



Many-Lights Algorithms in Autodesk® 360 Rendering

Adam Arbree, Autodesk Inc.



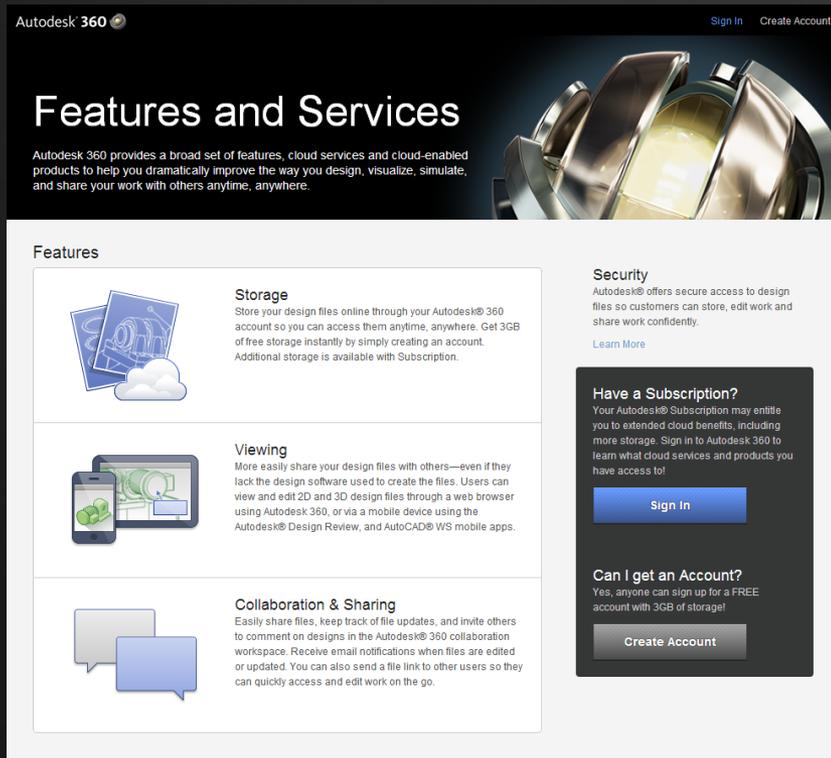
Cloud Platforms

Autodesk

What is Autodesk 360 Rendering?



Autodesk® 360



The screenshot shows the Autodesk 360 website with a dark header. The main heading is 'Features and Services' with a subtext: 'Autodesk 360 provides a broad set of features, cloud services and cloud-enabled products to help you dramatically improve the way you design, visualize, simulate, and share your work with others anytime, anywhere.' Below this, there are three feature cards: 'Storage' (with an icon of a cloud and documents), 'Viewing' (with an icon of a smartphone and a tablet), and 'Collaboration & Sharing' (with an icon of speech bubbles). To the right, there are sections for 'Security' and 'Have a Subscription?' (with a 'Sign In' button) and 'Can I get an Account?' (with a 'Create Account' button).

Autodesk 360 [Sign In](#) [Create Account](#)

Features and Services

Autodesk 360 provides a broad set of features, cloud services and cloud-enabled products to help you dramatically improve the way you design, visualize, simulate, and share your work with others anytime, anywhere.

Features

Storage

Store your design files online through your Autodesk® 360 account so you can access them anytime, anywhere. Get 3GB of free storage instantly by simply creating an account. Additional storage is available with Subscription.

Viewing

More easily share your design files with others—even if they lack the design software used to create the files. Users can view and edit 2D and 3D design files through a web browser using Autodesk 360, or via a mobile device using the Autodesk® Design Review, and AutoCAD® WS mobile apps.

Collaboration & Sharing

Easily share files, keep track of file updates, and invite others to comment on designs in the Autodesk® 360 collaboration workspace. Receive email notifications when files are edited or updated. You can also send a file link to other users so they can quickly access and edit work on the go.

Security

Autodesk® offers secure access to design files so customers can store, edit work and share work confidently.

[Learn More](#)

Have a Subscription?

Your Autodesk® Subscription may entitle you to extended cloud benefits, including more storage. Sign in to Autodesk 360 to learn what cloud services and products you have access to!

[Sign In](#)

Can I get an Account?

Yes, anyone can sign up for a FREE account with 3GB of storage!

[Create Account](#)

- 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



Render Gallery

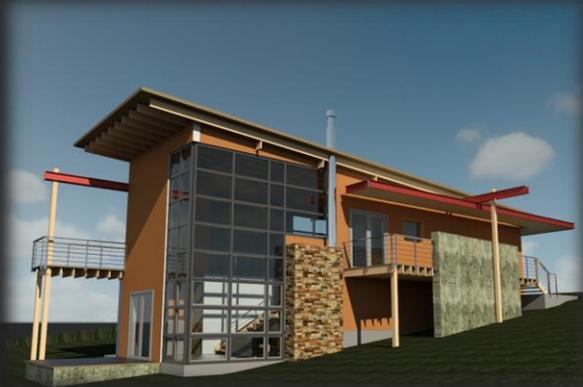


Autodesk® Homestyler®

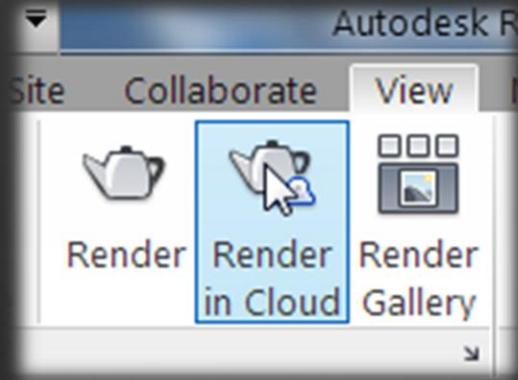


- Build and decorate your own model home
- Take “snapshots” to visualize your design
- Images created using Autodesk 360 Rendering

Goals of Our Service



**Architectural & Design
(i.e. Predictive)**



Render Quickly, Anywhere



Scalable



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®





Autodesk 360 Rendering's Albums



Customer Renderings
104 photos



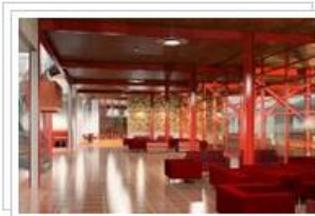
Customer Renderings - Archive Volume 5
100 photos



Customer Renderings - Archive Volume 4
200 photos



Customer Renderings - Archive Volume 3
200 photos



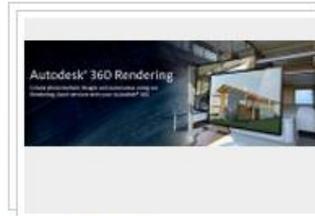
Customer Renderings - Archive Volume 2
200 photos



Customer Renderings - Archive Volume 1
200 photos



Profile Pictures
3 photos



Cover Photos
1 photo

www.facebook.com/Autodesk360Rendering/photos



Overview



Our Algorithm



Advantages of Many Lights



Algorithm Overview

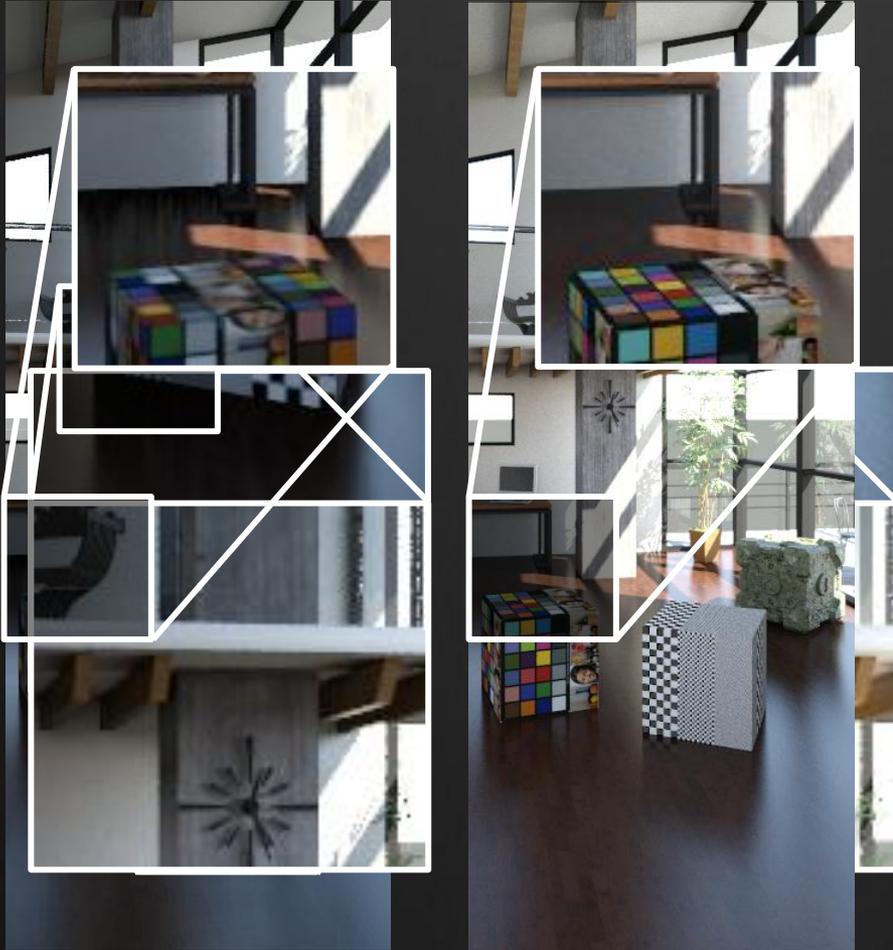


MDLC

- Multidimensional Lightcuts
 - Walter et. al., SIGGRAPH 2006
- Advantages
 - Scalability
 - Uniform light model
 - Support for advanced effects



Algorithm Overview



MDLC

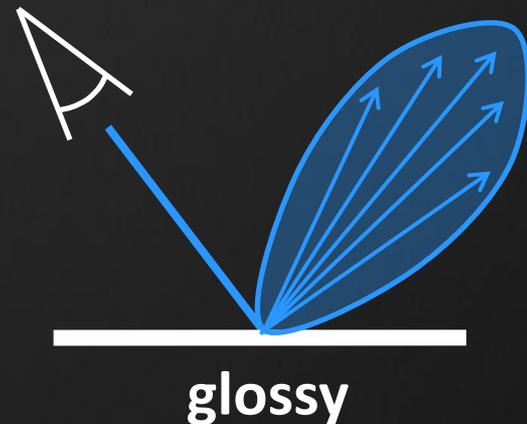
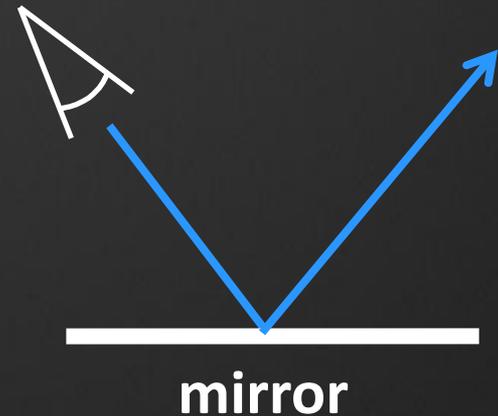
+ VPLs

- **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

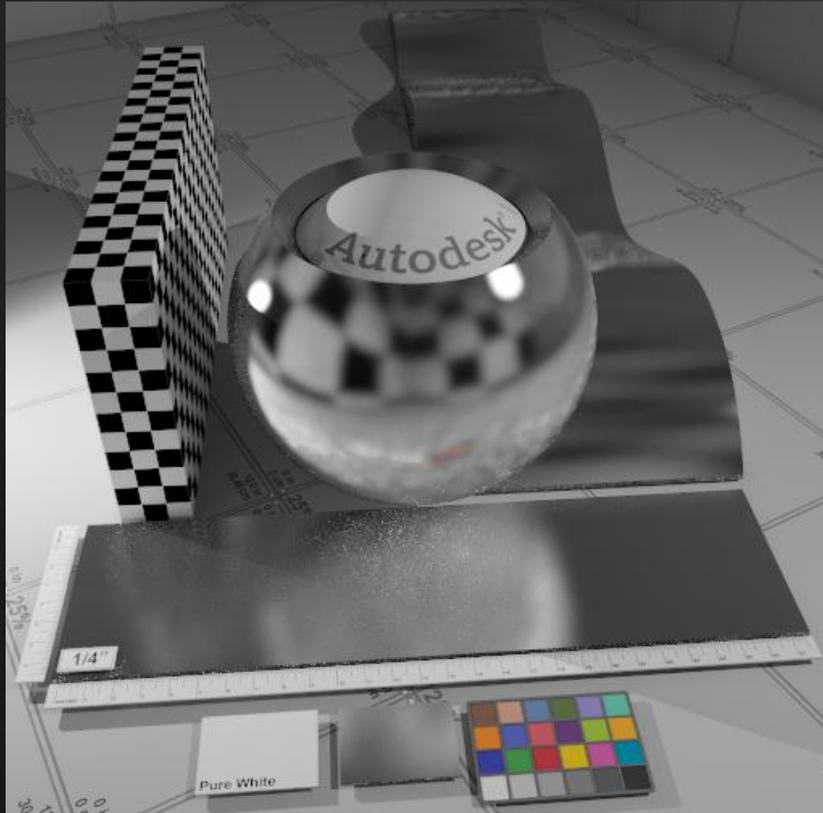


Issue #1: Eye Ray Splitting

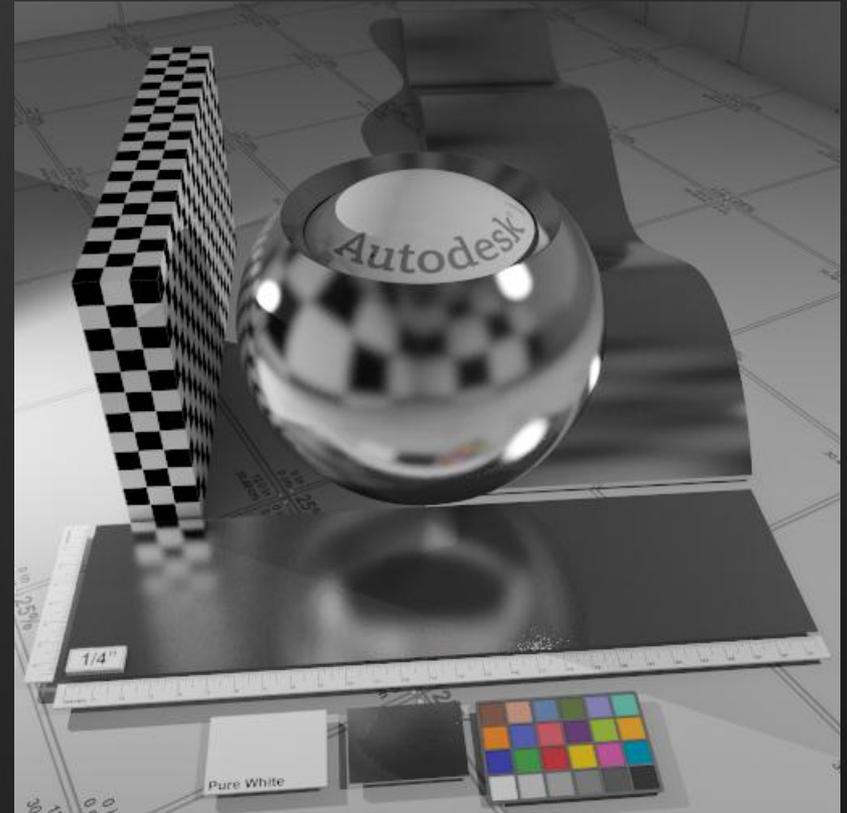
- Split and recursively trace eye rays for glossy materials
- Heuristic determines split rate from material's glossiness
- Increase maximum cut size to accommodate increased sampling



Issue #1: Glossy Objects



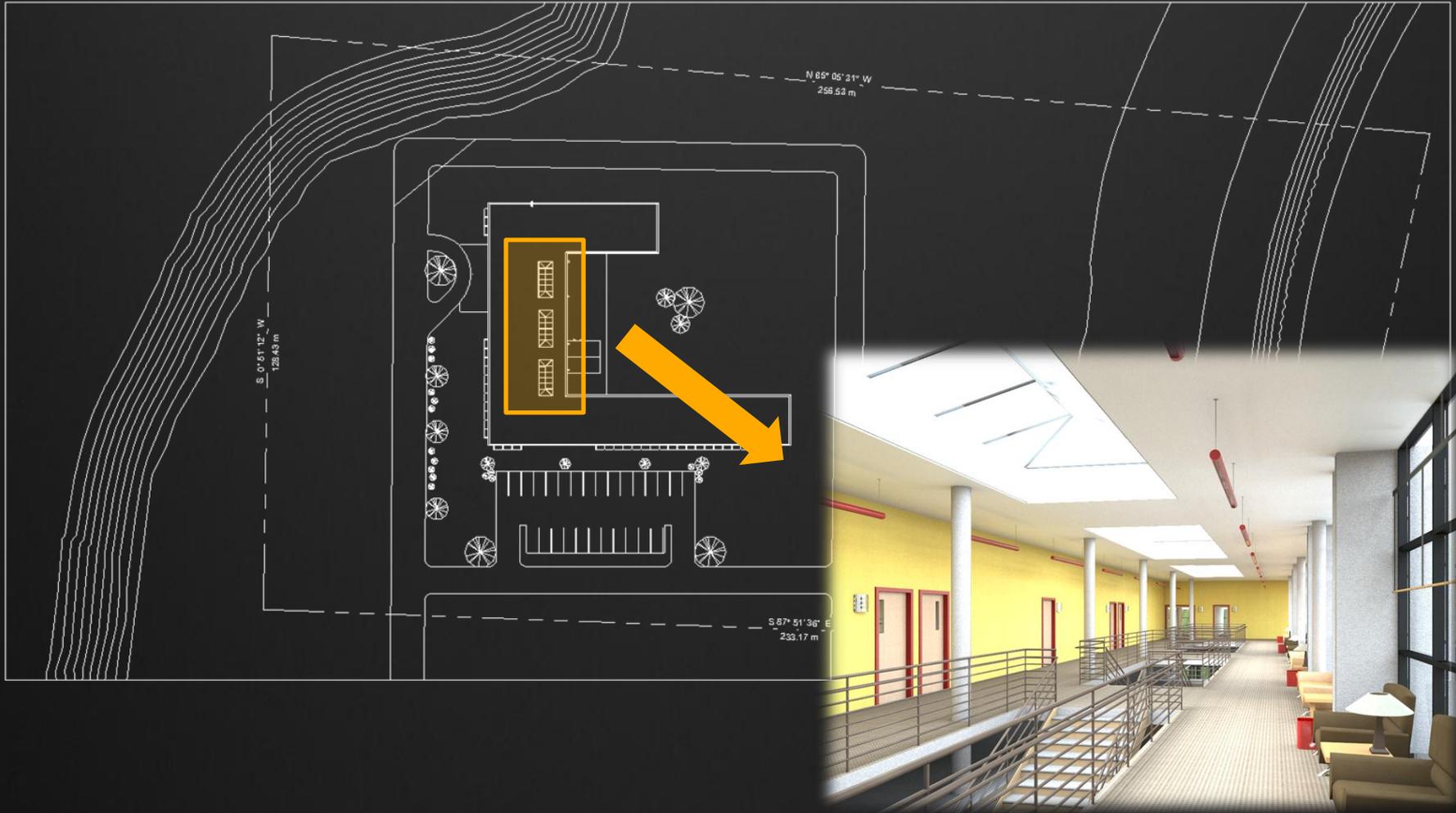
No Splitting



With Splitting



Issue #2: Big Model, Small Scene



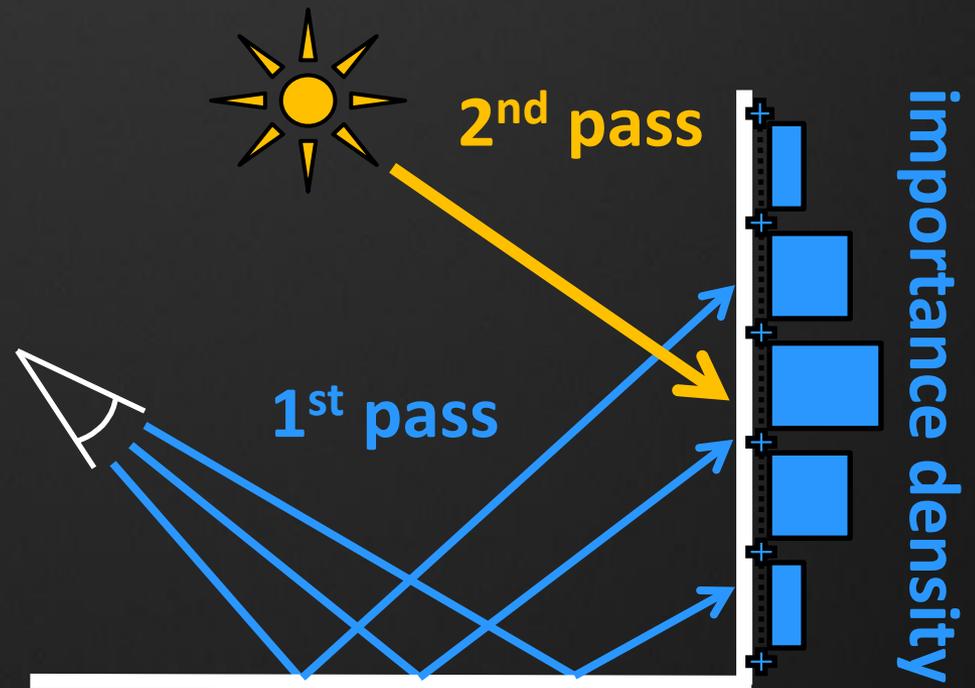
Solution #2: VPL Targeting

- 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:
 - [Per Christensen. *Adjoints and Importance in Rendering: An Overview*. TVCG 2003.](#)
 - [Georgiev et al. *Simple and Robust Iterative Importance Sampling of Virtual Point Lights*. EG 2010.](#)



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



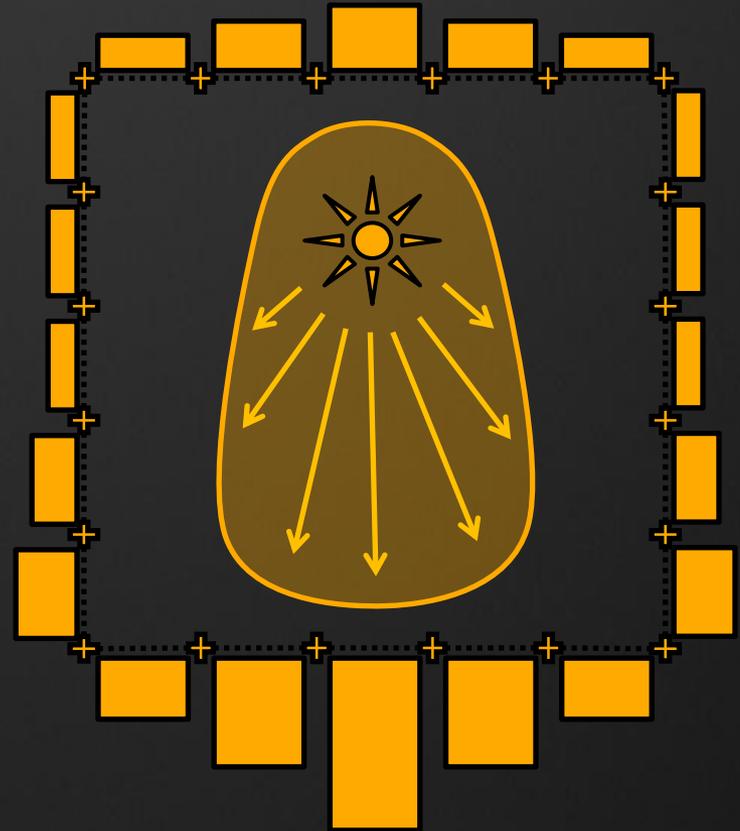
With Targeting

No Targeting

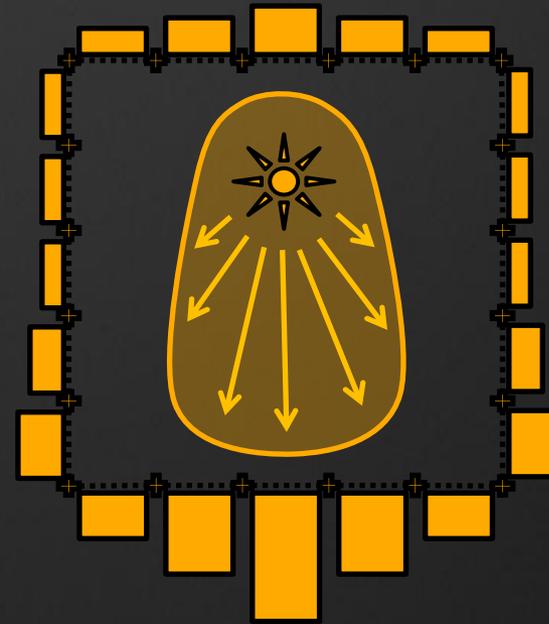
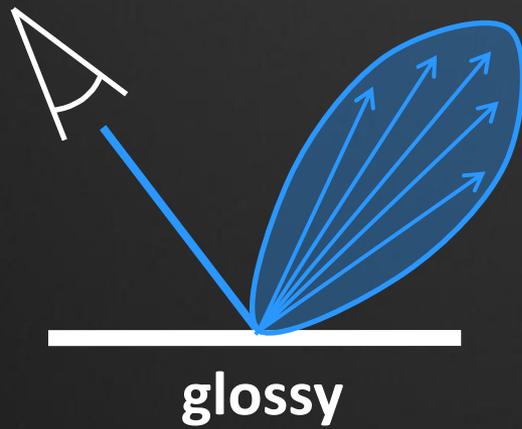


Issue #3: Directionally Variant Lights

- 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



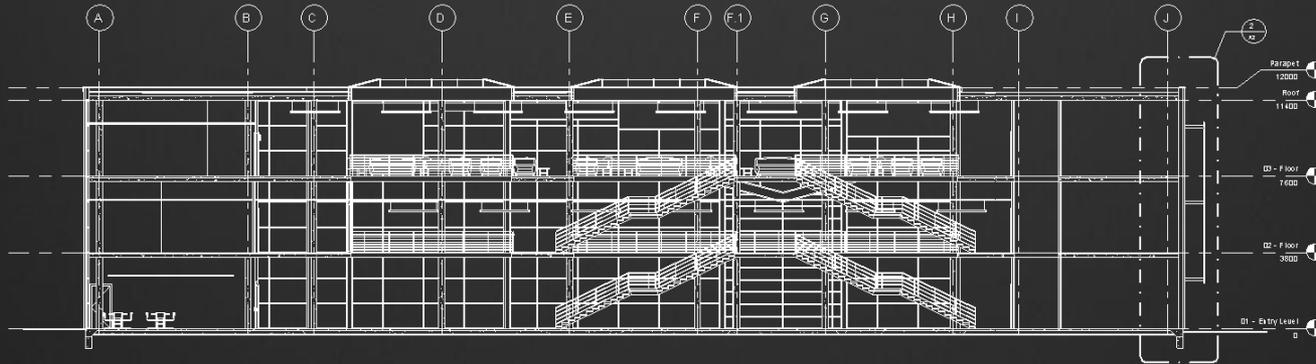
Many Lights



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)

Night (sky off)

Sectioned



Baseline

2.5x

Full Model

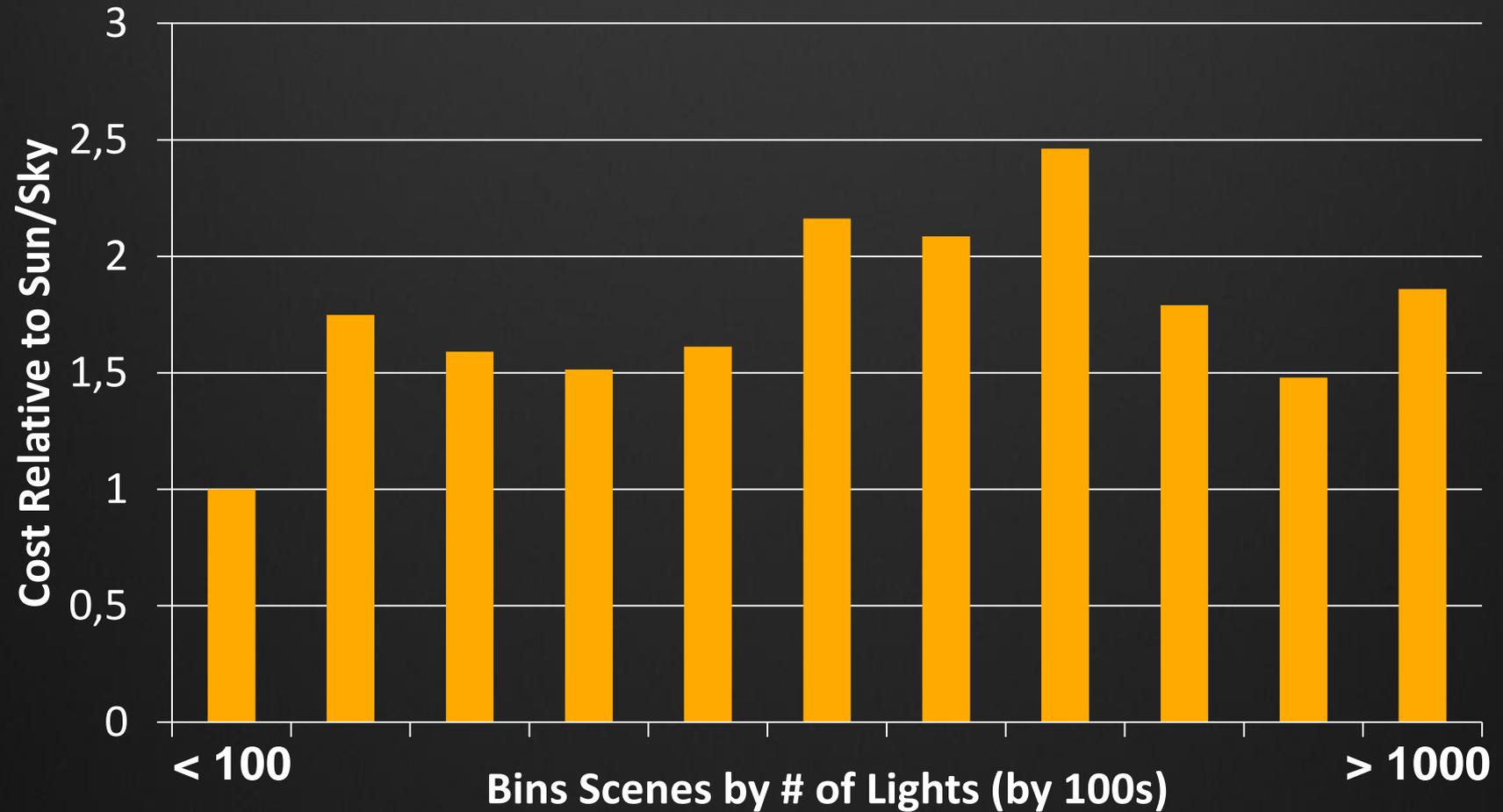


1.25x

2.6x

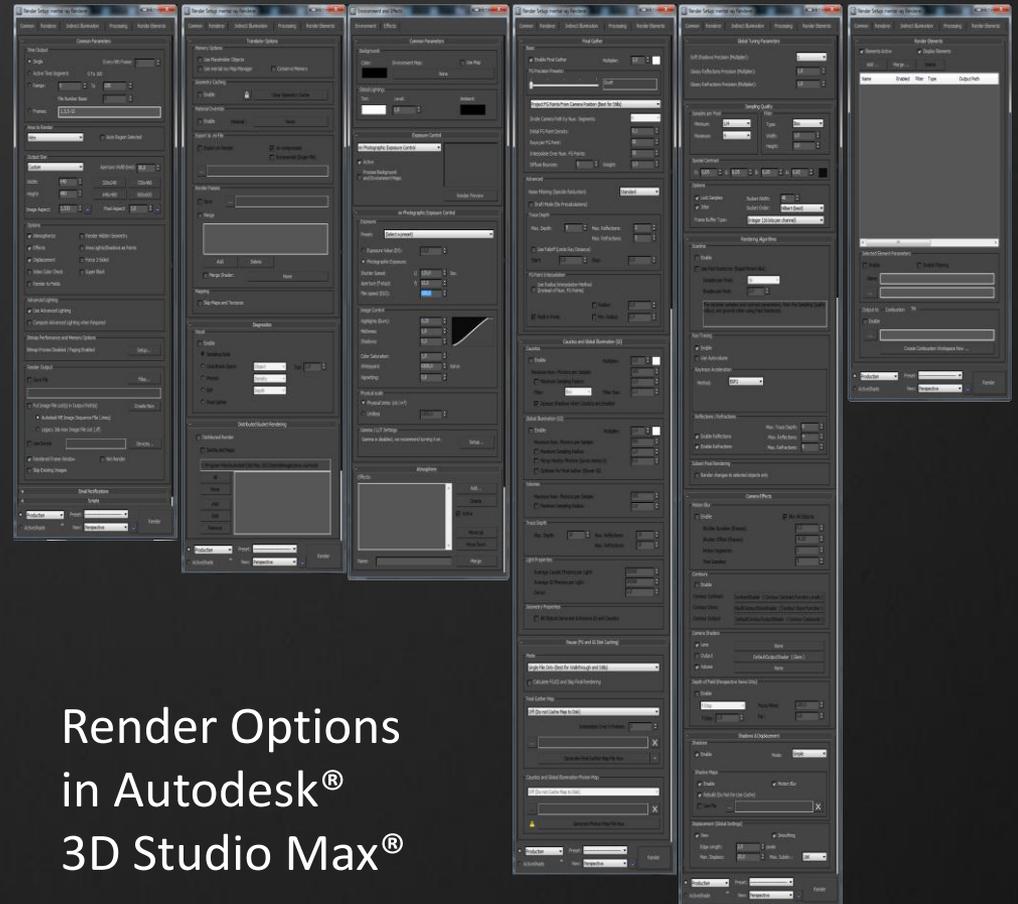


Relative Render Time by Lighting



Advantage #4: Automatic Rendering

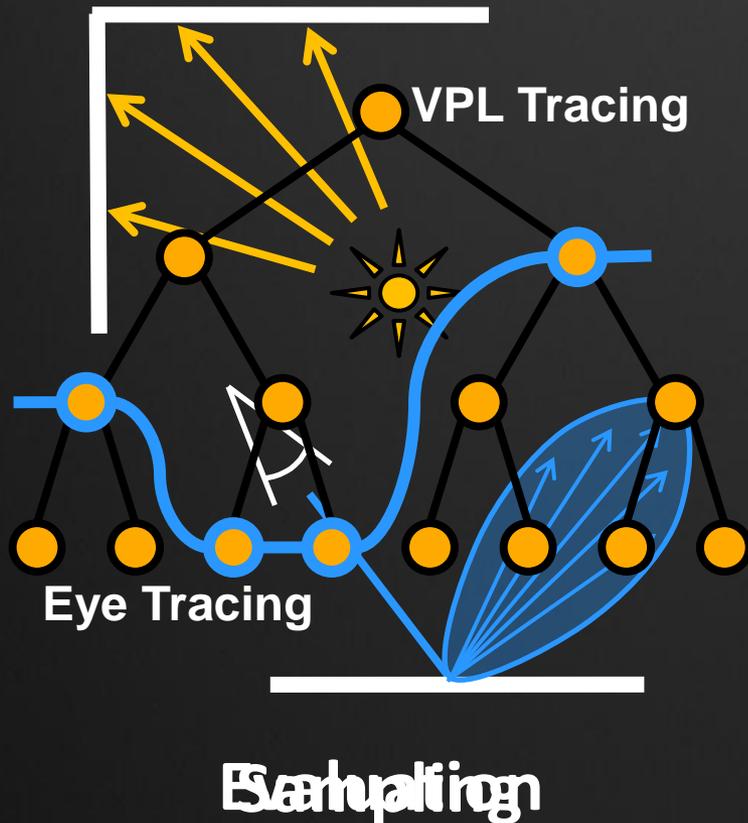
- Configuring a render can be a challenge...
 - Requires expertise
 - Image dependent
 - Time consuming
- Especially in design visualization where users want predictive images.



Render Options
in Autodesk®
3D Studio Max®



Advantage #4: Automatic Rendering

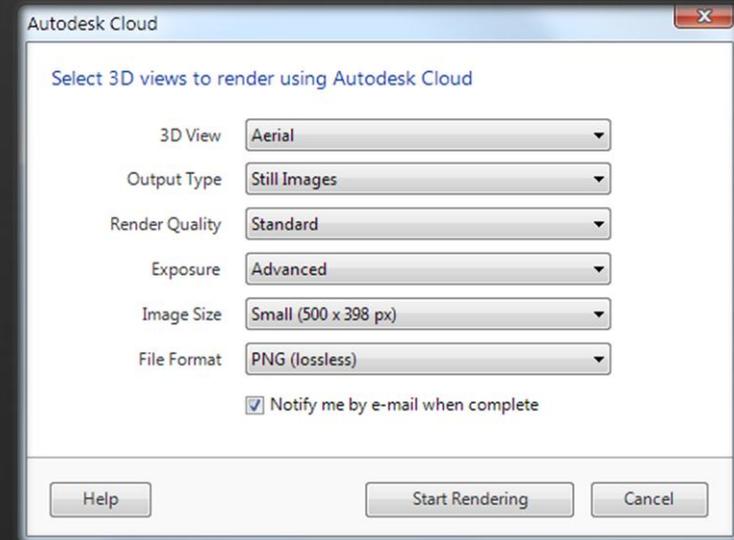


- A many-lights algorithm's two-part structure helps automation.
- **First part:** Sampling
 - Sets overall lighting quality
 - Requires expert knowledge
 - Unimportant to novices
- **Second part:** Evaluation
 - Determines images quality
 - Easy to understand
 - Controls cost/quality tradeoff



Advantage #4: Automatic Rendering

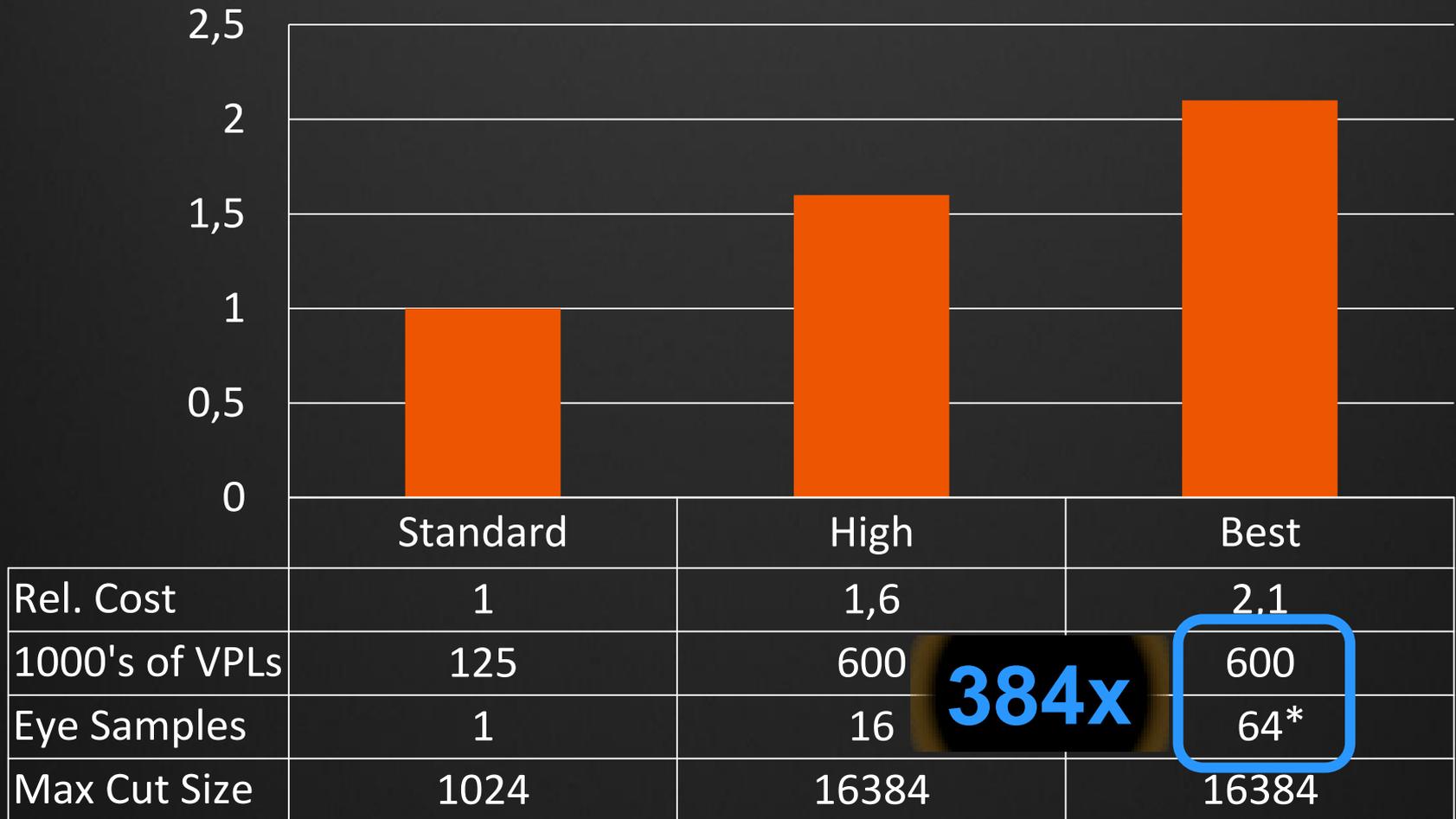
- Many-lights algorithms facilitate automation
 - Set conservative sampling settings internally
 - Hide complex details the user
 - Use predefined quality settings for eye sampling rate and error thresholds
 - Rely on the scalable evaluation to avoid extra work



Render Options
in Autodesk®
360 Rendering



Relative Render Time By Quality (50K scenes)

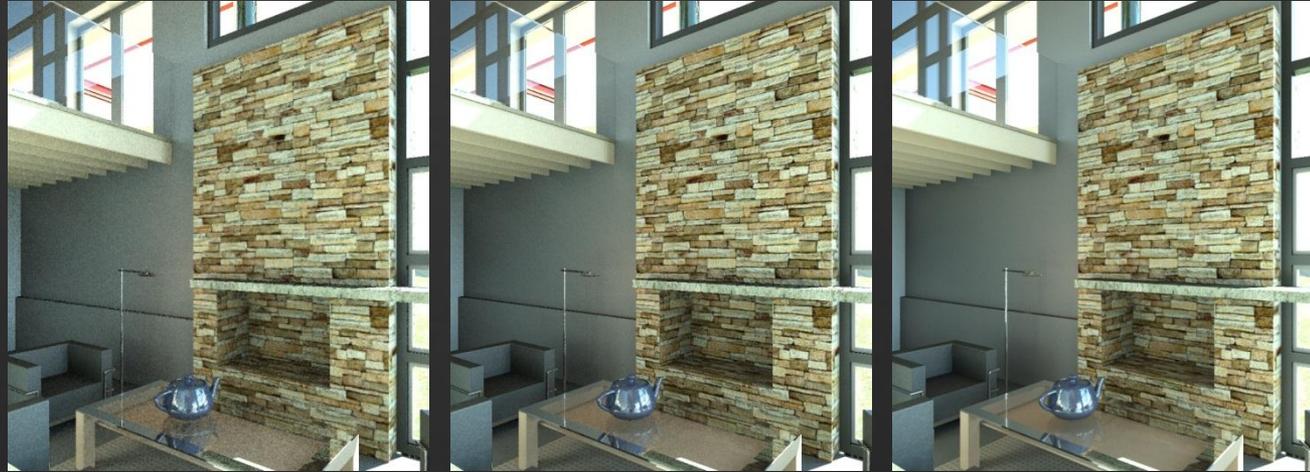


* Approximate average of 32-256 adaptive sampling



Advantage 5: High Quality Preview

Autodesk® 360
Renderer

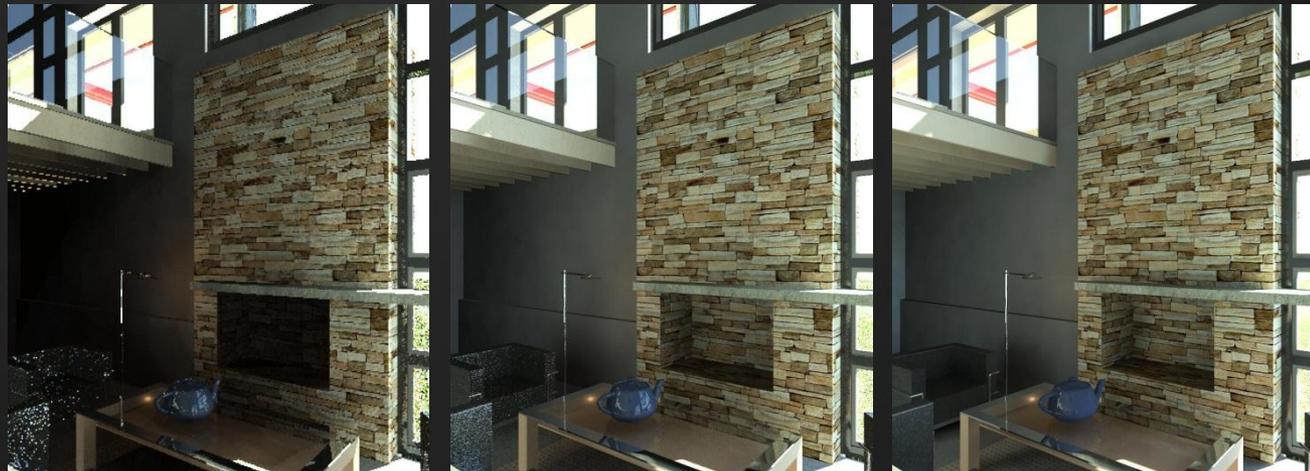


1x



10x

Path Tracer
with Irradiance
Caching

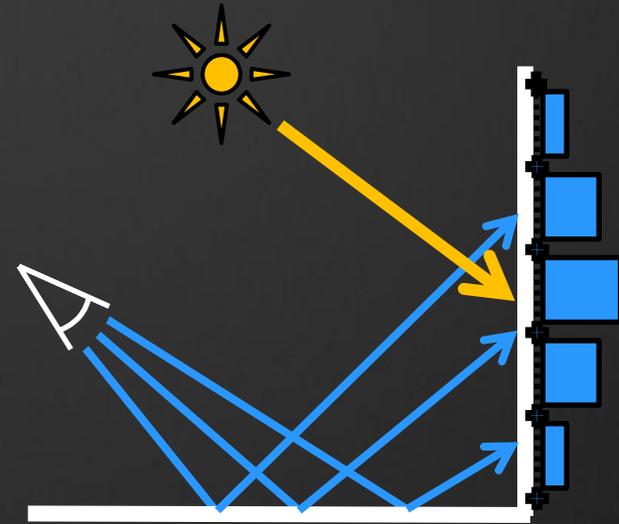


Cloud Platforms

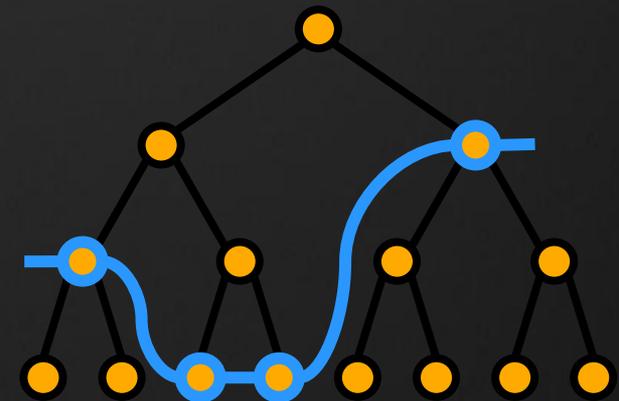
Autodesk

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



VPL Generation



Error and Refinement



Conclusion

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

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Questions?



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