Radiosity

Last lecture

- Radiosity equation
- Form factors
- Solution methods

Today

Two major problems

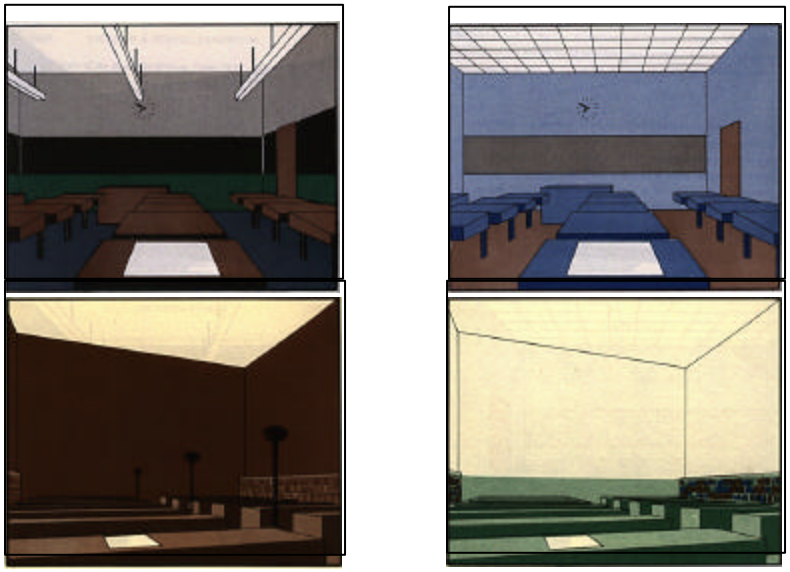
- Quality of approximation

  Meshing given shadows

- Compulational expense

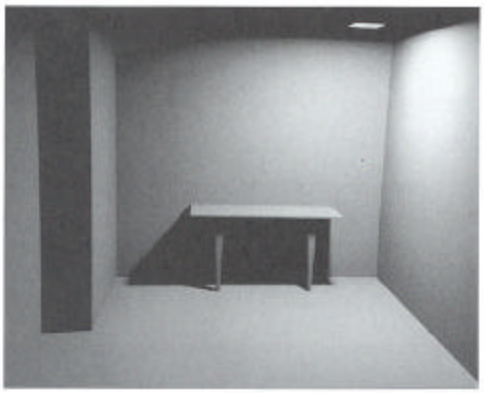
  Quadratic to linear time using hierarchical techniques

First Radiosity Pictures ...



Parry Moon and Domina Spencer (MIT), Lighting Design, 1948

Accuracy

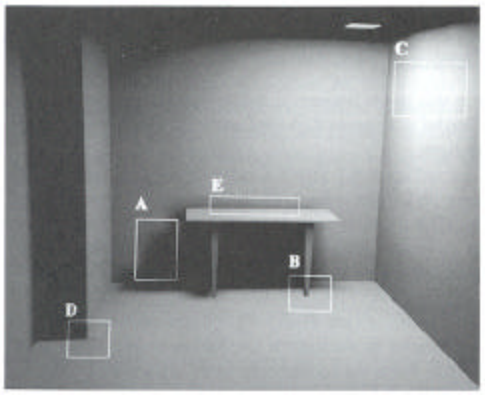


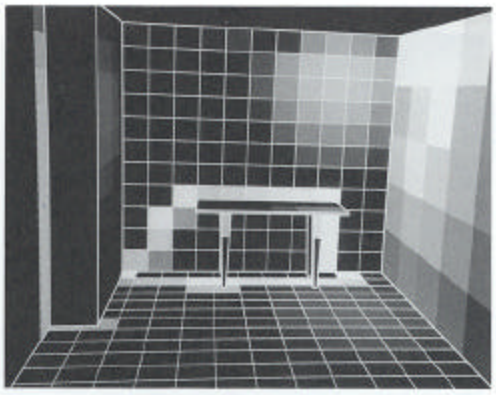
Reference Solution

Uniform Mesh

Table in room sequence from Cohen and Wallace

Artifacts





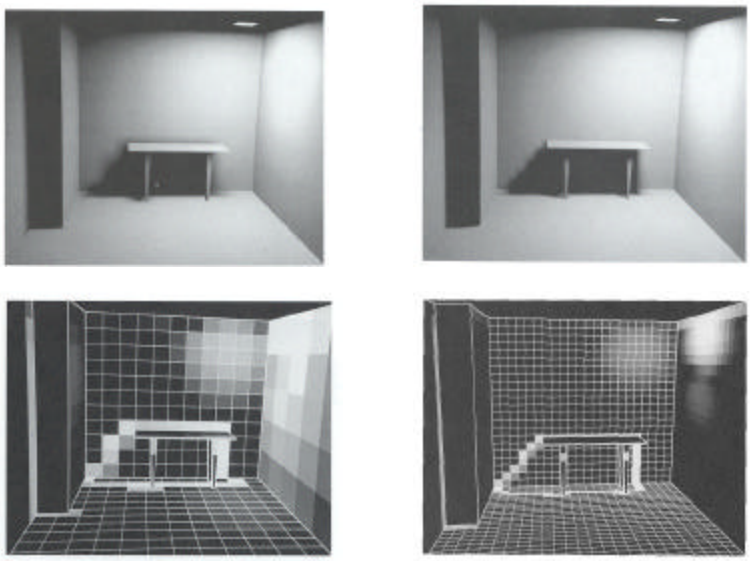
A. Blocky shadows
B. Missing features
C. Mach bands
D. Inappropriate shading discontinuities
E. Unresolved discontinuities

Error Image

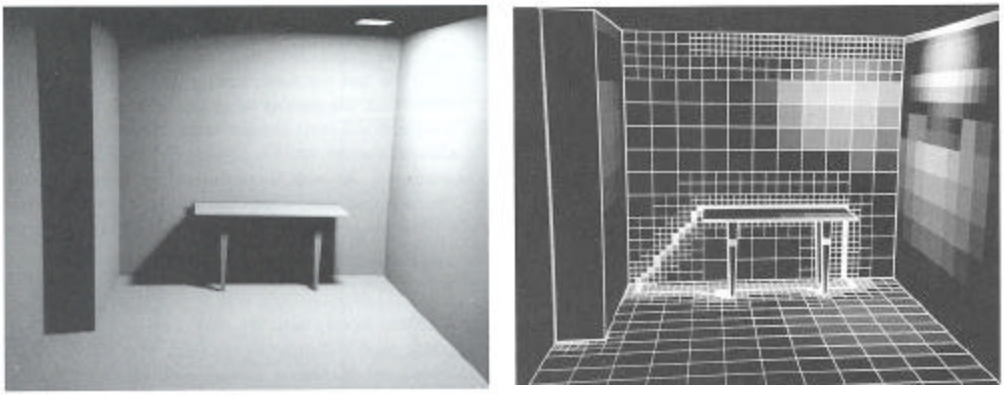
Meshing Options

- Element type
  - Regular or structured: quadrilaterals
  - Irregular or unstructured: triangles
- Element size
  - Resolution: ***h***
- Element order and continuity
  - Polynomial order: ***p***
  - Degree of continuity across elements
- Element goodness
  - Shape, e.g. aspect ratio
  - Placement, e.g. grading

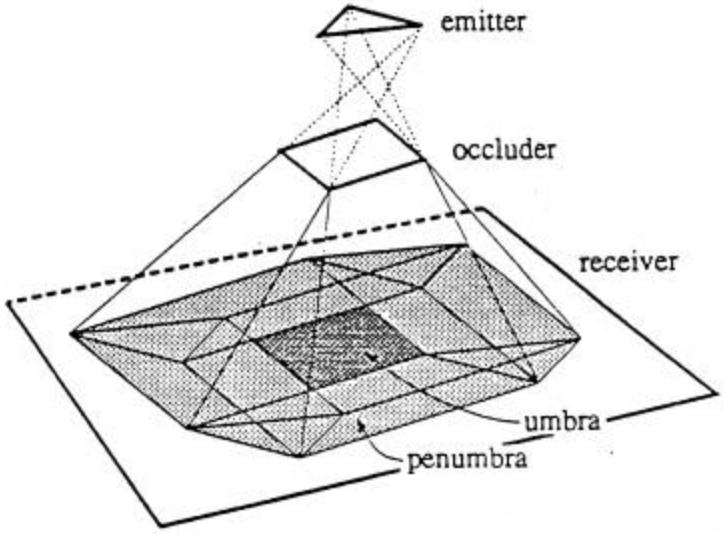
Increasing Resolution



Adaptive Meshing



Penumbras and Umbras

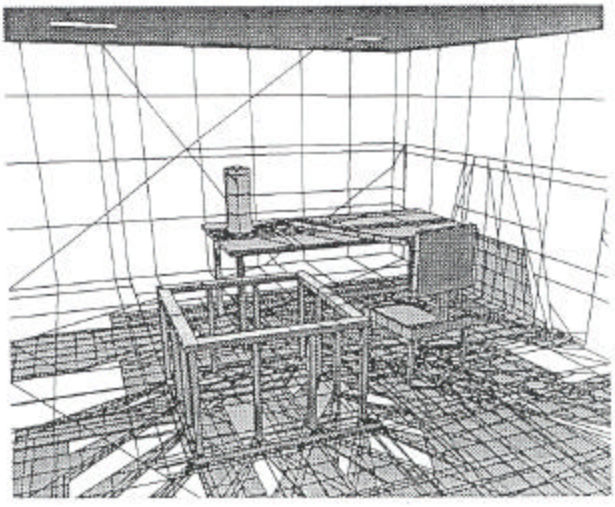


Irradiance Discontinuities

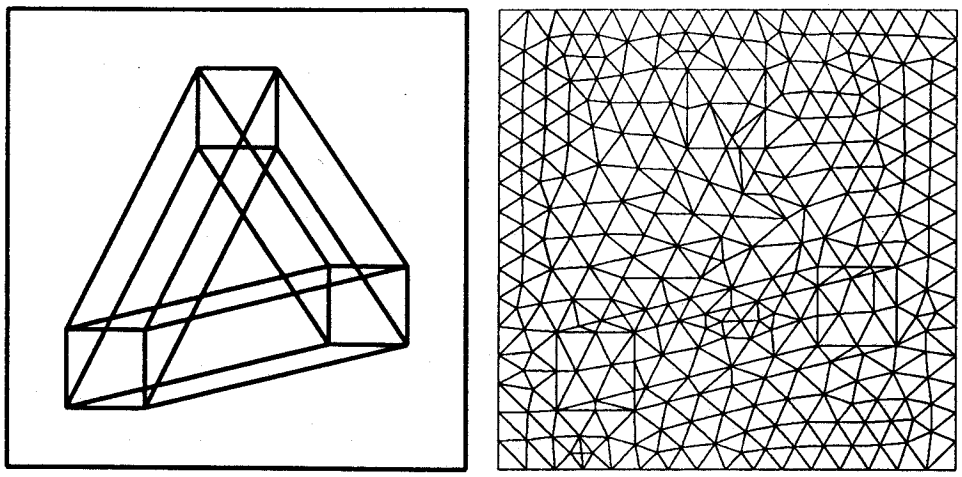
Lischinski, Tampieri, Greenberg

- Figure 4: D0 discontinuity
- Figure 5: D1 discontinuity
- Figure 6: D2 discontinuity

Campbell et al. BSP Mesh



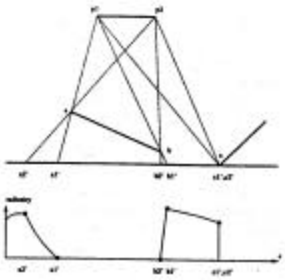
Heckbert Constrained DT Mesh



Critical edges

h- vs. p-refinement

Subdivide element vs. raise degree?

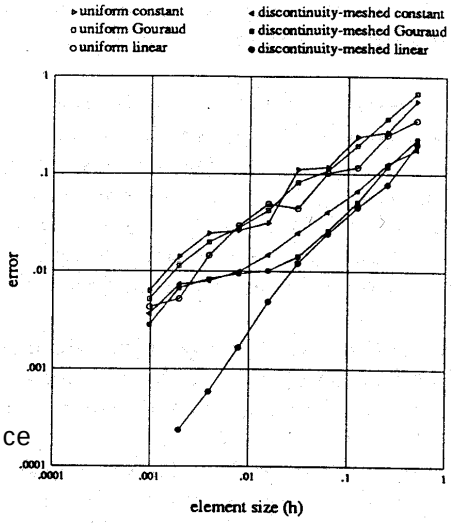


Continuous, smooth functions

- Raise degree $O(h^p)$ convergence

Discontinuous functions

- Subdivide at discontinuity



From Heckbert

Hierarchical Techniques

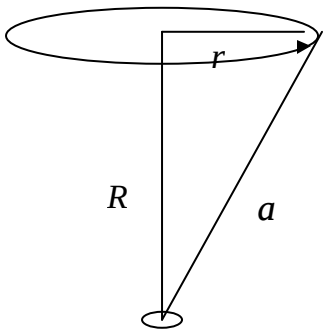
Problem: Form factor matrix has O(n2) entries

Basic approach:

1. Numerical calculations subject to error.
   Only compute things to the required precision.
2. Small, far-away elements can be replaced by larger elements
3. These observations lead to a linear time algorithm

Motivated by solutions to the N-body problem

Disk Form Factor



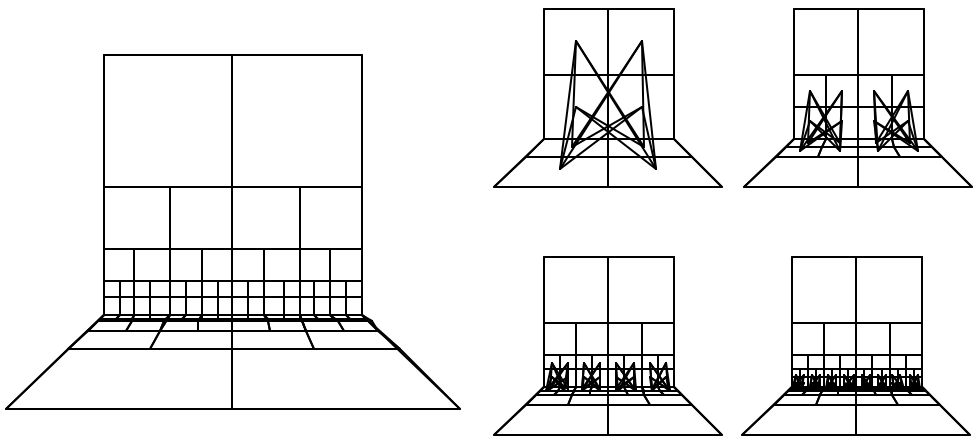
$$F_{disk} = \sin^2 a$$
$$= \frac{r^2}{r^2 + R^2}$$
$$= \left(\frac{r}{R}\right)^2 \left(1 - \left(\frac{r}{R}\right)^2 + \left(\frac{r}{R}\right)^4 - \cdots\right)$$

The five-times rule: A finite area Lambertian reflector may be modeled as a point light source when the distance to the receiving surface is five times greater than the size of the light source

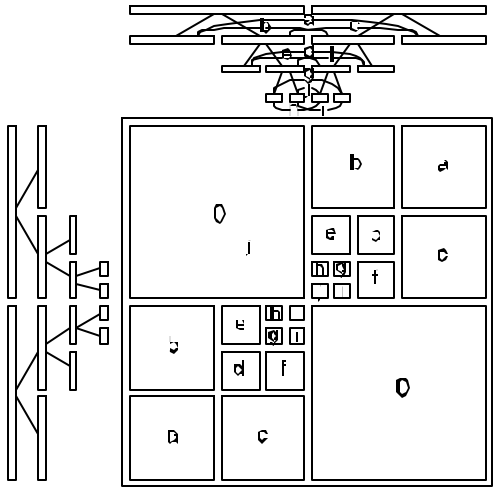
Basic Refinement Algorithm

```
Refine(Patch *p, Patch *q, float Feps, float Aeps)
{
    float Fpq = FormFactorEstimate(p,q);
    float Fqp = FormFactorEstimate(q,p);
    if( Fpq < Feps && Fqp < Feps ) Link(p,q)
    else {
        if( Fpq > Fqp ) {
            if( Subdiv( q, Aeps ) ) {
                  Refine( p, q->ne, Feps, Aeps );
                  Refine( p, q->se, Feps, Aeps );
                  Refine( p, q->nw, Feps, Aeps );
                  Refine( p, q->sw, Feps, Aeps );
            }
             else Link( p, q );
        }
        else …
    }
}
```

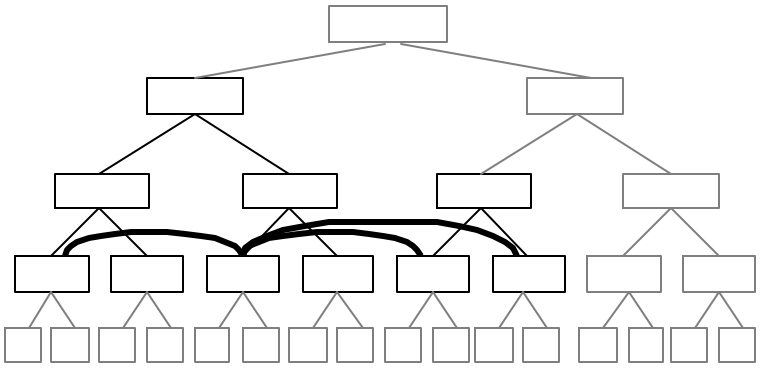

Example: Two Perpendicular Polygons



Blocking Form Factor Matrix



O(n) Interactions



Recursive Gather

```
Gather(Patch *p)
{
    Patch *q; float Fpq;

    if( p ) {
        p->Bg = 0;
        ForAllElements( q, p->interactions ) {
           Fpq = FormFactor( p, q );
           p->Bg += Fpq * p->Cd * q->B;
        }
        Refine( p->ne );
        Refine( p->se );
        Refine( p->nw );
        Refine( p->sw );
    }
}
```


Results

A Rapid Hierarchical Radiosity Algorithm

Figures 7

Figures 8

Figures 9

Figures 10