More Ray Tracing, Radiosity

CS116B
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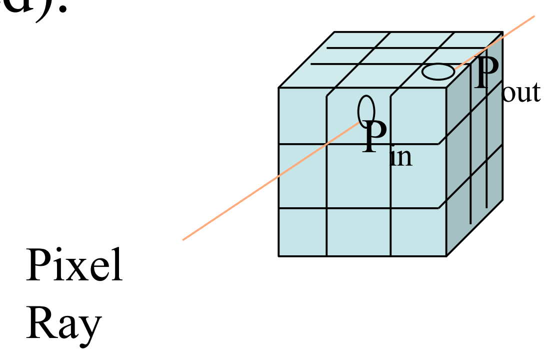
Outline

- Space Subdivision
- Camera simulation
- Anti-aliased Ray-tracing
- Radiosity

Space Subdivision Method

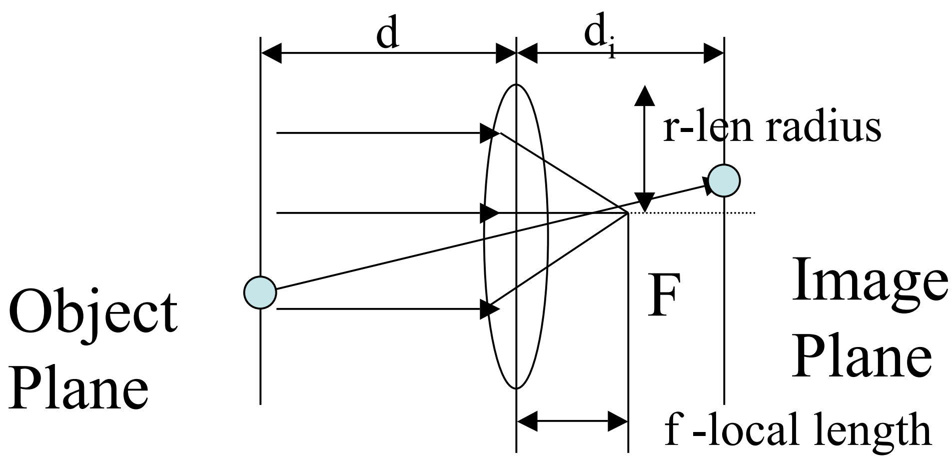
- In this method, the entire scene is enclosed within a cube and this cube is divided into smaller cubes.This may be done *uniformly* (all cells same size) or *adaptively* (only non-empty cell divided).



- One can determine the cell a ray enters and the one it leaves.
- From this one can figure out which cells it passes through.
- One keeps a pre-computed list of which surfaces live on each cell.
- Now one only does intersection only with the surfaces lying in cells on the path of the ray.

Simulating Camera Focusing effect

- To model a convex camera lens, we need to specify a focal length f and a lens radius r. We assume that the lens is to be positioned in front of the projection plane.

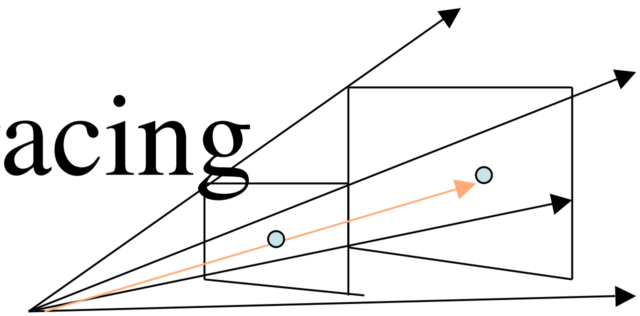


- The camera apertures can be described with f -stops numbers n=f/2r.
- The thin lens equation from optics gives: 1/d + 1/d_i = 1/f. This equation is used to determine what light focuses at a point on the image plane.

More on Camera Focusing

- To make a point at distance d from the lens be in focus we position the image plane at the position d_i.
- Points at a distance d’ >d, will be in focus at a position in front of the image plane; and points at a distance d’< d will be in focus behind the image plane.
- On the image plane itself these points will project to a small circle called the *circle of confusion* with radius given by $2r_c = |d' - d| * f / n * d$.
- We can choose the camera parameters to minimize this circle if we want a deeper field of view.

Anti-aliased Ray-tracing



- What corresponds to a single pixel at the front of the view frustrum corresponds to a larger region on the the back of the frustrum.
- One way to slightly compensate for this is to supersample each view plane pixel. i.e., divide it into subpixels and ray-trace corners of those subpixels.
- If an adaptive technique is used, then we might further split into sub-subpixels those sub-pixels whose four-corners are sufficient different.

Distributed Ray Tracing

- Another technique to get a more accurate intensity value of a pixel, is to subdivide the pixel into sub-pixels as before, but now we add a random jitter noise to each ray we shoot out.
- This is the basic idea of distributed ray tracing.

Radiosity

- Our basic lighting model is relatively weak at modeling radiant energy transfer in a scene.
- The **radiosity model** can be used to get a more realistic approximation.
- Remember from physics, we have that the radiant energy of a photon is given by E_{photon}=hf, where f is frequency of the photon and h is Planck's constant 6.62 x 10^{-34} J.s.
- Summing over all photons and frequencies gives a total radiant energy E.
- The change in this with respect to time is called the **radiant power** or **flux**. $\Phi = dE/dt$.
- The radiant flux per unit surface area (the **radiosity**) is given by $B= d\Phi/dA$.
- Finally, the intensity I is the radiant flux in a given direction.

The Basic Radiosity Model

- Imagine we split the scene into surface area patches $P_1, \ldots, P_k$ with corresponding radiosities B_i.
- Our goal is to find the average brightness of each patch.
- The radiosity equation says $B_i = E_i + R_i B^{in}_i$.
- Here B^{in}_i is the light shining on P_i. This is equal to $\sum_j F_{i,j} B_j$ where $F_{i,j}$ is called the **form factor**.
- E_i and R_i are respectively the emissivity and reflectivity of the patch.
- Given the E_i, R_i, and $F_{i,j.}$ we want to solve the linear equations for the B_i's.
- Let $\mathbf{M} = R_i F_{i,j}$. Then $\mathbf{B} = \mathbf{E}(\mathbf{I}-\mathbf{M})^{-1}$.
- We will discuss ways to avoid having to calculate the inverse of **I-M** next day.

More on Form Factors

- Form factors satisfy a number of useful properties:
  - $\sum_i F_{ij}=1$ for all j (Conservation of energy)
  - $A_i F_{ij}= A_j F_{ji}$ (uniform light reflection)
  - $F_{ii} = 0$ (only plane patches)
- Next day, we will also describe how to calculate form factors.