CS 4620 Homework 2 (v.2): Perspective and Ray Tracing

out: Sunday 7 September 2008
due: Friday 12 September 2008

This homework is on perspective and ray tracing. Note 1(c) and 2(c) are starred problems.

1. Consider a scene in which a unit cube frame is placed on a horizontal plane (Fig. 1, AB $= 1$), and you are looking from some position P. Figures 2(a) and 2(b) are two possible views when you move around. Suppose in both 2(a) and 2(b) the front and back faces are both squares, and the front faces are centered in the view. Given that AB : CD : EF $= 1 : 0.8 : 2$ in 2(a), and AB : CD : EF $= 1 : 0.6 : 1.5$ in 2(b), please compute

   (a) the distance from the eye position P to the plane, for 2(a) and 2(b) respectively;

   (b) the field of view (f.o.v.) of 2(a);

   (c)* the f.o.v. of 2(b).

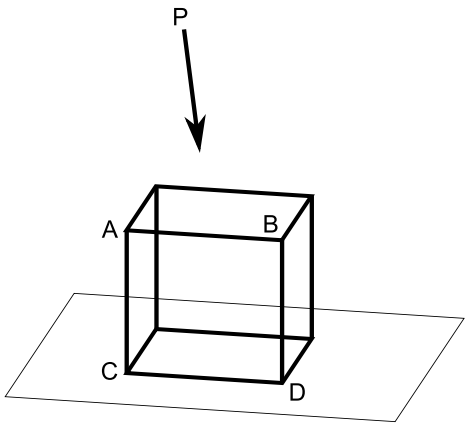
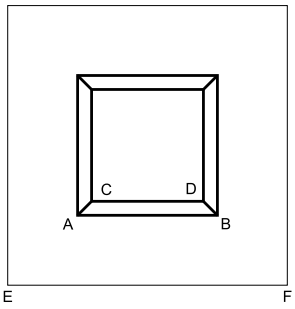
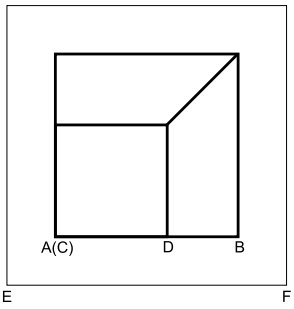


Figure 1: A unit cube frame placed on a horizontal plane.

2. We can often see the sunlight on water at the lakeside or seashore (Fig. 3). To analyze the scene, let's consider a simple model (Fig. 4), in which 4(a) is the description of the model and 4(b) is our field of view. Our model regards the water as a plane W with a lot of waves on the surface, and ignores the fact that the Earth is round. Suppose we are standing on the bank and looking from position E towards the direction V. The viewing direction $\vec{\text{EV}}$ has an angle $\beta = 5^\circ$ with the water. Also suppose our eyes have a maximum vertical view angle $\alpha = 30^\circ$, which means A and B in 4(a) correspond to the top and bottom lines in 4(b). The sun can be regarded as an infinite far away object whose angular size is $\delta = 0.5^\circ$, and the center of the sun is $\gamma = 5^\circ$ above the water. In other words, we can simply think of the sunlight as a beam of light whose angle with the water ranges in $\gamma \pm \frac{\delta}{2}$.



(a) AB : CD : EF $= 1 : 0.8 : 2$. Both the front and back faces are centered in the view.



(b) AB : CD : EF $= 1 : 0.6 : 1.5$. The front face (i.e. the larger square) is centered in the view.

Figure 2: Two possible views while moving around

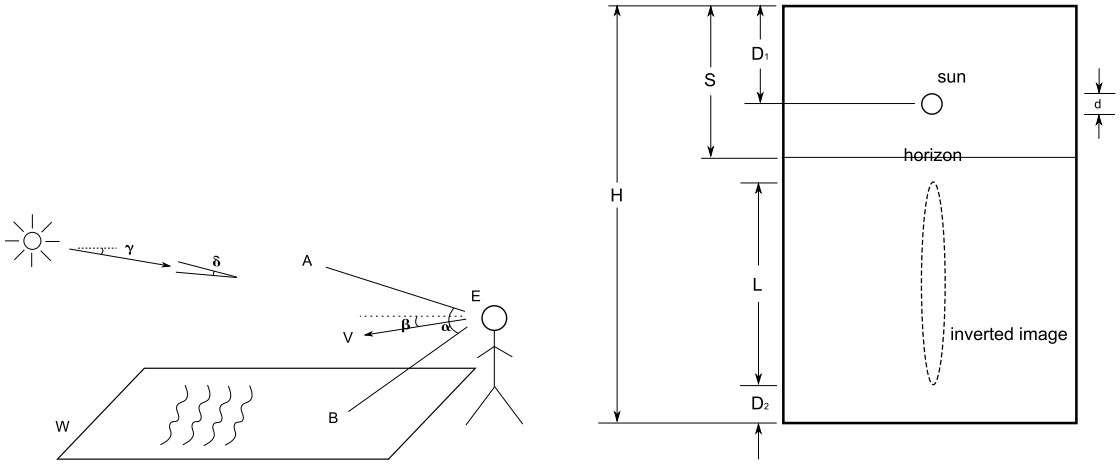
(a) In the field of view (Fig. 4(b)), H is the total height of the view, S is the portion of the view occupied by the sky, D_1 is the distance from the center of the sun to the top, and d is the diameter of the sun. Please compute $\frac{S}{H}$, $\frac{D_1}{H}$ and $\frac{d}{H}$.

(b) What's the shape of the inverted image of the sun if the water surface is perfectly flat?

(c)* Now take the waves into consideration. Suppose the waves have a maximum slope of $4°$. The inverted image will be stretched because larger areas of water surface can reflect the sunlight to us. Let L denote the length of the inverted image, and D_2 is the distance from the bottom of the sun's image to the edge of the view. Please compute $\frac{L}{H}$ and $\frac{D_2}{H}$.

(d) A small sailboat appears in our view from far away. We find the height of the boat looks roughly the same as the diameter of the sun, but its actual height is 16ft. Please approximately compute the distance to the boat. Again, ignore the fact that the Earth is round.

Figure 3: Sun Light on water from http://www.alaska-in-pictures.com



(a) The model (b) Field of view

Figure 4: The model for the scene in figure 3