Radiosity

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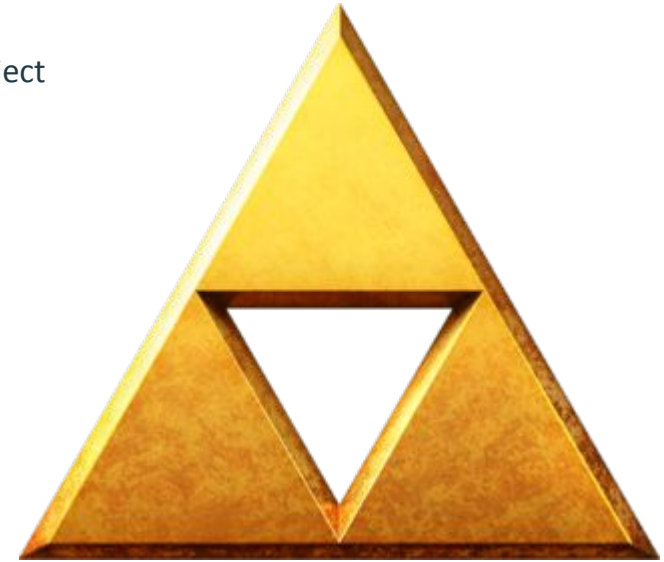
What is Radiosity?

- Global Illumination using only diffuse and ambient lighting
- Break up scene into patches, and tessellate patches to some desired size/level
- Shoot light from light sources to patches once, and patches to each other visible patch n number of times
- Done until a steady state is reached

Implementation Specifics

Patch tessellation

- We use triangles for ease of use with object files
- Use Tri-force style tessellation to tessellate the faces of each object



Form Factor Calculations

- Once triangles are tessellated, precompute the patch form factors
- Form factors are essentially a value that expresses how much light can transmit from one patch to another
- Worst case if every patch is visible to each other patch, N^2 matrix
- Attempted to mitigate by only storing triangles visible to patch
- Culled form factors < .00001
- Between patches i and j: F_{ij} = cos(angle between patch i normal and distance vector) cos(angle between patch j normal and distance $vector_j$) / (π distance $vector^2$)

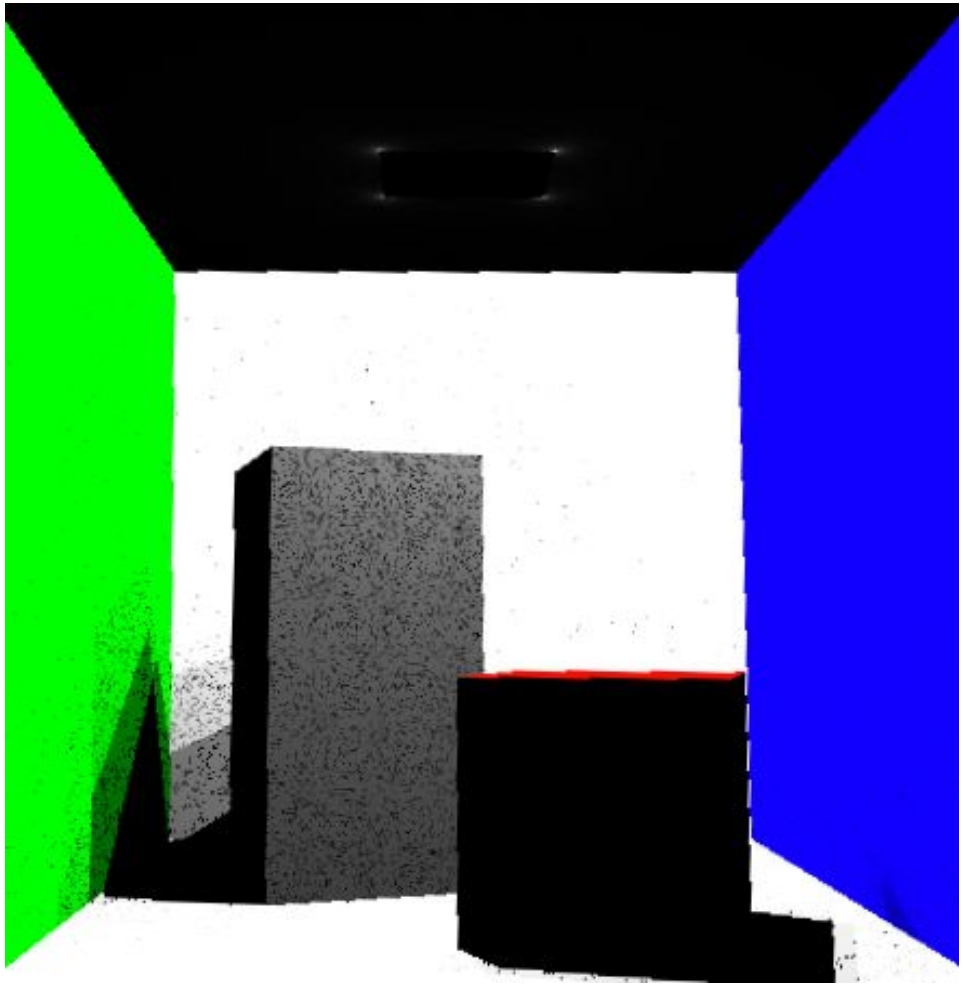
Detecting Visible Triangles

- Shoot ray from centroid of each triangle, to centroids of each other triangle
- This resulted in our preprocessing being N^3
- Reduced to $N^2\log(N)$ by using BVH while shooting rays
    - BVH partitions triangles into 2 equal groups, cutting longest dimension by half
- For direct illumination, we calculate a visibility factor by dividing triangle into Tri-force configuration, and sampling the 4 centroids
    - Visbility factor = number of visible points / 4
    - Results in softer shadows

Calculating Per Patch Lighting

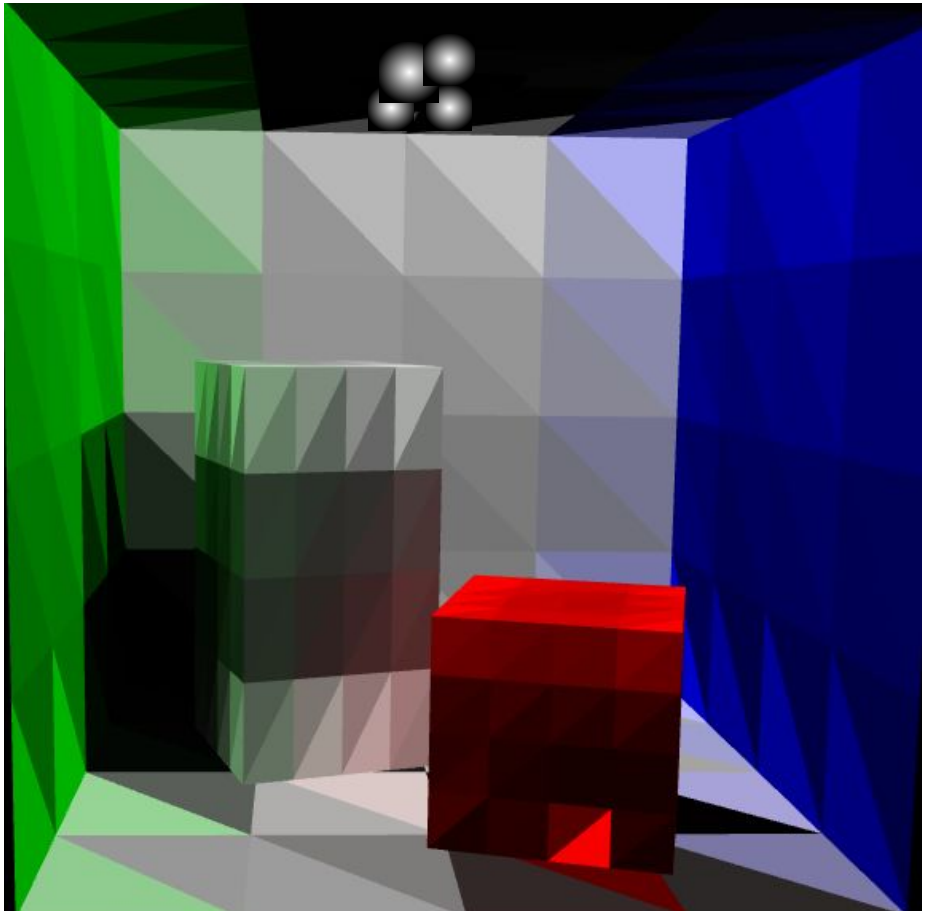
- A patch keeps a residual light B_i and an accumulated light L_i
- Direct illumination = light intensity * distance attenuation * visibility factor
  - Distance attenuation = $1 / (1.5 + 1.5\ d + 1.5d^2)$
- Each patch now has an amount of light to emit, or B_i for patch i, where B_i = direct illumination * d_i
- Now shooter patch shoots light to all other visible patches, where residual light and accumulated light are incremented by d * form factor * B_i, and residual light of the shooter becomes 0
- Accumulated light becomes the diffuse color of the patch

Results/Observations

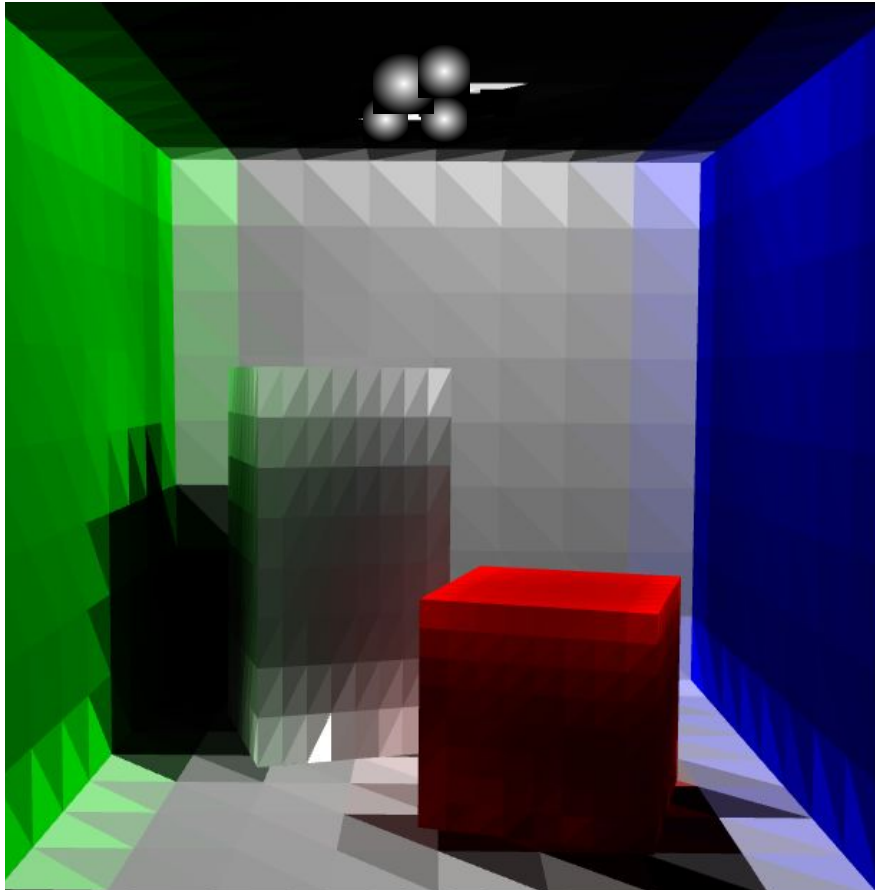


Ray Tracer Cornell Box

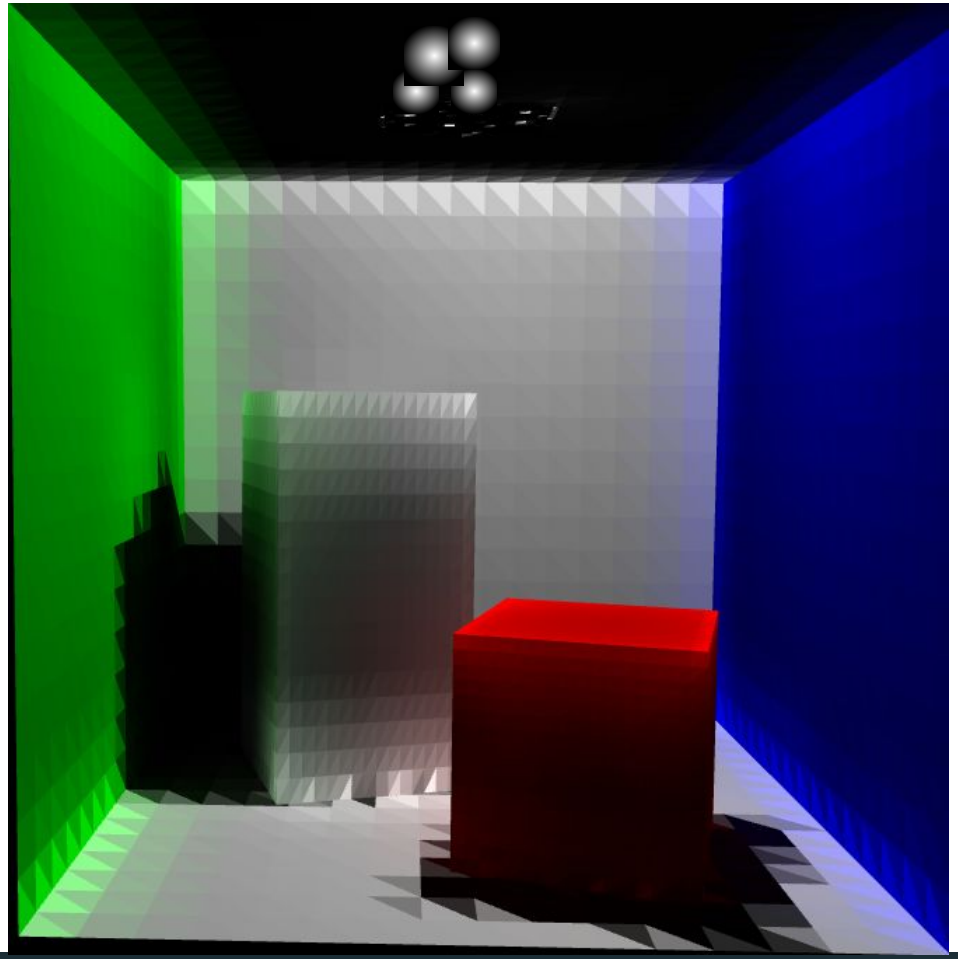
Level 1 Tessellation, .00005 form factor culling,
1 second runtime locally, 576 faces



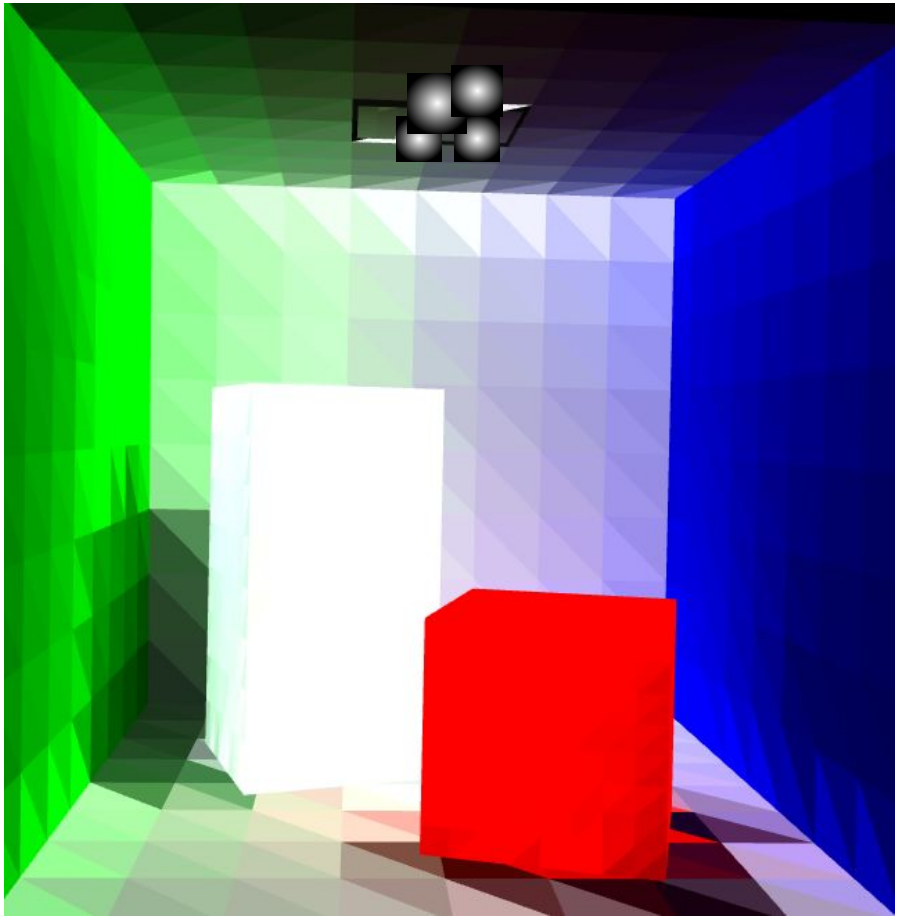
Level 2 Tessellation, .00005 form factor culling,
2 minute runtime locally, 2300 faces



Level 3 Tessellation Radiosity, .00005 form factor culling, 2.5 hr runtime locally,



Tessellation Level 2, form factor .000005,
1 hour



Level 3 Tessellation Radiosity, .00005 form factor culling, 3.5 hr runtime on GCP 16 core machine, 8500 faces