Many-Lights Algorithms in Autodesk® 360 Rendering

Adam Arbree, Autodesk Inc.
What is Autodesk 360 Rendering?
Autodesk® 360

- Cloud Application Suite
- Extends the desktop
  - Storage
  - Collaboration
  - Sharing
- Rendering is a new application in Autodesk 360
Autodesk® 360 Rendering

- Released in March
- Focus
  - architectural and engineering visualization
- Features
  - Seamless rendering from desktop applications
- Render Gallery
  - Rerender, enhance and share images
Autodesk® Homestyler®

- Build and decorate your own model home
- Take “snapshots” to visualize your design
- Images created using Autodesk 360 Rendering
Goals of Our Service

- Architectural & Design (i.e. Predictive)
- Scalable
- Render Quickly, Anywhere
- Efficient
Problem

How to automatically, efficiently and reliably produce a large number of physically-accurate renderings in a predictable amount of time?

Solution?

A many-lights rendering algorithm.
1,000’s of images/day

150s/megapixel (64 cores)

1st million images this year

Courtesy of Jonathan Paul Reyes Martinez, DreamsFactory

Tian Tian, Autodesk® Homestyler®
www.facebook.com/Autodesk360Rendering/photos
Overview

Our Algorithm

Advantages of Many Lights
Algorithm Overview

- Multidimensional Lightcuts
  - Walter et. al., SIGGRAPH 2006

- Advantages
  - Scalability
  - Uniform light model
  - Support for advanced effects
Algorithm Overview

- Eye ray splitting
  - Improves glossy appearance

- Virtual Point Light Targeting
  - Reduces clamping bias in scenes with high occlusion

- Polish
  - Virtual Spherical Lights
  - Directionally Variant VPLs
Issue #1: Eye Ray Splitting

- Split and recursively trace eye rays for glossy materials
- Heuristic determines split rate from material’s glossiness
- Increase maximum cut size to accommodate increased sampling
Issue #1: Glossy Objects

No Splitting

With Splitting
Issue #2: Big Model, Small Scene
Solution #2: VPL Targeting

- VPL targeting is essential
  - Several good options discussed in Section 3 of this course

- Our focus: the global VPL distribution
  - Eye ray splitting addresses local contribution

- Similar to:
Solution #2: VPL Targeting

- Two-pass Algorithm
  1. Trace eye ray samples
  2. Build importance function using eye sample density
  3. Use importance function to reject VPLs with Russian roulette
Issue #2: High Occlusion

With Targeting  No Targeting
Issue #3: Directionally Variant Lights

- Measured light emission profiles are commonly used
- Easy to add
- Use the material bounding cube map to bound the light emission function
Formalized in Bidirectional Lightcuts

Bruce Walter, Pramook Khungurn and Kavita Bala, Cornell University

Light Rays
TUESDAY, 7 AUGUST 2:00 PM - 3:30 PM | Room 502AB
Overview

Our Algorithm

Advantages of Many Lights
Advantages of Many-Lights algorithms

1. Performance
2. Robust to design size models
3. Automatic render setup
4. Predictable cost
5. High quality preview
Advantage #1: Performance

Many Lights

Path Tracing – 2x Longer
Advantage #2: Supports Design-size Models

Models have many purposes.

Rendering should have minimal impact on these other applications.
Advantage #3: More Predictable Cost

Day (sky on) vs Night (sky off)

- Sectioned
  - Baseline: 2.5x
  - 1.25x

- Full Model
  - Baseline: 2.6x
  - 2.5x
Relative Render Time by Lighting

Bins Scenes by # of Lights (by 100s)

Cost Relative to Sun/Sky

< 100

> 1000
Advantage #4: Automatic Rendering

- Configuring a render can be a challenge...
  - Requires expertise
  - Image dependent
  - Time consuming

- Especially in design visualization where users want predictive images.

Render Options in Autodesk®
3D Studio Max®
Advantage #4: Automatic Rendering

- A many-lights algorithm’s two-part structure helps automation.

  **First part:** Sampling
  - Sets overall lighting quality
  - Requires expert knowledge
  - Unimportant to novices

  **Second part:** Evaluation
  - Determines images quality
  - Easy to understand
  - Controls cost/quality tradeoff
Advantage #4: Automatic Rendering

- Many-lights algorithms facilitate automation
- Set conservative sampling settings internally
- Hide complex details the user
- Use predefined quality settings for eye sampling rate and error thresholds
- Rely on the scalable evaluation to avoid extra work

Render Options in Autodesk® 360 Rendering
Relative Render Time By Quality (50K scenes)

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>High</th>
<th>Best</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rel. Cost</td>
<td>1</td>
<td>1.6</td>
<td>2.1</td>
</tr>
<tr>
<td>1000's of VPLs</td>
<td>125</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Eye Samples</td>
<td>1</td>
<td>16</td>
<td>64*</td>
</tr>
<tr>
<td>Max Cut Size</td>
<td>1024</td>
<td>16384</td>
<td>16384</td>
</tr>
</tbody>
</table>

* Approximate average of 32-256 adaptive sampling
Advantage 5: High Quality Preview

Autodesk® 360 Renderer

Path Tracer with Irradiance Caching
Future Work

- VPL Generation
  - Estimates of VPL/VSL error
  - Generalized targeting

- Error and Refinement
  - Quantification of error
  - Faster convergence
    - More efficient trees
    - Representative selection
    - Refinement ordering
Conclusion

How to you make rendering a service?
How to automatically, efficiently and reliably produce a large number of physically-accurate renderings in a predictable amount of time?

- Robust and dependable algorithm
- Fast and efficient
- Automatic for novice users
- Supports complex “design-size” models
- Uniform cost across quality and model
- Predictive high quality preview

Use a many lights algorithm.
Acknowledgements

- **My Team**
  - John Hutchinson
  - Roberto Ziche
  - Seema Jaisinghani
  - Brian Budge
  - Nolan Goodnight
  - William Xiao (肖健)
  - Jacky Lee (李吉超)
  - Yonggao Pan (潘永高)
  - Anders Huang (黄运新)
  - Mintao Huang (黄敏涛)
  - Xiaqing Zhuang (庄晓青)
  - Ada Yan (严超)
  - Sally Dong (董月娟)
  - Winnie Yu (喻超华)
  - Rick Wu (吴懿)
  - Jieqi Ding (丁洁琦)
  - Stella Zhou (周翊)

- **Presenters**
  - Jaroslav Křivánek
  - Miloš Hašan
  - Carsten Dachsbacher
  - Alexander Keller
  - Bruce Walter

- **Cornell University**
Questions?