Computer Graphics

Lecture 4: Raytracing

Kartic Subr
Albrecht Dürer, 1525
Johannes Vermeer
17th Century
Vermeer’s comparator mirror

https://youtu.be/deAK0oV6Vt8
Ray casting

Ray Casting

Virtual Viewpoint

Virtual Screen

Objects

for each pixel p
cast ray r through p into the scene
test if r intersects objects in the scene
if yes
  find closest intersection point h
  shade h
else
  return background colour (black)
endif
Ray intersection

intersection point?
Ray – plane intersection
Computation: test many objects

hit!

missed
Acceleration data structures

- grids
  - uniform
  - adaptive e.g. octree

- bounding box
  - simple
  - concave objects?

- arbitrary bounding volume
  - ‘tight’ but more tests
  - concave objects?
Acceleration: bounding volume hierarchy
Acceleration: bounding volume hierarchy
Acceleration: bounding volume hierarchy

test ray at highest level
- recurse based on intersection result

Interested readers: slides
NVIDIA OptiX™ Ray Tracing Engine

A software development kit for achieving high performance ray tracing on the GPU.
Ray intersection - GPU

- Reduce computation time by executing parallel tests

- Reduce number of tests via acceleration structures
  - trade off: building data structures and book-keeping
  - exploring data structures may not be easy or efficient
Shading

ambient light (constant) +
diffuse +
specular reflection of light
Phong shading

\[ I_p = k_a i_a + \sum_{m \in \text{lights}} (k_d (\hat{L}_m \cdot \hat{N}) i_{m,d} + k_s (\hat{R}_m \cdot \hat{V})^\alpha i_{m,s}) \]

- **Material property**: \( k_a \) (ambient)
- **Light property**: \( k_d, k_s \)
- **Reflection direction**: \( \hat{R}_m \)

R is the mirror reflection direction

Shadows

Virtual Viewpoint

Virtual Screen

Objects

Light Source

Mirror (specular) reflection/refraction

Mirror Reflections/Refractions

Virtual Viewpoint
Virtual Screen
Objects

10.6 in textbook

Reflection

\[ \mathbf{v}' = \mathbf{v} - 2(\mathbf{v} \cdot \hat{n}) \hat{n} \]
What’s new?

BATTLEFIELD V

nvidia GeForce RTX
Resources

https://www.cs.utah.edu/~shirley/books/fcg2/rt.pdf
http://www.realtimerendering.com/raytracing/roundup.html
http://rtintro.realtimerendering.com/
https://benedikt-bitterli.me/tantalum/tantalum.html