CS 280, Computer Vision (Prof. Jitendra Malik) March 15, 1999
Lecture #15 (Occlusion and Radiometry/Photometry) **DRAFT** Notes by Jeng Lung

- Occlusion
  - Stereo
  - Motion
- Radiometry and Photometry
  - Events
  - Irradiance
  - Radiance
  - Reflectance BRDF

# 1 Occlusion

In the previous lecture, we talked about cues to identify occlusion. The cues include texture, junction, stereo, and motion. Today we will look at identifying occlusion with stereo and motion.

## 1.1 Stereo

From the last lecture, we saw that some points does not have correspondence between the left eye's image plane and the right eye's image plane. We called this **half occlusion** and it is best demonstrated with the DaVinci Stereopsis model.

In the case where the length of the wall in front is greater than the interocular distance between the left and right eyes, objects behind the wall can not been seen as shown in Figure 1.

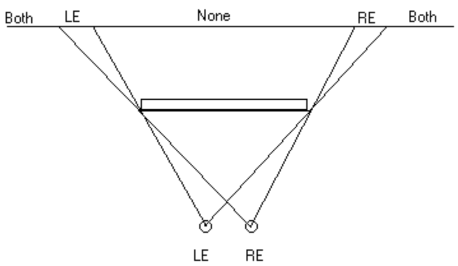


Figure 1: Length of the wall is longer than interocular distance

In the case where the length of the wall in front is less than the interocular distance, however, objects behind the wall can be seen as shown in Figure 2.

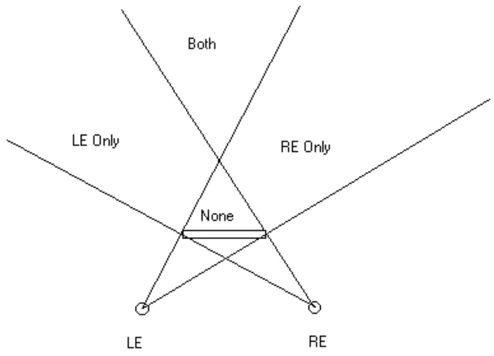


Figure 2: Length of the wall is shorter than interocular distance

### 1.2 Motion

When you have images from time t and time t+1, there are points that are visible at time t but disappear at time t+1, known as **accretion/deletion of texture**. There are also points that are not visible at time t but visible at time t+1, known as **occlusion/disocclusion**. These regions occurs when you have occluding surfaces along with motion as shown in Figure 3.

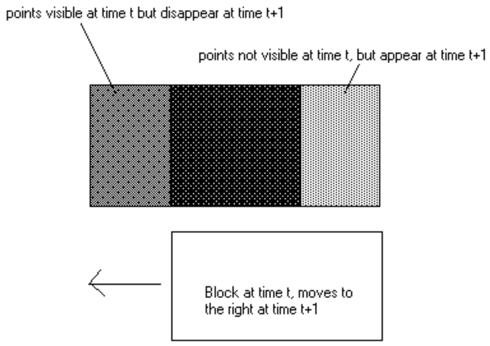


Figure 3: Occlusion from motion

## 2 Radiometry and Photometry

So far we have been studying the statics and kinematics of projection where we were concerned about coordinates and directions. We asked question like, "where are the points imaged?" Now with radiometry and photometry we ask questions such as, "what is the brightness and intensity of points imaged?" Radiometry deals with light of all wavelengths while photometry deals only with visible lights.

## 2.1 Events

Events in photometry include **self shadow/attached shadow** and **cast shadow**, as illustrated in Figure 4. Note that the shadow is not completely dark since light bounces and causes **mutual illumination**. For example, the sun is a primary light source and all secondary light sources are surfaces on which the sun's ray bounces off of. Also, the more alignment between the light ray and the surface normal, the brighter the patch.

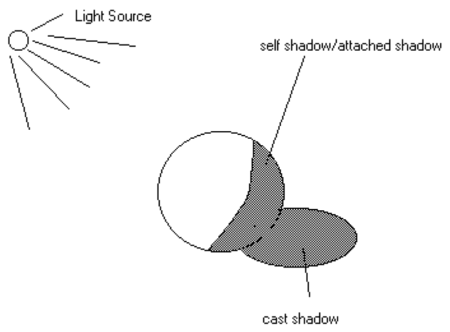


Figure 4: self shadow/attached shadow and cast shadow

## 2.2 Irradiance

We measure the irradiance using pixel values on the image. The pixel values represent the energy received in that area in a given amount of time. These values are proportional to power per unit area (W/$m^2$). The image brightness can be thought of as a intensity function at all the points on the image plane I(x, y).

## 2.3 Radiance

Unlike irradiance, radiance is a directional concept and it is measured as power per unit area per unit solid angle. In a 2-D circle, the solid angle $\theta_s$ is merely the arclength over the radius s/r as shown in Figure 5. For a 2-D square, the solid angle would be $\theta_s$ = scos$\theta$/r. In 2-D, the maximum value that the solid angle can be is $2\pi$.

For a 3-D sphere, the solid angle subtended at the center of sphere is equal to Acos$\theta/r^2$, where A is the area. In 3-D, the maximum value that the solid angle can be is $4\pi$. In the example shown in Figure 6, the area of the element is $r^2$sin($\theta$)d$\theta$d$\phi$ so the solid angle would be sin($\theta$)d$\theta$d$\phi$.

The solid angle subtended by the northern hemisphere in this case would be

$$\int_0^{\pi/2}\int_0^{2\pi} sin\theta\, d\theta\, d\phi = 2\pi \int_0^{\pi/2} sin\theta\, d\theta = 2\pi$$

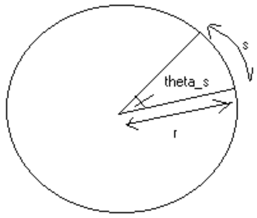


Figure 5: Solid angle of a circle

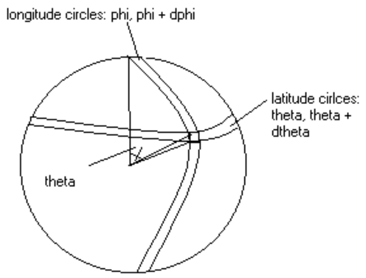


Figure 6: Solid angle of a sphere

In Figure 7, the power transferred from x to y would be:

$$L(x, \theta_x, \phi_x)\, dx cos\theta_x(\theta_s)$$

$$= L(x, \theta_x, \phi_x)\, dx\, dy \frac{cos\theta_x cos\theta_y}{r^2}$$

where $\theta_x$ is the angle between the normal of dx and the ray and $\theta_y$ is the angle between the normal of dy and the ray. $\theta_s$ is the solid angle subtended by dy at x.

The power received by y from x would be:

$$L(y, \theta_y, \phi_y)\, dy cos\theta_y(\theta'_s)$$

$$= L(x, \theta_y, \phi_y)\, dx\, dy \frac{cos\theta_x cos\theta_y}{r^2}$$

where $\theta'_s$ is the solid angle subtended by x as seen from y.

Hence, L(x, $\theta_x$, $\phi_x$) = L(y, $\theta_y$, $\phi_y$) and this equation states that the radiance is conserved along a ray (but this is only true in vacuum where there is no absorption).

Inverse Square Law results from the fact that the radiance remains the same with distance along the ray but the solid angle changes by a factor of $1/r^2$.

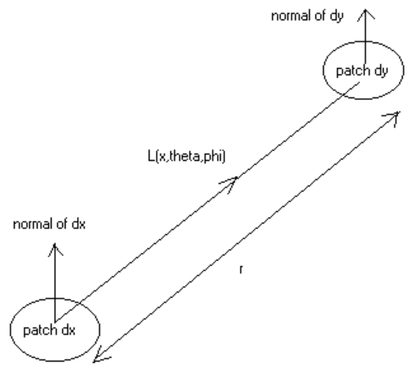


Figure 7: Power transfer between patch dx and patch dy

## 2.4 Reflectance BRDF

To be continued in the next lecture ...