Ray Tracing in Practice

CSCI 4239/5239
Advanced Computer Graphics
Spring 2025

Simple Ray Tracing Algorithm

- Initialize ray (**O**,**d**)
  - color = black
  - coef = 1
- Find closest intersection **P**
  - color += coef*ambient*material
  - *if not in shadow color* += coef***N•L***diffuse*material
  - coef *= reflectivity
  - redirect ray from **P** to **d** – 2(**d•N**)**N**
- Stop when no intersection, or coef<<1, or maximum number of bounces

Ex 26: Three Ray Traced Spheres

- Simple scene
  - Three highly reflective spheres
  - Two white lights (one close, one far)
  - OpenMP for parallel processing
- Support classes
  - Vec3, Mat3, Color
- Base classes
  - Ray, Material, Light
- Object classes
  - Sphere

Implementation Notes

- Written in ***very bad*** C++
  - *KISS*
  - No object abstraction
- Use STL vector<> class for lists
- Calculate array of pixel values *width* x *height*
  - View by transforming pixel location
  - OpenMP parallel calls to RayTracePixel()
  - Copy to screen using *glDrawPixels*
- All calculations in ***global*** coordinates
  - Preprocess scene as needed

Building a real Ray Tracer in C++

- Base classes
  - Ray
  - Object
  - Light
  - Material
- Derived Object Classes
  - Sphere
  - Cube
  - Triangle
  - Triangle Mesh

Object Class

- Type of object
  - Implicit Surface
    - Sphere
    - Torus, cylinder, cube, ...
  - Compound objects
    - Triangular mesh
- Intersection with a ray
  - Point of intersection
  - Normal
  - Textures, etc

Virtual Methods

- Base class
  - hit
  - sample
  - color
- Each object class overrides the base class

Intersecting a Complex Object

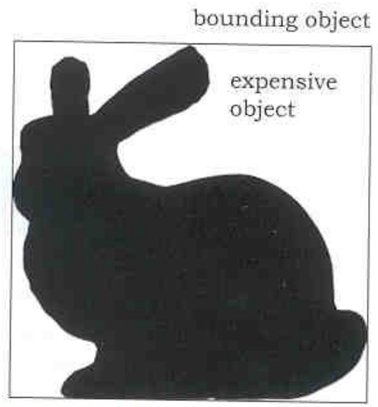


Figure 19.1. The Stanford bunny and a bounding box.

- Defining a complex object
  - Triangle mesh on vertexes
  - Gouraud shading
- Expensive to ray trace
  - Test every ray against every triangle in the object
  - Test bounding box of entire object
- Intersections
  - Plane
  - Axis-aligned box
  - Generic triangle

Perspective Ray Tracing

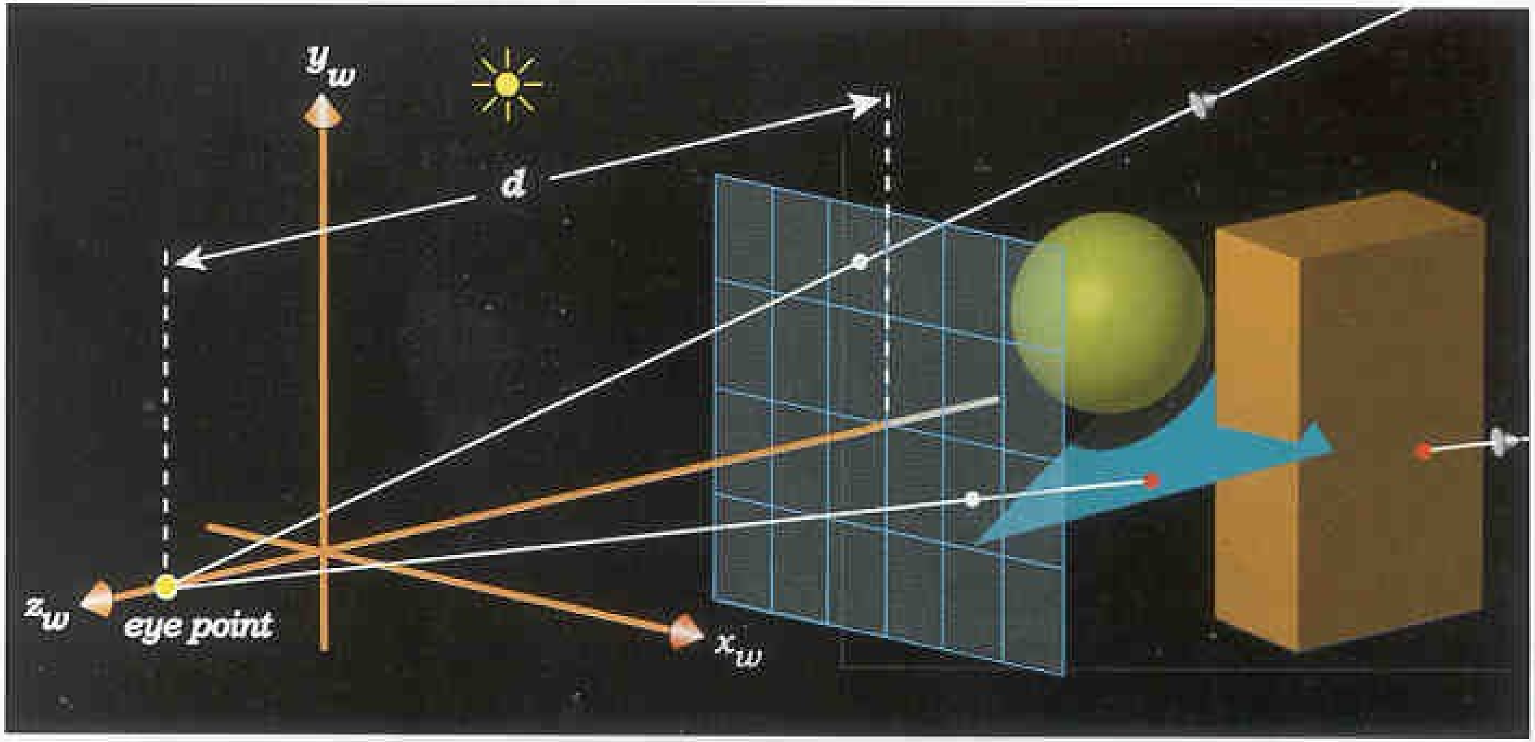
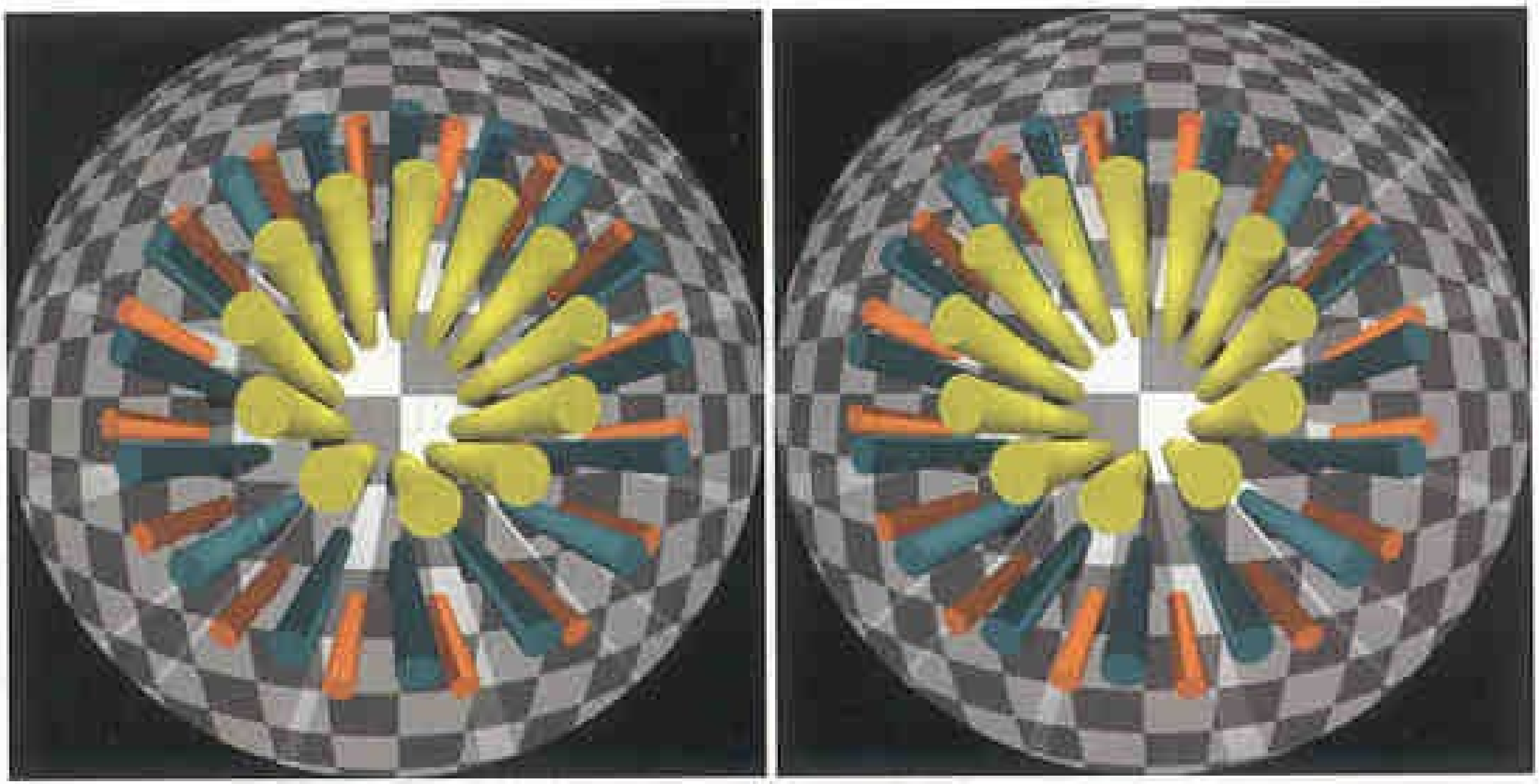


Figure 8.14. Set-up for axis-aligned perspective viewing with the eye point and two rays going through pixel centers.

Stereoscopy



left-eye view

right-eye view

Installing PBRTv3

- Build code from github
  - `git clone --recursive https://github.com/mmp/pbrt-v3.git`
  - `cd pbrt-v3`
  - `mkdir build`
  - `cd build`
  - `cmake ..`
  - `make -j8`
  - `sudo make install`
- Run using `pbrt foo.pbrt`
- Examples `ex25-3.pbrt` and `ex25-3.png`

Installing PBRTv4

- Build code from github
  - `git clone --recursive https://github.com/mmp/pbrt-v4.git`
  - `git clone git://git.pbrt.org/pbrt-v4-scenes`
  - `cd pbrt-v4`
  - `mkdir build`
  - `cd build`
  - `cmake PBRT_OPTIX7_PATH=xxxx ..`
  - `make -j8`
  - `sudo make install`
- Run using `pbrt --gpu foo.pbrt`
- Examples `ex25-4.pbrt` and `ex25-4.png`
- See differences in input with `diff ex25-3.pbrt ex25-4.pbrt`