Midterm Review

Steve Rotenberg

CSE168: Rendering Algorithms

UCSD, Spring 2014

Midterm

- General guidelines:
  - Midterm will cover all material up to and including Monday 4/28
  - Not very math heavy, but be familiar with core vector & matrix math
  - Pay attention to any terms in *italics* that are defined in the lecture notes
  - The test will focus more on concepts and understanding
  - In situations where multiple options are provided (such as BRDF types, data structure types, number sequence types, etc.), be prepared to compare and contrast the different options

Camera & Scene

- Camera ray generation
- Look-at function
- Horizontal-vertical FOV relationship
- Instancing logic

Intersections

- Ray equation: $\mathbf{r}(t)=\mathbf{p}+t\mathbf{d}$
- Ray-sphere concepts
- Ray-plane math:

  $d = \mathbf{q}\cdot\mathbf{n} = (\mathbf{p}+t\mathbf{d})\cdot\mathbf{n} = \mathbf{p}\cdot\mathbf{n} + t\mathbf{d}\cdot\mathbf{n}$

  $t = (d-\mathbf{p}\cdot\mathbf{n}) / (\mathbf{d}\cdot\mathbf{n})$
- Ray-box concepts
- Ray-triangle concepts
- Barycentric coordinates:

  $\mathbf{q} = \mathbf{a} + \alpha(\mathbf{b}-\mathbf{a}) + \beta(\mathbf{c}-\mathbf{a})$

Fresnel

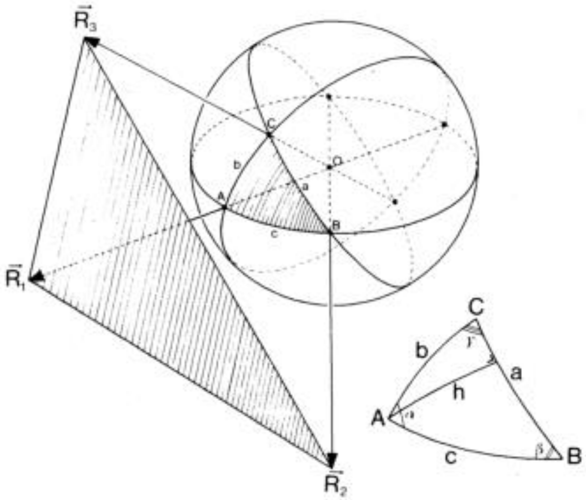
- Dielectric behavior & concepts
  - Snells law
  - Total internal reflection
- Metal behavior
- Concept and trends in Fresnel equation
- Fresnel effect
- Beer-Lambert law concepts
- Recursive ray tracing

Materials

- Diffuse material behavior
- Microgeometry
  - Shadowing/masking
  - Distribution
- Opposition effect
- Oren-Nayar model
- Cook-Torrance model
- Isotropic vs. anisotropic

Shadows & Area Lights

- Umbra & penumbra
- Area light sampling
- Solid angles



Spatial Data Structures

- Render performance
- Hierarchical data structures
  - Tree construction
  - Ray traversal
  - BVH vs. spatial partitions
  - AABB, sphere tree, K-Tree, BSP, nested grid, octree
- Scene graph & animation issues

Antialiasing

- Aliasing problems & their causes: shimmering, Moiré, stairstepping, strobing
- Signals, sampling, & reconstruction concepts
- Low/high frequency signals
- Pixel sampling (uniform, jittered, random, weighted…)

Texture

- Wrap modes
- Sampling modes
- Minification / magnification
- EWA sampling
- Normal & displacement mapping concepts

Random

- Random & jittered numbers
- Quasi-random numbers
- Concepts behind mappings

BRDFs

- Bidirectional reflectance distribution function
- Physical validity:
  - Conservation of energy $\forall \boldsymbol{\omega}_i, \int_{\Omega} f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_r) \cos\theta_r d\,\boldsymbol{\omega}_r \leq 1$
  - Reciprocity $f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_r) = f_r(\boldsymbol{\omega}_r, \boldsymbol{\omega}_i)$
- Isotropic vs. anisotropic
- Qualities of different BRDF models
- BRDF sampling
- Radiance equation

$$L_r(\boldsymbol{\omega}_r) = \int_{\Omega} f_r(\boldsymbol{\omega}_i, \boldsymbol{\omega}_r) L_i(\boldsymbol{\omega}_i) \cos\theta_i d\boldsymbol{\omega}_i$$

Project 3

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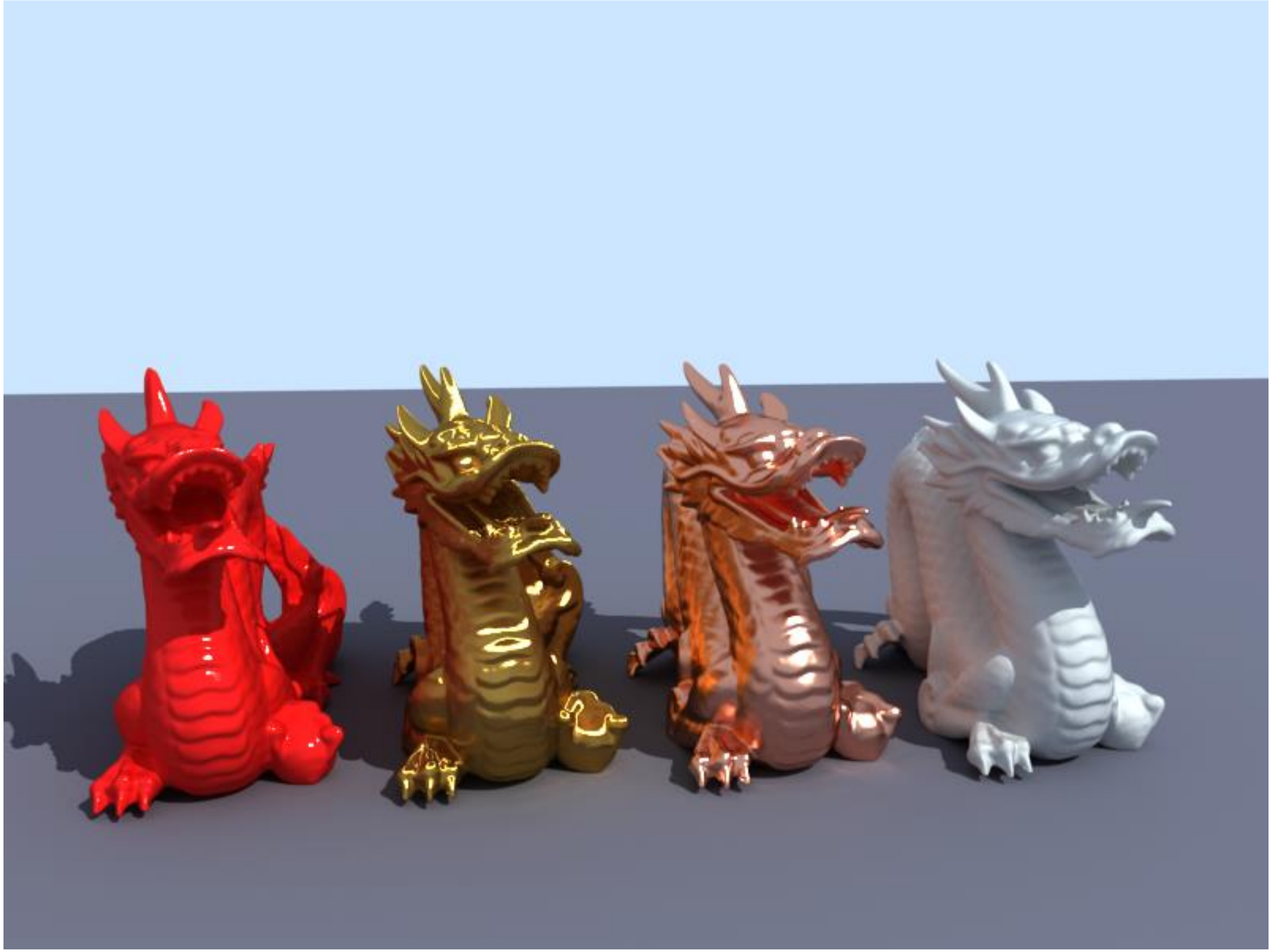


Ashikhmin BRDF

$$\rho(\mathbf{k}_1, \mathbf{k}_2) = \rho_s(\mathbf{k}_1, \mathbf{k}_2) + \rho_d(\mathbf{k}_1, \mathbf{k}_2)$$

$$\rho_s(\mathbf{k}_1, \mathbf{k}_2) = \frac{\sqrt{(n_u + 1)(n_v + 1)}}{8\pi} \frac{(\mathbf{n} \cdot \mathbf{h})^{n_u \cos^2 \varphi + n_v \sin^2 \varphi}}{(\mathbf{h} \cdot \mathbf{k}) \max\big((\mathbf{n} \cdot \mathbf{k}_1), (\mathbf{n} \cdot \mathbf{k}_2)\big)} F(\mathbf{k} \cdot \mathbf{h})$$

$$F(\mathbf{k} \cdot \mathbf{h}) = R_s + (1 - R_s)\big(1 - (\mathbf{k} \cdot \mathbf{h})\big)^5$$

$$\rho_d(\mathbf{k}_1, \mathbf{k}_2) = \frac{28 R_d}{23\pi}(1 - R_s)\left(1 - \left(1 - \frac{(\mathbf{n} \cdot \mathbf{k}_1)}{2}\right)^5\right)\left(1 - \left(1 - \frac{(\mathbf{n} \cdot \mathbf{k}_2)}{2}\right)^5\right)$$

Issues

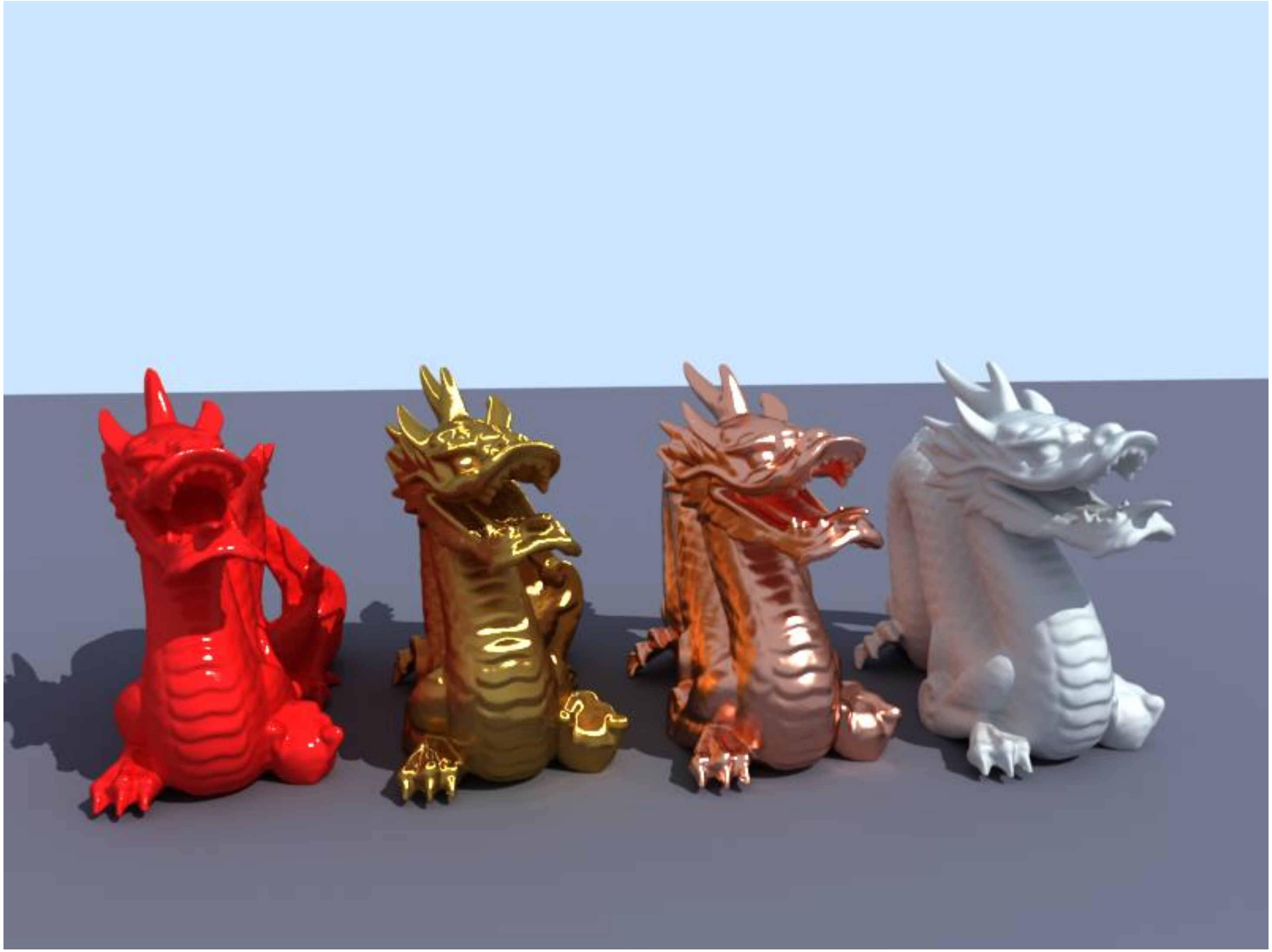
- Tangents
- Instance materials
- Supersampling
- Noise

Recursive Ray Tracing

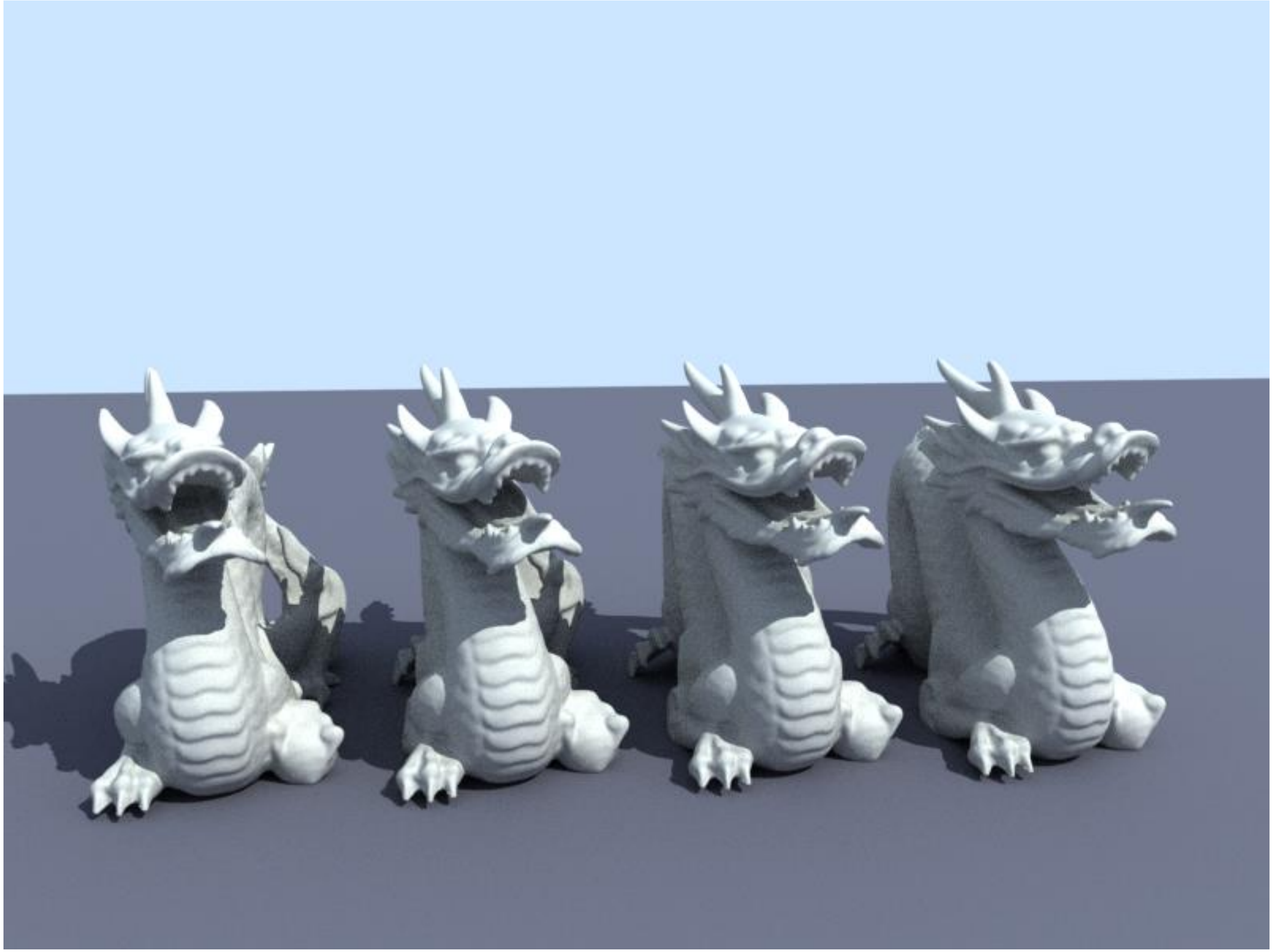
- Material::GenerateSample()
- Virtual functions
- Direct lighting
- Radiance estimation

Forward BRDF Evaluation

Forward + Reflections



Diffuse Material (albedo = 0.6)



Extra Credit