CS4803DGC Design and Programming of Game Consoles

Spring 2011
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Ray Tracing Problem

- What is it?
  - Simulate light rays from light source to eye
“Forward” Ray Tracing

- Trace rays from light
- Lots of work for little return
“Backward” Ray-Tracing

- Trace rays from eye instead
- Do work where it matters

*This is what most people mean by “ray tracing”.*
Rendering in Computer Graphics

Rasterization:
Projection geometry forward

Ray Tracing:
Project image samples backwards
Ray-Tracing Algorithm 101

1) Construct ray from camera through pixel

2) Find first primitive hit by ray

3) Determine color at intersection point
   - Simple diffuse shading,

4) Draw color
Primary vs. Secondary Rays

Blue: reflected rays
Green: refracted rays
Red: light source (useful for occlusion, shadow)
Triangle Intersection

- Want to know: at what point \( p \) does ray intersect triangle?
- Compute lighting, reflected rays, shadowing from that point
Shadow Test

- Check against other objects to see if point is shadowed

www.plunk.org/COEN-290/Notes/Week8.ppt
Lab #3: Improving Ray Tracing

• http://cg.alexandra.dk/2009/08/10/triers-cuda-ray-tracing-tutorial/
Display with CUDA

• CUDA + openGL
• “postProcessGL” SDK example shows a good example
• Simply,
  – Create a PBO (Pixel buffer object) using openGL
  – Render the scene to the framebuffer
  – Copy the image to a PBO
  – Map PBO so that it’s accessible from CUDA
  – CUDA process data
  – Copy PBO to a texture
  – Display the texture.
Examples of Aliasing

- Aliasing occurs because of sampling and reconstruction

Source: groups.csail.mit.edu/graphics/classes/6.837/F04/lectures/13_aliasing.ppt
Anti-Aliasing

- Aliased rendering: color sample at pixel center is the color of the whole pixel
- Anti-aliasing accounts for the contribution of all the primitives that intersect the pixel

Triangle Geometry  Aliased  Anti-Aliased
Assignments

A group project: 2 people
Provide an example code of ray tracing
(1) implement one anti-aliasing algorithm and compare the results
- supersampling
(2) To-be-announced
• Load images into Texture memory
  – Stores edges instead of vertex points to save some calculations

• OpenGL setup
• PBO (Pixel buffer object)
• I/O (setting up camera position, light source etc.)
  – AntTweakBar library provides the APIs
• RayTraceImage: interface with C
  – blocksize (8,8,1)

• raytrace
  – Each thread (different image pixel)
  – Calculate ray (origin, direction)
  – Ray sphere intersection, (search the nearest hit point) : traverse all triangle
  – Continue the light (depth level 4) until the light is out of the screen
  – Calculate simple diffuse and secular light
  – Shadow light
    • Create a shadow ray
    • Check whether there is a blocker on the path or not, it is then make it darker

• HitRocord contains color and normal vector and store out_data (PBO pointer)
Anti-aliasing with Super Sampling

- More than one array per pixel
- Average the results

- Adaptive sampling (increase the resolution based on the color differences)
- Stochastic sampling: Instead of regular grid, random subgrid

Suggesting Anti-aliasing Implementation

• Create more rays
  – How? (naïve super sampling, adaptive, stochastic )
  – Recalculate $x_f$, $y_f$
  – Repeat all the computation
  – Average the values before out_data
**Performance Issues**

- Ray tracing pipeline
- Ray generation → Intersection → closest hit shade
- Traverse requires finding closest primitives
- Source of performance degradations
- Optimizations:
  - Better data structures, (KD-tree, BVH (Bounding Volume Hierarchy Data Structure))
  - Monte Carlo simulations
- Branch...