

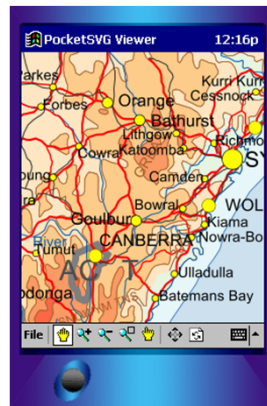


IMGD 4000: Hot Topics in Graphics

by Emmanuel Agu

Professor Background

- Dr. Emmanuel Agu
- Research interests
 - Computer Graphics & mobile graphics
 - wireless networking and mobile computing

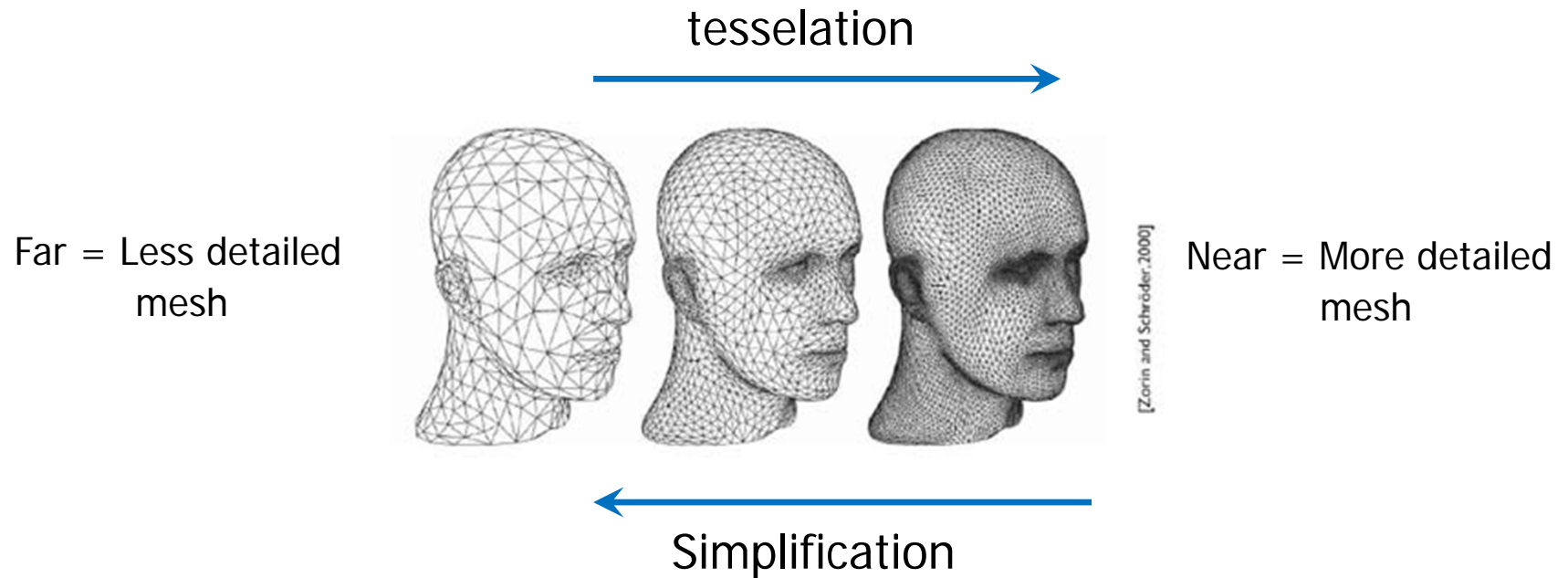




Graphics Trends for Games

1. Real Time LoD Management
2. Capture rendering data
3. Ray tracing
4. Pre-computation to speed up run-time
5. New Real Time Global Illumination Algorithms
6. Physics engines on GPUs

Trend 1: Real-Time LoD Management



- **Previously:** Pre-generate mesh versions offline
- Geometry shader unit added to GPU in DirectX 10 (2007)
 - generate new vertices, primitives from mesh
- Mesh simplification/tessellation on GPU = Real time LoD
- Tessellation: [Demo](#)

Trend 2: Capture Rendering Data

- Old way: Mathematically model geometry, lighting (Phong), animation, etc
- **Problem:** Humans can still tell it's fake
- New way: capture parameters from real world
- **Example:** motion in sports games (e.g. NBA 2K live) is captured.
 - How? Put sensors on actors
 - Actors play game
 - Capture motion into database
 - During game: play back motion
- Mo-cap demo



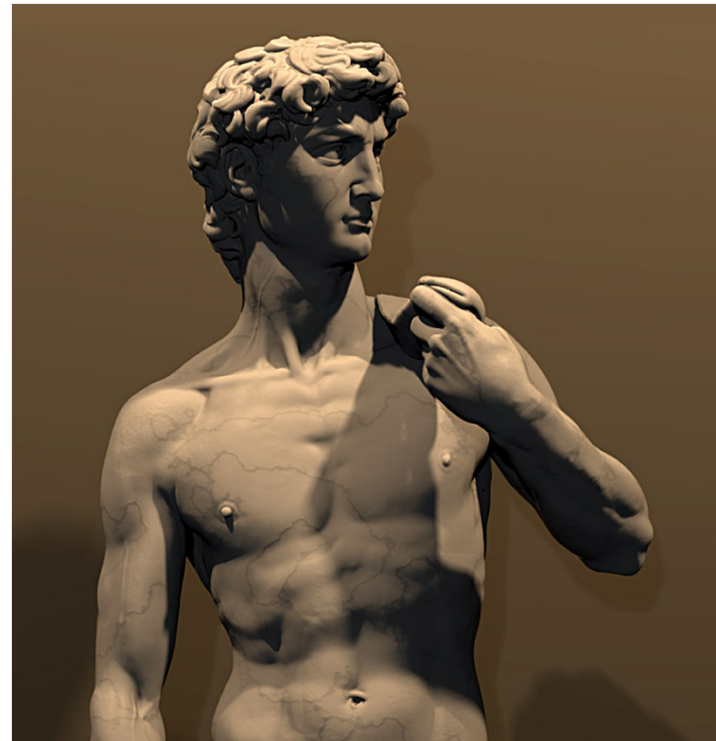
Courtesy: NBA 2010 Live

Geometry Capture: 3D Scanning

- **Capturing geometry trend:** Projects on precise 3D scanning (Stanford, IBM, etc) produce very large polygonal models

Model: David

Largest dataset Size: 2 billion polygons, 7000 color images!!



Courtesy: Stanford Michael Angelo 3D scanning project

How is capture done?

- **Capture:**
 - Digitize real object geometry and attributes
 - Use cameras, computer vision techniques to capture rendering data
 - Place captured data in database, many people can re-use
- **Question:** What is computer vision?

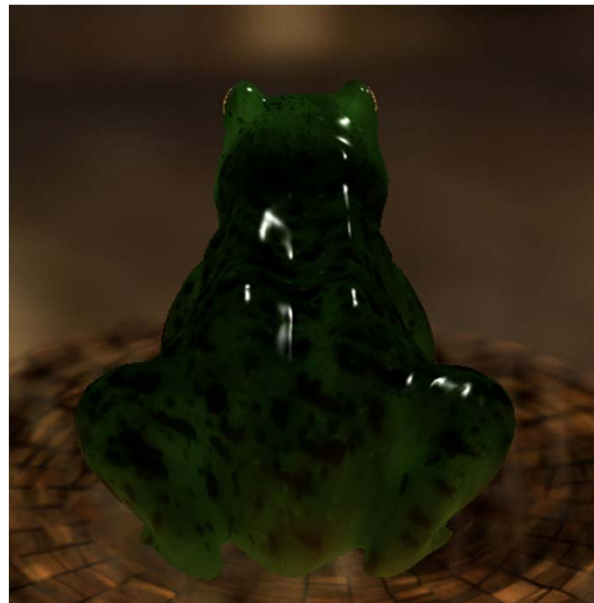
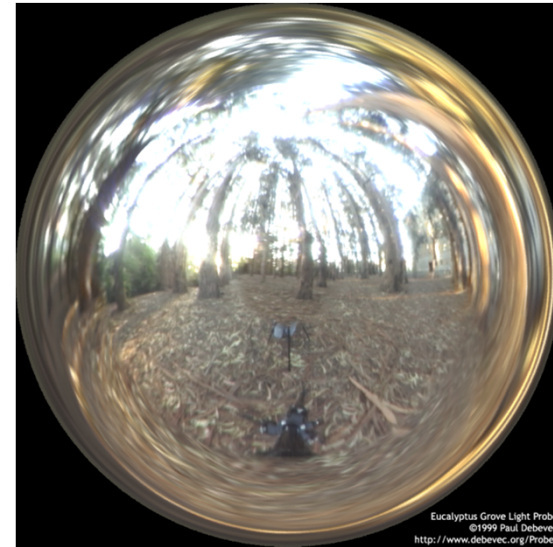
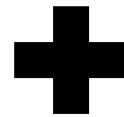
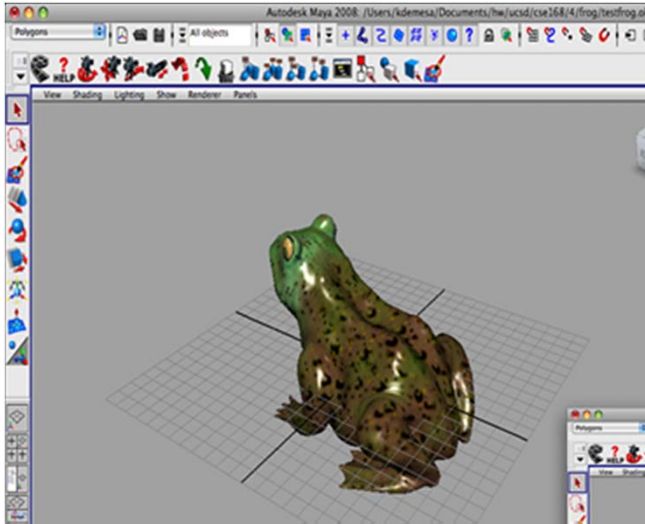


Light Probes: Capturing light

Amazing graphics, High Dynamic Range?

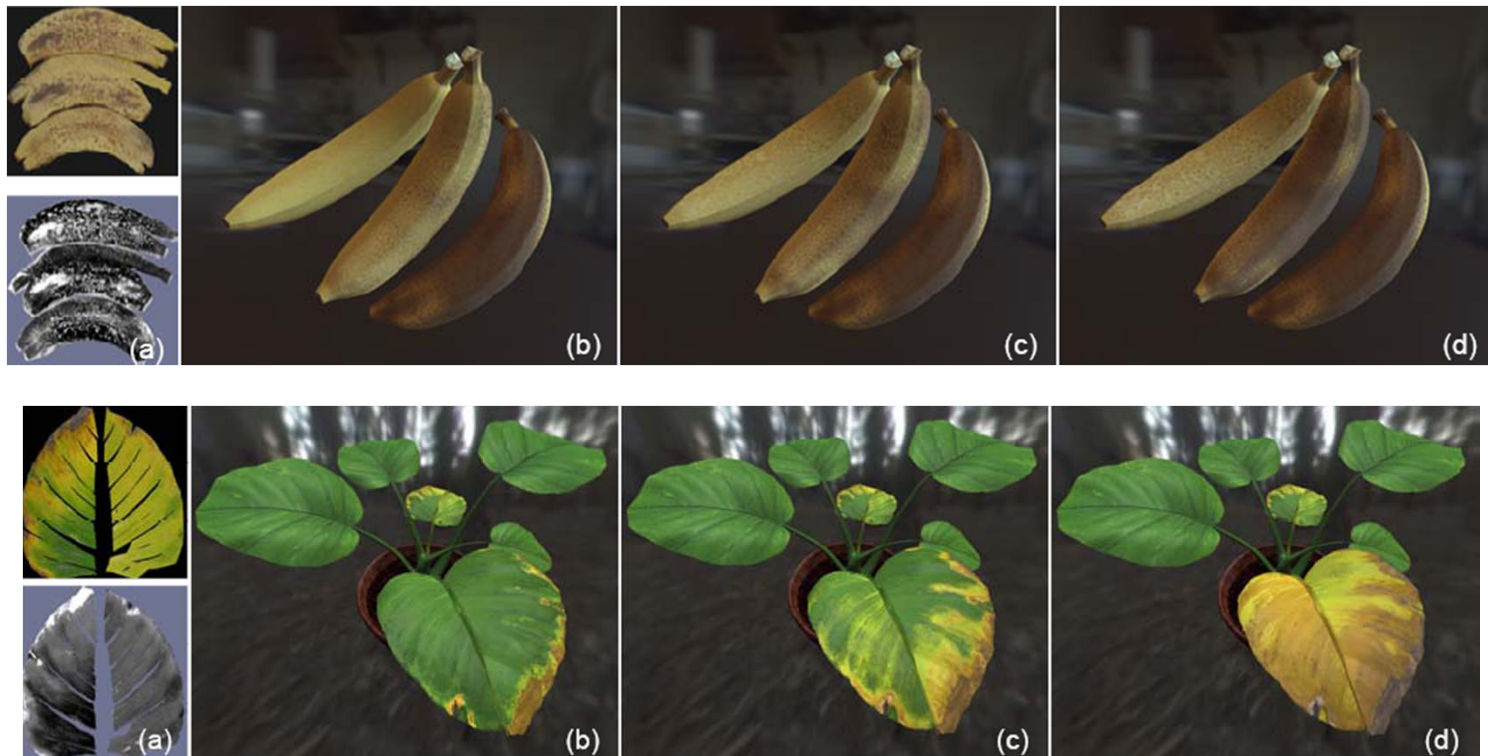


Light Probes Example



Capture Material Reflectance (BRDF)

- BRDF: How materials reflect light
- **Examples:** cloth, wood, velvet, etc
- Time varying?: reflectance changes over time
- **Examples:** weathering, ripening fruits, rust, etc

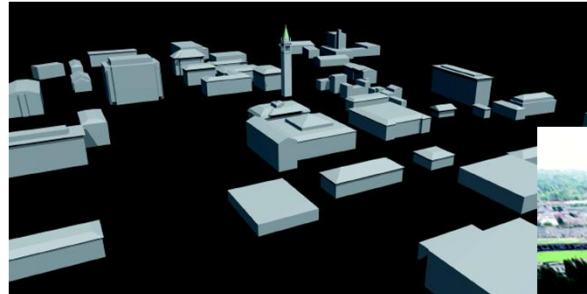


Exactly What Can We Capture?

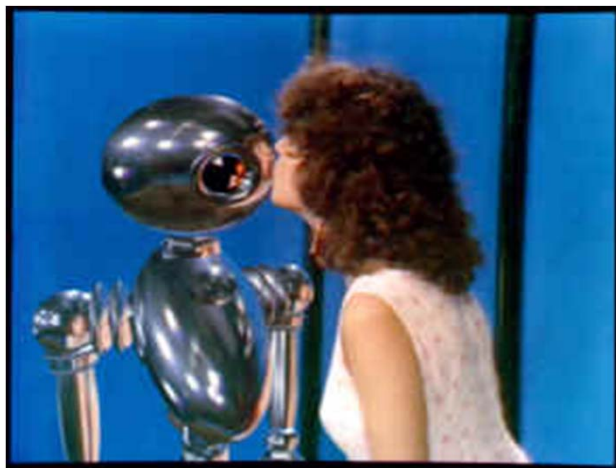
1. Appearance (volume, scattering, transparency, translucency, etc)



2. Geometry



3. Reflectance & Illumination



4. Motion





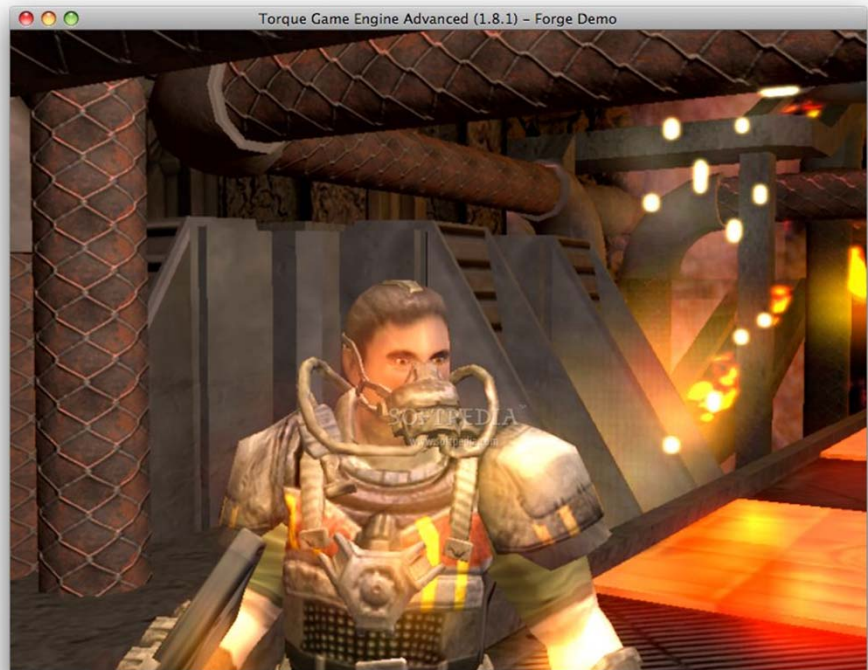
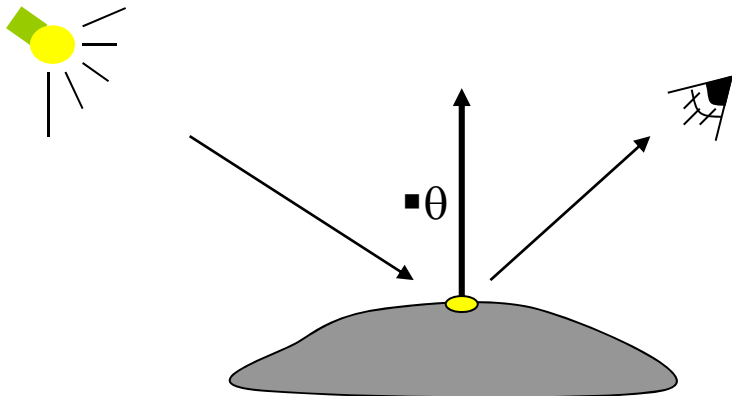
Why effort to capture?

- **Big question:**

“If we can capture real world parameters, is this really **computer graphics?**”

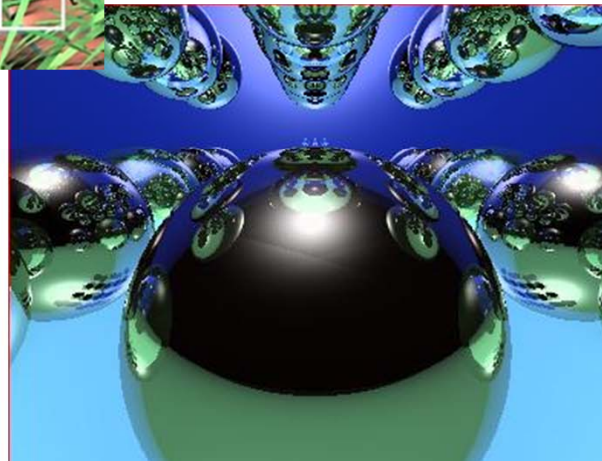
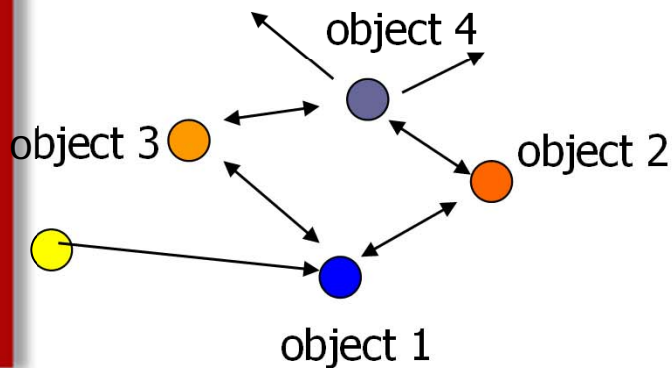
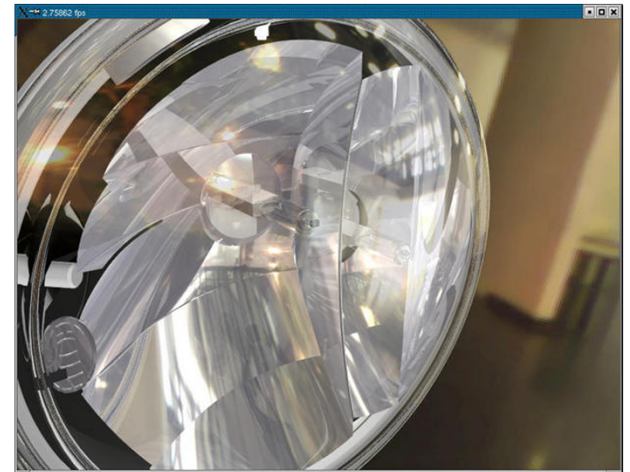
Local Illumination

- Consider 1 bounce only
- OpenGL does this
- Looks fake
- E.g. Torque 3D game engine



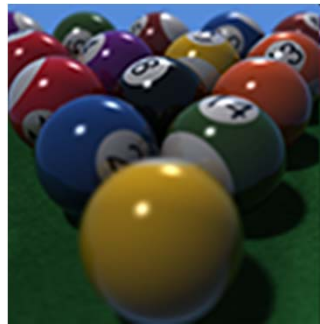
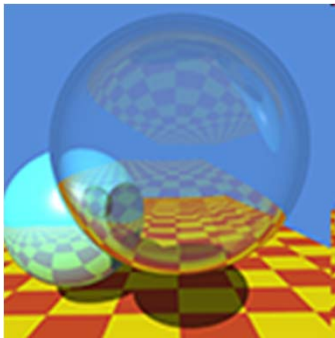
Trend 3: Raytracing in Games


- Global Illumination: 2 or more bounces
- Raytracing: A global illumination rendering (takes hours/days)
 - Better Reflection / refraction / shadow



Trend 3: Raytracing in Games

- Nvidia Optix ray tracer
- Needs high end Nvidia graphics card
- SDK is available on their website
- <http://developer.nvidia.com/object/optix-home.html>





Trend 4: Pre-computation to speed up run-time

- Ray tracing/GI still slow on GPUs
- Pre-compute whatever you can
 - Lighting
 - Occlusion
 - Radiance Transfer (Use spherical harmonics)
 - Results in: pre-computed Global Illumination
- **Notes:**
 - Object or light movement changes shading.
 - Pre-computation works if scene and light sources are static

Pre-computed Global Illumination

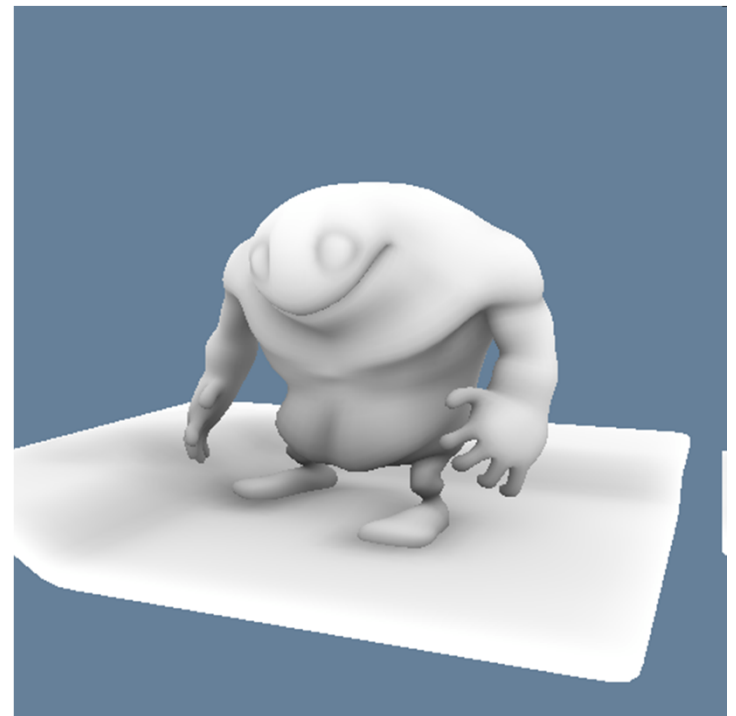
HALO 3

BUNGIE

SIGGRAPH2009

Pre-Computed Ambient Occlusion

- Ambient shading proportion to how much hemisphere above location is blocked



Courtesy Nvidia
SDK 10

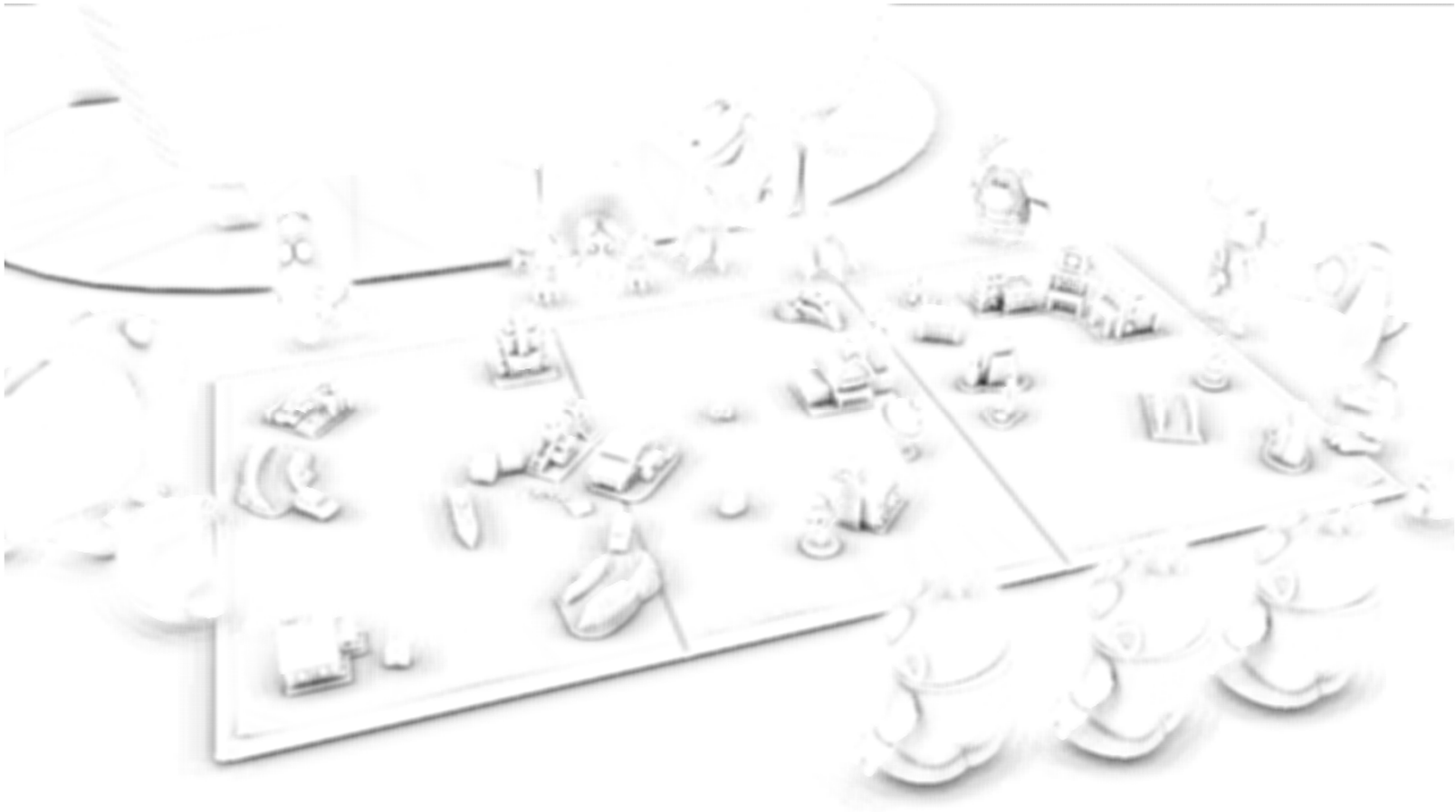
Screen-Space Ambient Occlusion

- Toy Story 3: Screen space Ambient Occlusion



SSAO in Toy story 3

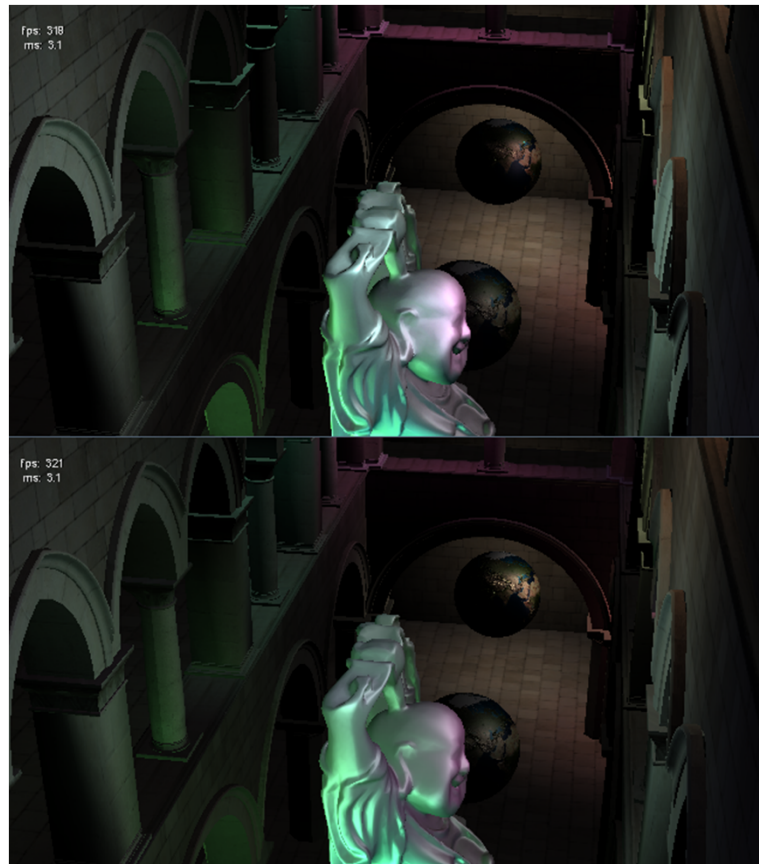
- Viewing just the ambient term of shading



Precomputed Radiance Transfer (PRT)

- Factorize and precompute light and material into Spherical Harmonics
- Light reflection is dot product at run time (Fast)

Courtesy Sponza Atrium
by Marko Dabrovic:





Trend 5: New Real time Global Illumination Algos

- Dynamic scenes: Need real-time GI, on-the-fly
- Real Time Global Illumination: state-of-the art
 - Calculate GI equations on GPU at run-time
- Improves:
 - Shadows
 - Ambient Occlusion
 - Reflections
 - Transmittance
 - Refractions
 - Caustics
- What does RT-GI look like?

Real-time Lighting in Games



CRYENGINE 3

SIGGRAPH2009

Better Sky Model

- [BrunetonNeyret2008]
- Single and multiple scattering
- Pre-computation on the GPU
- Viewable from space
- Light shafts

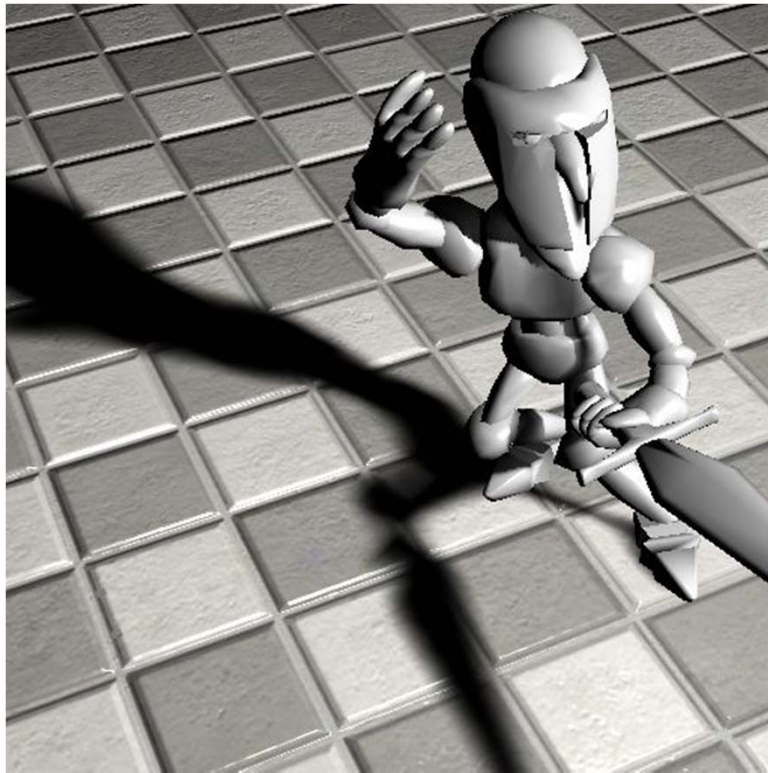
Different Atmospheres



Time Of Day



Better Shadows

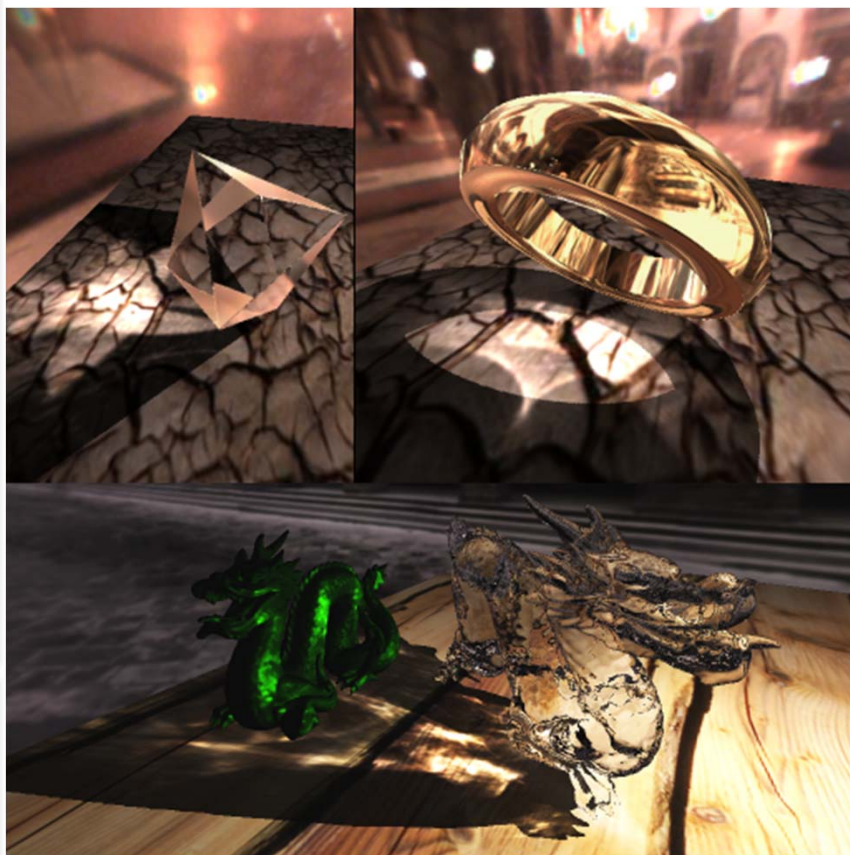


Variance shadow mapping
Courtesy Nvidia SDK 10



Courtesy Hellgate:London,
flagship studios inc

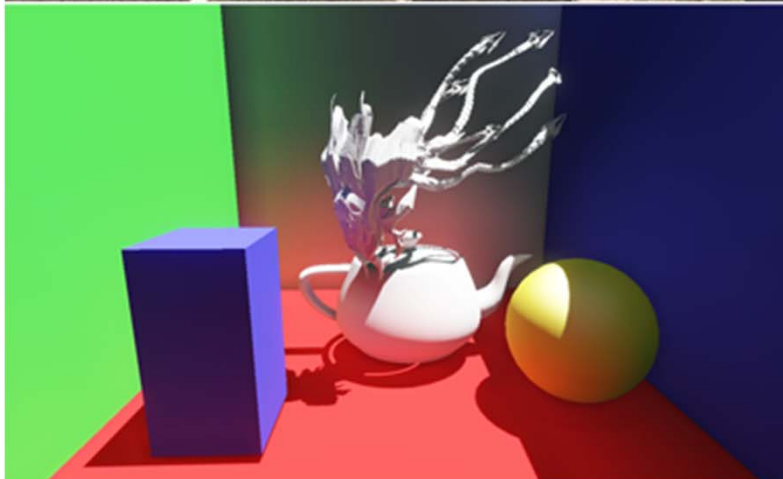
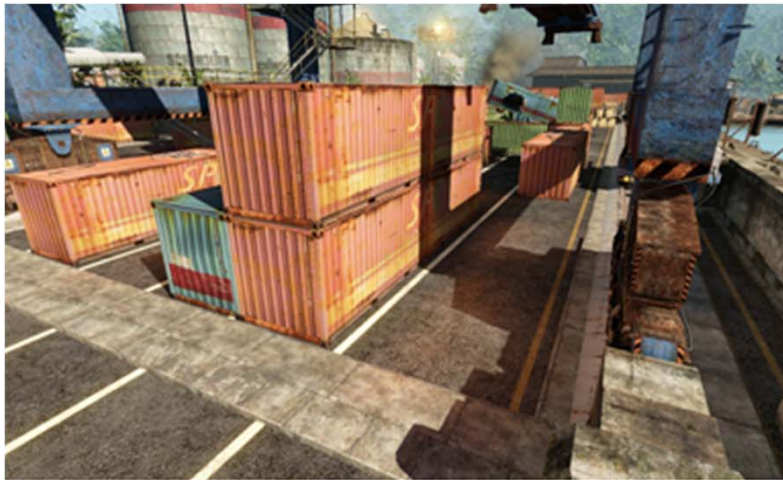
Better Caustics and Refraction



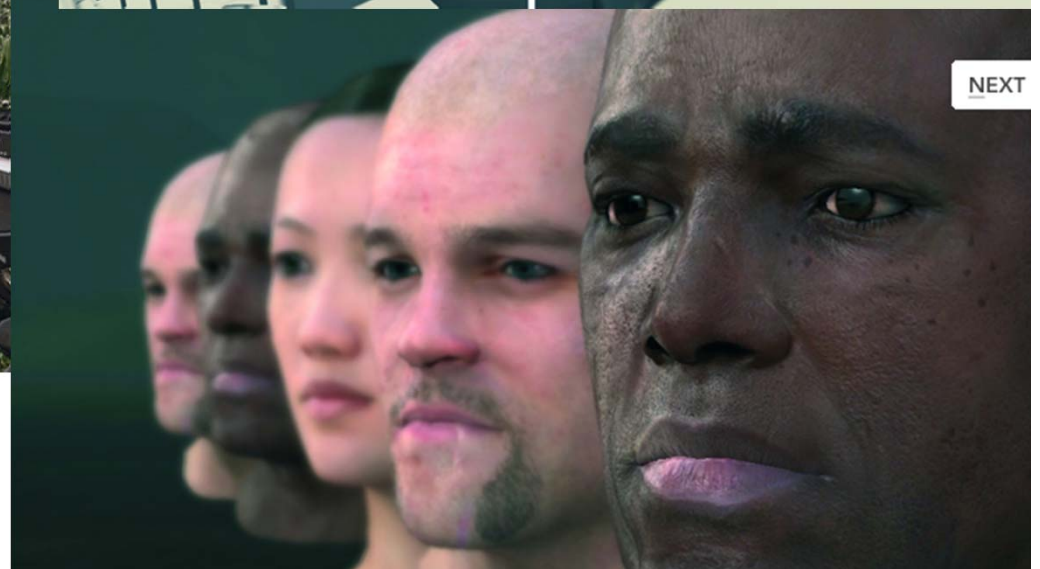
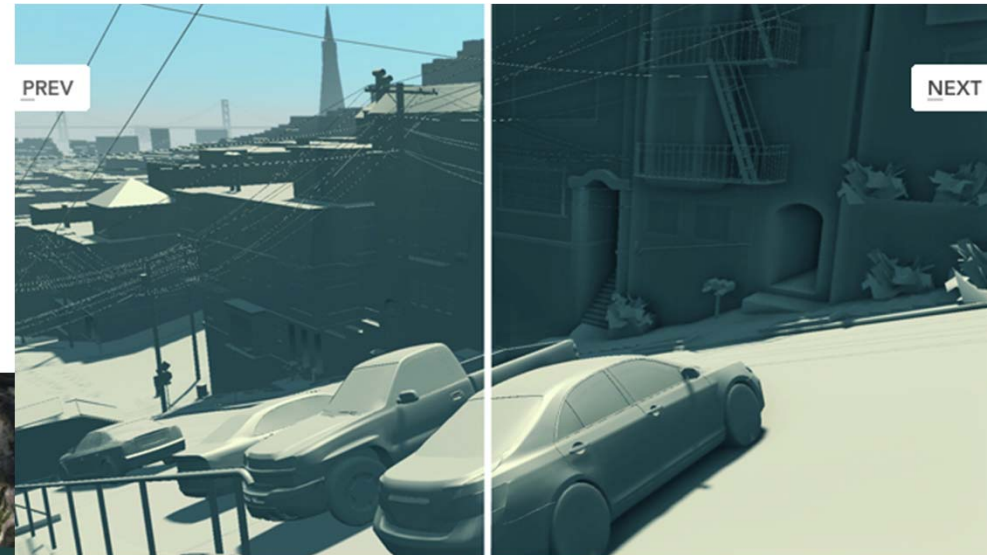
Courtesy Chris Wyman, Univ Iowa

Light Propagation Volumes (LPV)

- CryEngine: new **physically-based** game engine by CryTek
- LPV: new real time Global Illumination algorithms, used in CryEngine
- Runs faster than ray tracing on GPU



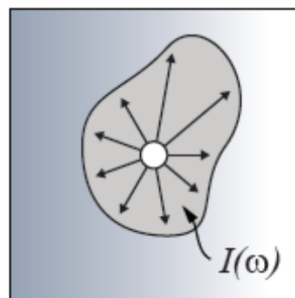
Crytek Crisis Engine Screenshots



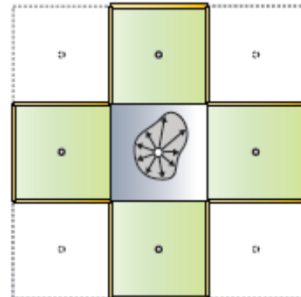
- Light Propagation Volumes [Demo](#)

LPV Idea

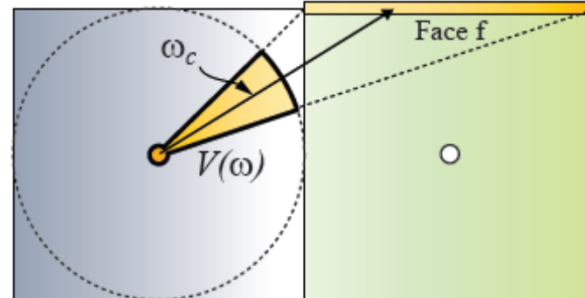
- **Main idea:** represent light propagation as Virtual Point Lights (VPL)
- Re-project VPL into adjacent cells



source cell

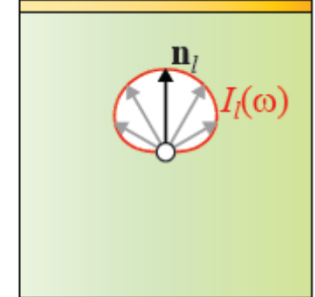


propagation along
axial directions

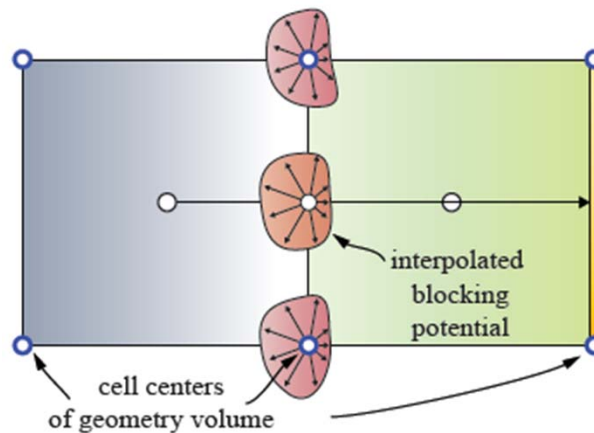



source cell

destination cell



reprojection of the flux
into a point light





Trend 6: Physics Engines on GPU

- Nvidia Physx engine
- SDK: developer.nvidia.com/object/physx_features.html
 - Complex rigid body object physics system
 - Multi-threaded/Multi-platform/PPU Enabled
 - Volumetric fluid simulation
 - Cloth authoring and playback
 - Soft Bodies
 - Volumetric Force Field Simulation
 - Vegetation



References

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- Advances in Real-Time Rendering in 3D graphics and games, SIGGRAPH course notes 2009
- Anton Kaplanyan and Carsten Dachbacher, Cascaded light propagation volumes for real-time indirect illumination, in Proc. Si3D 2010
- Hao Chen and Natalya Tatarchuk, Lighting Research at Bungie, Advances in Real-Time Rendering in 3D Graphics and Games SIGGRAPH 2009 Course notes
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