_d = (1, 0, 0)$ and $k_s = (1, 1, 1)$; a parallel (directional) light $L = (0, -1, 0)$ with $I_d = I_s = (1, 1, 1)$; and an eye location, as shown, at $(-3, 1, 0)$. Assume there are no other light-sources.



(a) (7 points) At what point (coordinates) on the sphere will we get maximal specular reflection (white dot)? Explain your answer.

$(-1, 1, 0)$ The angle between the reflected light and the view direction is 0.

(b) (7 points) At what point (coordinates) on the sphere will we get maximal diffuse illumination (red dot)? Explain your answer.

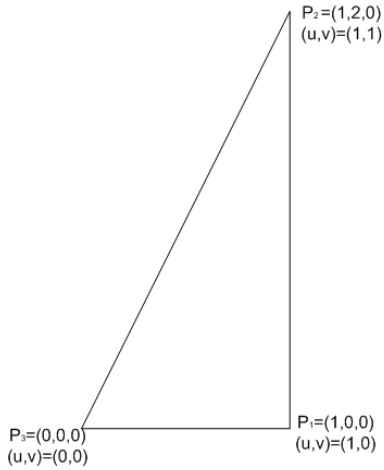
$(0, \sqrt{2}, 0)$ The angle beteen the light and the surface normal is 0.

(c) (6 points) Given a single ambient light source with $I_a = (1, 0, 0)$ and a triangle P_1, P_2, P_3 with $k_a = (0, 0, 1)$, what color will be assigned to P_1 using the light equation? Show your work.

Black - $(0, 0, 1) \cdot (1, 0, 0) = (0, 0, 0)$

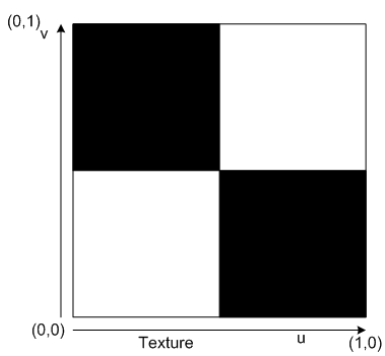
4. Texture mapping.

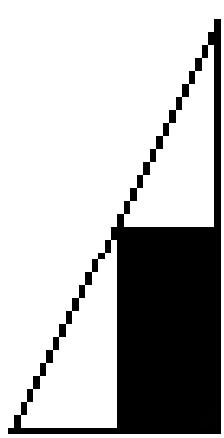
(a) (6 points) Given the triangle $T = (P_1, P_2, P_3)$ with $P_1 = (1, 0, 0)$,$P_2 = (1, 2, 0)$,$P_3 = (0, 0, 0)$ and with texture (u, v) coordinates at the vertices defined as $(1, 0)$, $(1, 1)$, and $(0, 0)$ respectively, compute the texture coordinates at point $P = (0.5, 1, 0)$ on the triangle.



$\alpha = 0$ since P is on the line P_2P_3
$\beta = \gamma$ since P is in the middle of the line, thus $\beta = \gamma = 0.5$
$P^u = 0.5P_2^u + 0.5P_3^u = 0.5$ $P^v = 0.5P_2^v + 0.5P_3^v = 0.5$

(b) (6 points) Given the following black and white texture defined on $[0,1] \times [0,1]$ and the triangle described above, draw the triangle with the texture mapped to it (explain your drawing).



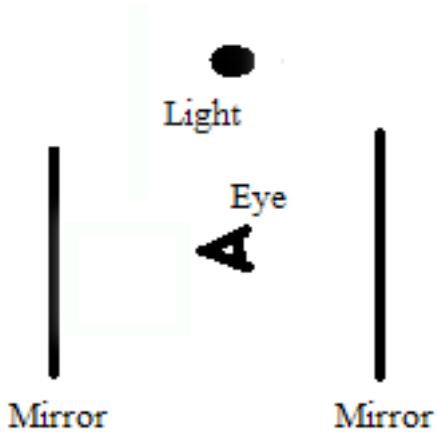


5. Ray Tracing

   (a) (6 points) If the modeled scene contains no reflective of transparent objects, will ray-tracing produce a different image than Phong shading using the illumination equation? Explain.

   Yes. Phong shading will not take into account if one object shadows another. If you do not consider shadows between objects the images would be identical.

   (b) (6 points) Draw a simple scene containing only reflective (specular) objects, for which basic ray-tracing can go into an infinite loop (unless attenuation or recursion depth are considered). Explain your drawing.



   (c) (6 points) Compute the intersection(s) between a ray $R = P + Vt$ ($P = (0, 0, 4)$, $V = (1, 1, 0)$, $t \in [0, \infty)$) and a paraboloid $z = x^2 + y^2$.

   Solve for t $(P_x + V_x t)^2 + (P_y + V_y t)^2 = (P_z + V_z t)$
   $2t^2 = 4$ $t = \sqrt{2}$ (only positive t since R is a ray)

6. Barycentric Coordinates.

   (a) (5 points) Does perspective warp preserve barycentric coordinates? (Answer yes/no). No, see question 1, assignment 2

   (b) (5 points) Does rotation preserve barycentric coordinates? (Answer yes/no). Yes,

   rotation preservers lengths and angles.