SURFACE SHADING METHODS
(Section 14-3 in *Computer Graphics*)

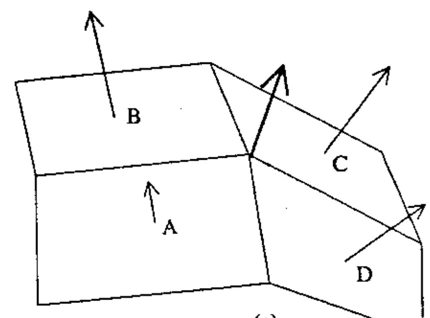
- Contrast Intensity
- Gouraud Shading
- Phong Shading
- Ray-tracing Algorithms
- Radiosity
- Octree Methods
- Fractal Surface
- Antialiasing Surface Boundaries

Constant Intensity

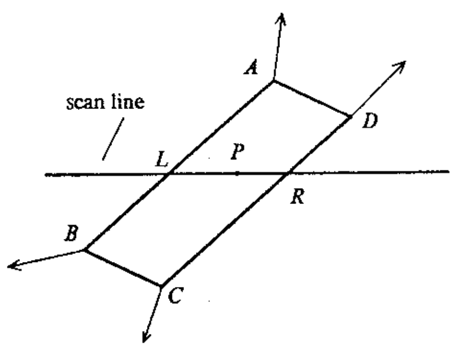
- in some cases, constant surface intensities produce realistic shading
  - ambient light, no surface patterns, texture or shadows
  - point source light and a view reference point far from the surface
  - sufficiently small planar polygons approximating a curved surface, especially with
    - gradual changes in surface curvature and
    - distant light sources and view reference point
      - see figure 14-24 on page 290

Gouraud Shading

- linearly vary the intensity over each plane so that intensity values match at the plane boundaries
  - discontinuities between adjacent planes disappear
- technique
  - determine a normal for each surface
  - determine a normal for each vertex from the normals of the surfaces meeting at that vertex
  - calculate an intensity (monochrome or color) at the vertex, based on the normal
  - interpolate intensities along each edge
  - interpolate intensities across each surface (see figure 14-27 on page 291)



(a)

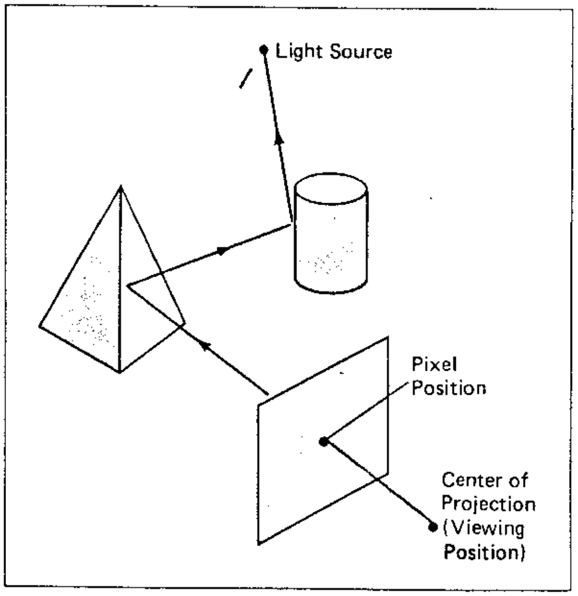


Phong Shading

- Gouraud shading introduces Mach bands which Phong shading overcomes
- technique
  - similar to Gouraud shading, except that normals rather than intensities are interpolated
  - intensities are calculated at each point along each scan line

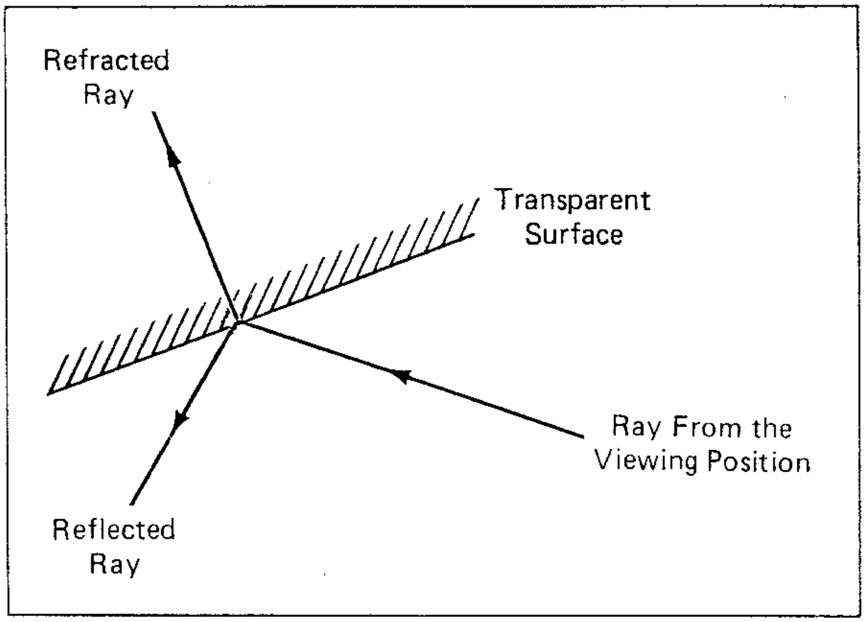
Ray-tracing Algorithms

- an infinite number of intensity points could be generated over the surfaces of a scene
- ray tracing determines specular intensities at visible surface positions by tracing rays backwards from the viewing position to the light source(s)
- technique
  - start from the viewing position
  - pass a ray through each pixel in the view plane
  - attempt to trace each ray to a surface in the three-dimensional scene
  - reflect the ray from this surface as long as it encounters surfaces and until it encounters a point light source or exits the scene



Ray-tracing Algorithms, continued

- at transparent surfaces, divide the ray into two components



- after the ray has been processed, set the intensity of the pixel

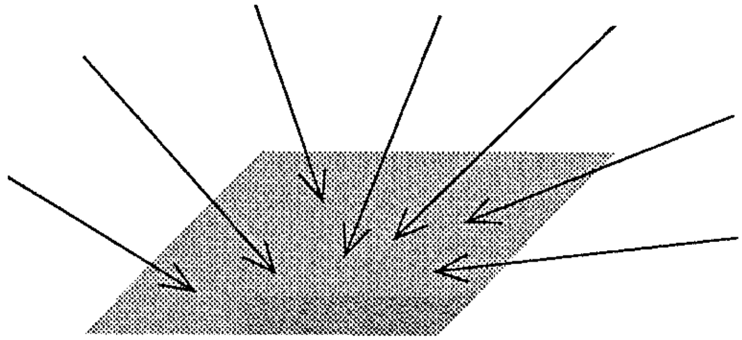
Radiosity

- calculation of diffuse interreflection
  - surfaces are discretized into patches of roughly uniform size
  - energy exchange between patches is computed in a view-independent manner
- relationship between the radiosity of one patch and all other patches in the environment

$$B_i A_i = E_i A_i + \rho_i \sum_{j=1}^{n} B_j F_{ji} A_j$$

where
B_i = radiosity of patch i (energy/unit area/unit time),
E_i = emission of patch i (energy/unit area/unit time),
A_i = area of patch i, A_j = area of patch j,
F_{ji} = form-factor from j to i (fraction of energy leaving patch j which arrives at patch i),
ρ_i = reflectivity of patch i, and
n = number of discrete patches.

Radiosity, continued



- computing the form-factors requires determining the patches visible to each patch over the entire hemisphere of directions above the patch
- $\leq n^2$ form factors

● extendable to specular interreflection

- add bidirectional refectance
- use approximately pixel-size patches
- approaches computational intractability

Octree Methods

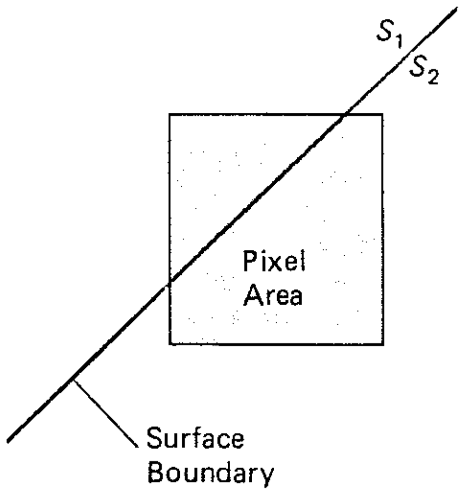
- each octant contains information about the "material" at the position, but nothing about surface orientation
- examine the region around each octant
  - some void neighboring regions mean the octant is part of a surface
  - the surface normal is related to the positions of the void regions
- use a transmission coefficient to superimpose intensities for transparent octants in front of background octants

Fractal Surfaces

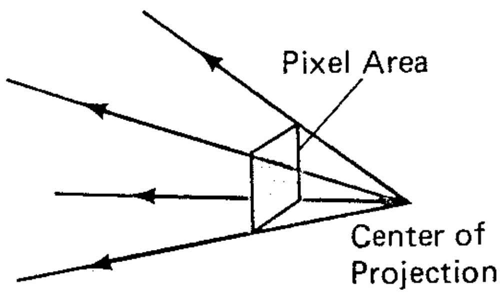
- represent fractal surfaces as several small planes, determining a surface normal for each plane
- unfortunately, fractal surfaces can contain infinite detail at each surface point
  - approximate normals can be calculated using coordinate differences between neighboring points

Antialiasing Surface Boundaries

- antialiasing smooths edges by adjusting pixel positions or pixel intensities
- boundaries between surfaces can be smoothed using similar techniques
  - combine intensities from all overlapping surfaces according to percentage overlap



- in the case of ray tracing, project rays through pixel corners rather than pixel centers, averaging the four intensities



  - subdivide areas containing substantial detail

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