Written Assignment 4

Surfaces, Lighting and Rendering

Mohamed Eldawy (eldawy@cs.wisc.edu)
(with corrections added by Mike Gleicher)

Question 1: Light Paths

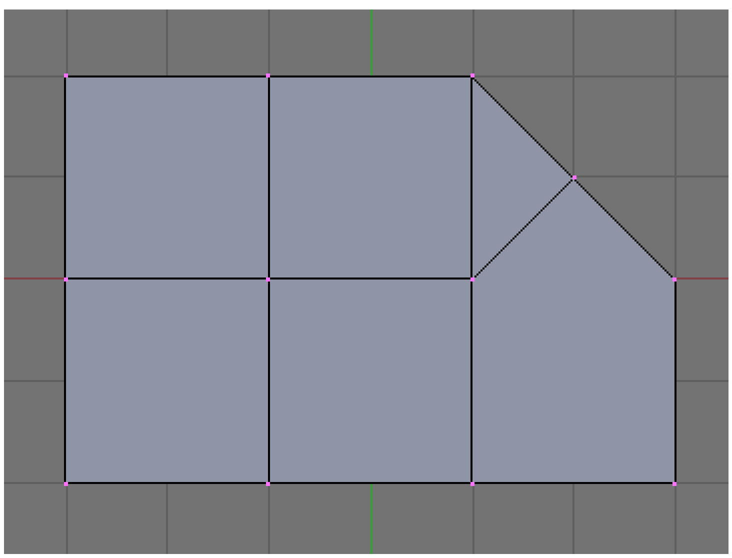
A) A typical example of an LSE light path is the shiny spot we see on silver spoons and forks.

B) A typical example of an LSDE light path is using a round mirror to create shiny spots on the wall. (Put a small mirror facing the sun, and it reflects some of the sun light to the wall, creating a shiny spot)

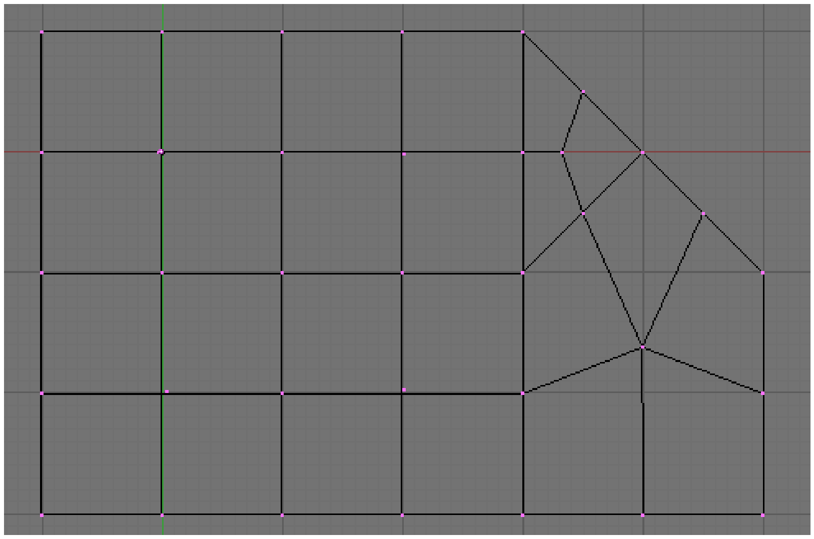
C) A typical example of an LDSE light path is seeing our image in a mirror.

D) A typical example of an LDDSE light path is using a mirror to see an object that is not directly exposed to light. For example, if my face is not directly exposed to light, the light can bounce off the wall, onto my face, into the mirror and finally back to my eye.

Question 2: Catmull Clark Subdivision



At stage 1, we will add a new vertex at the center of each face (6 points will be added in total), and a new vertex at the center of each edge (17 points will be added in total).



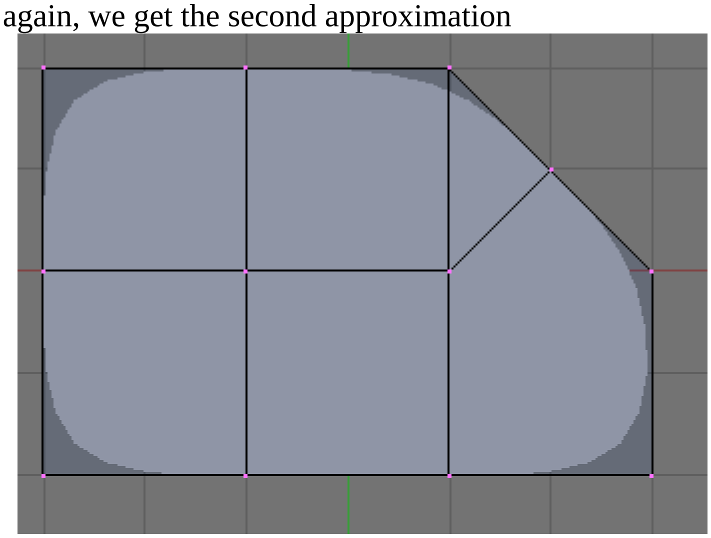
The next level of subdivision is similar – each quad (and everything is a quad) gets broken into 4 new qyads.

In the final diagram, we will have a total of 58 + 23 + 12 = 92 vertices. 42 of them will be extraordinary (40 on the edges, and 2 inside the polygon)

The number of polygons will be 24 * 4 = 96 polygons

Note: we did not ask for the positions of the points, only the topology (connections between the points. This student did show the final result:

Now, we repeat this again, we get the second approximation



Question 3: Butterfly Subdivision

Case 1: Whole cube

Checking the cube, we find that the different points corresponding to the edge going from (0,0,0) to (1, 0, 0) are

a points: (0, 0, 0) and (1, 0, 0)

b points: (½, ½, 0) and (½, 0, ½)

c points: (0, 1, 0), (0, 0, 1), (1, 0, 1), (1, 1, 0)

a points should be multiplied by ½. b points should be multiplied by 1/8, and c points should be multiplied by -1/16.
Doing this we get..
New point = (0,0,0) + (½,0,0) + (1/16,1/16,0) + (1/16,0,1/16) + (0,-1/16,0) + (0,0,-1/16) + (-1/16, 0, -1/16) + (-1/16, -1/16, 0)

New point = (½, -1/16, -1/16)
And this point gets added on the edge from (0,0,0) to (1,0,0) and is connected to both a points and both b points.

Case 2: Top and bottom surfaces removed

Note: As the hint suggested, just because the vertices have 6 points does not mean that are ordinary! They are edge vertices, so we use the edge rule.

Listing out the vertices along the whole edge surrounding the edge to be broken, we see:
(0,0, 1) ---- (0,0,0) ---- (where we'll insert the new vertex) --- (1,0,0) --- (1,0,1)
So we use the edge rule (4 point formula) to give:

-1/16 (0,0, 1) + 9/16 (0,0,0) + 9/16 (1,0,0) + -1/16 (1,0,1)

=

(1/2,0,-1/8)

The following is what you would have gotten if you didn't treat the bottom edge as an edge:

> In this case, each of the vertices incident to this edge have 5 neighbors. Here is a list of vertices and their neighbors
> Vertex 1: Location (0,0,0)
> Neighbors (counter clockwise direction): (1,0,0), (½,½,0), (0,1,0), (0, ½, ½), (0,0,1)
> Vertex 2: Location (1,0,0)
> Neighbors (counter clockwise direction): (0,0,0), (1,0,1), (1, ½, ½), (1,1,0), (½,½, 0)
>
> Now, the weights for the case of a vertex having 5 neighbors are like this Vertex itself gets a weight of ¾.
> Its neighbors get weights of (0.35, 0.154495, -0.404505, -0.40451, 0.1545)
>
> So, we start with the points on the first side, we get The new point is (0.427, -.5297, -0.04775),
> By the clear symmetry, the point calculated for the other side would be (0.573, -0.5297, -0.04775) + (3/4, 0, 0) = (1.323, -0.5297, -0.04775)
>
> So, overall, the new point on that edge will go to the point (0.875, -0.5297, -0.04775)

Question 4: Lighting

For the point (0,0,0)

Diffuse component: normal vector is (0,1,0)
Light vector is (10,10 ,0), normalized this becomes (0.707, 0.707, 0)
So, the diffuse component is (0,1,0) . (0.707, 0.707, 0) = 0.707

Specular component: eye vector is (0, 10, 0), normalized this becomes (0, 1, 0)
Reflected vector is (-10,10,0), normalized this becomes (-0.707,0.707,0)
So, the specular component is $[(0, 1, 0) . (-0.707, 0.707, 0)]^5 = 0.707^5 = 0.17664$

For the point (5,0,0)

Diffuse component: normal vector is (0,1,0)
Light vector is (5,10 ,0), normalized this becomes (0.447, 0.8945, 0)
So, the diffuse component is (0,1,0) . (0.447, 0.8945, 0)= 0.8945

Specular component: eye vector is (-5, 10, 0), normalized this becomes (-0.447, 0.8945, 0)
Reflected vector is (-5, 10, 0), normalized this becomes (-0.447, 0.8945, 0)
So, the specular component is $[(-0.447, 0.8945, 0). (-0.447, 0.8945, 0)]^5 = 1$

For the point (10,0,0)

Diffuse component: normal vector is (0,1,0)
Light vector is (0, 10 ,0), normalized this becomes (0, 1, 0)
So, the diffuse component is (0,1, 0) . (0, 1, 0) = 1

Specular component: eye vector is (-10, 10, 0), normalized this becomes (-0.707, 0.707, 0)
Reflection vector is (0,10, 0), normalized this becomes (0, 1, 0)
So, the specular component is $[(-0.707, 0.707, 0) . (0, 1, 0)]^5 = 0.707^5 = 0.17664$