Intel oneAPI Rendering Toolkit

# Overview & Introduction

Christoph Riesinger

# Intel® oneAPI Rendering Toolkit

## Render Your Vision in Highest Fidelity

- Enables high-performance, high-fidelity, modern graphics applications that scale
- Flexible, cost efficient development using open-source libraries
- Create amazing visual, hyper-realistic renderings via ray tracing with global illumination
- Access all system memory space to create renderings using the largest data sets


Learn More: intel.com/oneAPI-RenderKit

[1] Avengers: Infinity War - Digital Domain, Marvel Studios, Chaos Group V-Ray

# INTEL® EMBREE RAY TRACING LIBRARY

SVEN WOOP
CARSTEN BENTHIN
ATTILA T. ÁFRA
MANFRED ERNST
INGO WALD

ACADEMY CERTIFICATE

*For the past decade, the Intel Embree Ray Tracing Library has provided a high-performance, industry-leading, CPU-based ray-geometry intersection framework through well-engineered open source code, supported by a comprehensive set of research publications. It has become an indispensable resource for motion picture production rendering.*

https://oscars.org/sci-tech/ceremonies/2020

# Intel® oneAPI Rendering Toolkit: Advantages

## Render Your Vision in Highest Fidelity

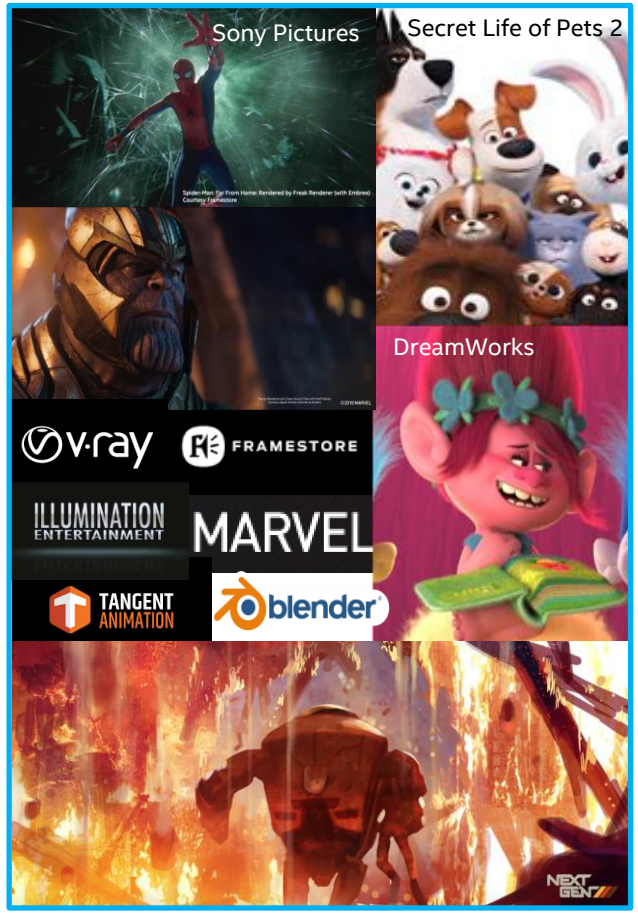
- Performance
- Functionality
- Flexibility
- Scalability
- Openness


[1]Moana Scene courtesy of Disney Animation

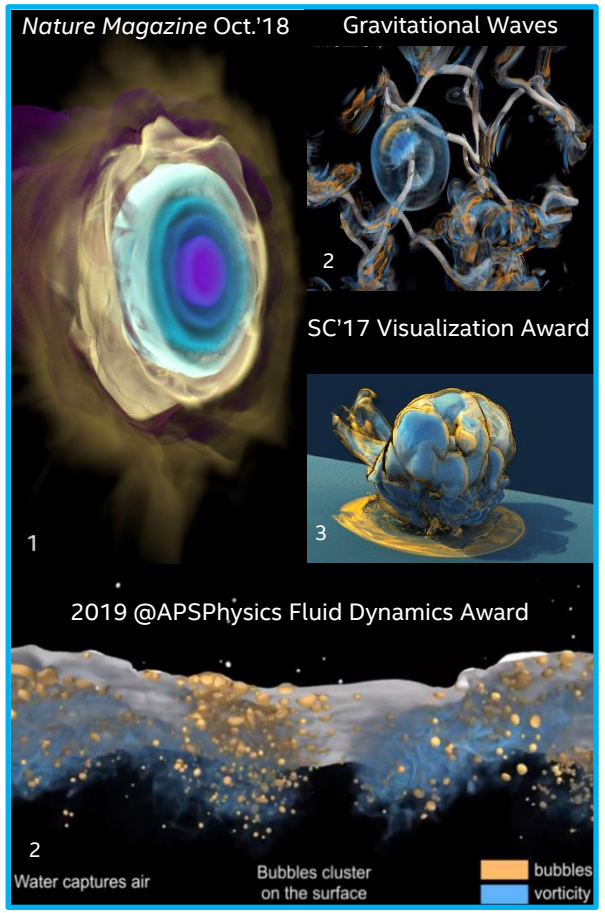
[1]Disney Cloud courtesy of Disney Animation

# Intel® oneAPI Rendering Toolkit: Coverage for Multiple Domains

## Studio Animation

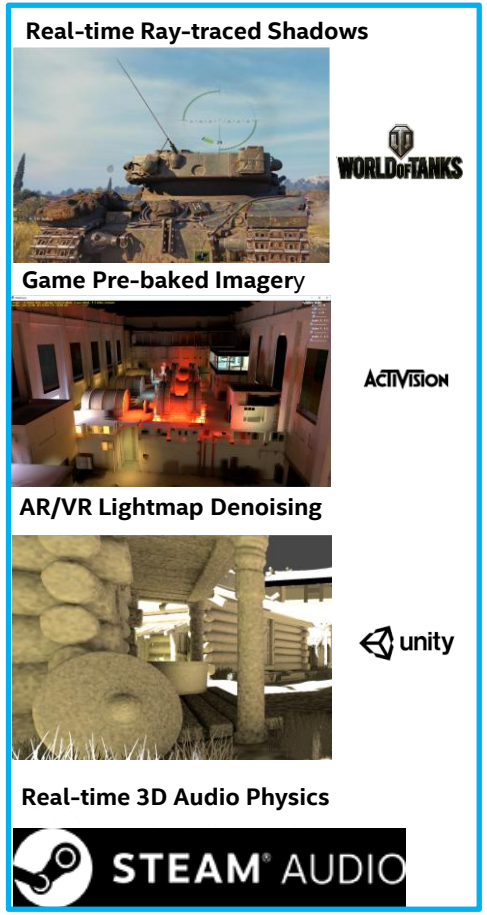



## Scientific Visualization




## 3D Product & Architectural Design


## Gaming AR VR




[1]UC Santa Barbara & Argonne National Labs, Spherical VolumetrIc Path Tracing;
[2]Amelia Drew, Paul Shellard, Stephen Hawking CTC, Carson Brownless, Intel
[3]John Patchett et al, Los Alamos National Lab
[4]Petr Karnakov, Sergey Litvinov, Petros Koumoutsakos, ETH Zurich Jean M. Favre, CSCS gfm.aps.org/meetings/dfd-2019/5d7522a5199e4c429a9b2bbe

*No Developer Left Behind!*

TANGENTSTUDIOS | intel

# Years-long Collaboration

- Tangent Studios' use of Open Source Blender allows fast production time for ultra high-quality projects—including Netflix productions
- AI-based Intel® Open Image Denoise decreases render time
- Intel® Embree adds predictability to stay on-time & on-budget as Tangent realizes **5X to 6X** reduction in renders*
- Tangent pushes innovation, fidelity boundaries with Universal Scene Description support & Intel® oneAPI Rendering Toolkit


*Tangent Studios' Jeff Bell Shares How Intel Helps Accelerate Rendering ▶ [2.35]

[1]Courtesy Baozou Production in association with Tangent Animation using Blender with Intel® Embree.
Media courtesy of Netflix, Inc. Now streaming on Netflix. Netflix subscription required.
*See Configuration slide for configuration details. For more complete information about performance and benchmark results, visit www.intel.com/benchmarks.

# Years-long Collaboration

*More than 300 Films!*

CPU advantage

- Maximizes every core & processor
- Seamless integration across Chaos Group's customers with consistent development targets, + support for future hardware generations

Intel® Embree delivers performance & advanced capabilities for V-Ray & Corona Renderers

Up to **90%** memory reduction using displacement* resulting in enriched scenes with less RAM

Intel® Open Image Denoise in Corona for great images faster


*Chaos Group's Phil Miller Shares How Intel oneAPI Tools Boost V-Ray & Corona ▶ [2.19]

[1]Courtesy Chaos Group.

*See Configuration slide for configuration details. For more complete information about performance and benchmark results, visit www.intel.com/benchmarks.

Refer to software.intel.com/articles/optimization-notice for more information regarding performance & optimization choices in Intel software products.

# What Customers are Saying…

ILLUMINATION MACGUFF

*"We found Intel's Embree ray-tracing kernels to be **the best efficient alternative** to our legacy code **to improve the performance.***

*This drastically improved multi-threaded and vectorization capabilities that **reduced our rendering time** helping Illumination Mac Guff and **increase the quality and richness** of our images."*

**Xavier BEC, Head of Research & Development**

MAXON
A NEMETSCHEK COMPANY

*"[Intel] Embree technology offers **faster raycasting for massive speedups** in scenes with lots of reflections and transparency"*

*"Cinebench R20 and Cinema 4D R20 incorporate the latest rendering architectures, including integration of Intel's Embree raytracing technology and advanced features on modern CPUs from… Intel that allow users to render the same scene on the same hardware **twice as fast** as previously."*

*"Rendering in Cinema 4D is synonymous with a high degree of quality in less time. The integrated Intel Embree library can **speed up rendering by up to 300% - depending on the scene – without loss of quality!**"*

**MAXON Cinema4D**

**Watch Standard Renderer Video >**
**CINEBENCH**
**ARCHICAD**

Embree

Open Image Denoise

Open VKL

OSPRay

*Data courtesy Bentley*, Disney* *Other names and brands may be claimed as the property of others

Embree



Open Image Denoise



Open VKL



OSPRay

*Data courtesy Bentley*, Disney*  *Other names and brands may be claimed as the property of others

# Intel® Embree: Overview

## High-Performance, Feature-Rich Ray-Geometry Intersection Library

- Highly-optimized ray tracing kernel library
- Support for latest CPUs and ISAs (e.g. Intel® AVX-512)
- Windows*, macOS* 10.x, Linux* support
- API for easy integration into applications
- Open Source under Apache* 2.0 license

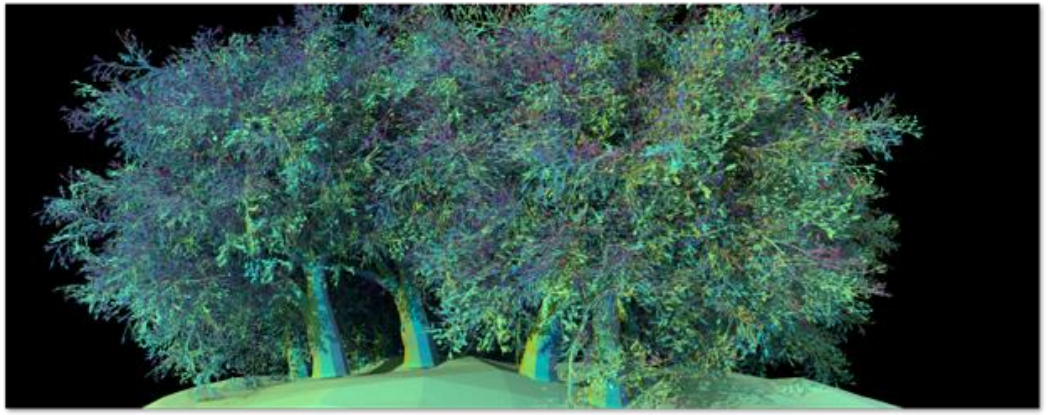
  www.embree.org


[1]The Grinch, Courtesy Illumination Studios

# Intel® Embree: Features

## High-Performance, Feature-Rich Ray-Geometry Intersection Library

- Provides rich functionality and flexibility
  - Hair, Fur, and Complex Line Geometry
  - Efficient Subdivision Surfaces
  - Multi-Segment and Quaternion Motion Blur
  - Multi-Level Instancing
  - User Specified Geometries
  - and much more



[1]Trolls, Courtesy DreamWorks Animation

# Intel® Embree

## High-Performance, Feature-Rich Ray-Geometry Intersection Library

- Widespread Adoption
- Academy Award Winning
- Best In Class Performance




[1]How To Train Your Dragon: The Hidden World – Dreamworks Animation
[2]Peter Rabbit – Animal Logic
[3]Abominable – Dreamworks Animation

# Intel® Embree: Integrations

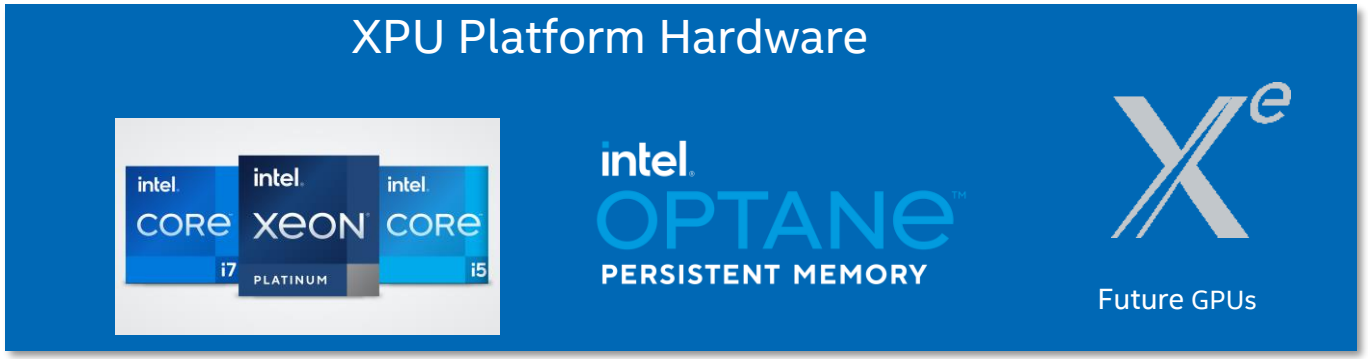
## High-Performance, Feature-Rich Ray-Geometry Intersection Library

# Intel® Embree: Upcoming Features

**High-Performance, Feature-Rich Ray-Geometry Intersection Library**

- ARM Support
- Embree 4.0
- XPU Support

oneAPI



Embree

Open Image Denoise

Open VKL

OSPRay

*Data courtesy Bentley*, Disney* *Other names and brands may be claimed as the property of others


Ground truth:
32K spp
RETAIL
The Junk Shop by Alex Treviño. Original Concept by Anaïs Maamar.
blender™


Ground truth:
32K spp
Low sample count:
16 spp
RETAIL
The Junk Shop by Alex Treviño. Original Concept by Anaïs Maamar.
blender

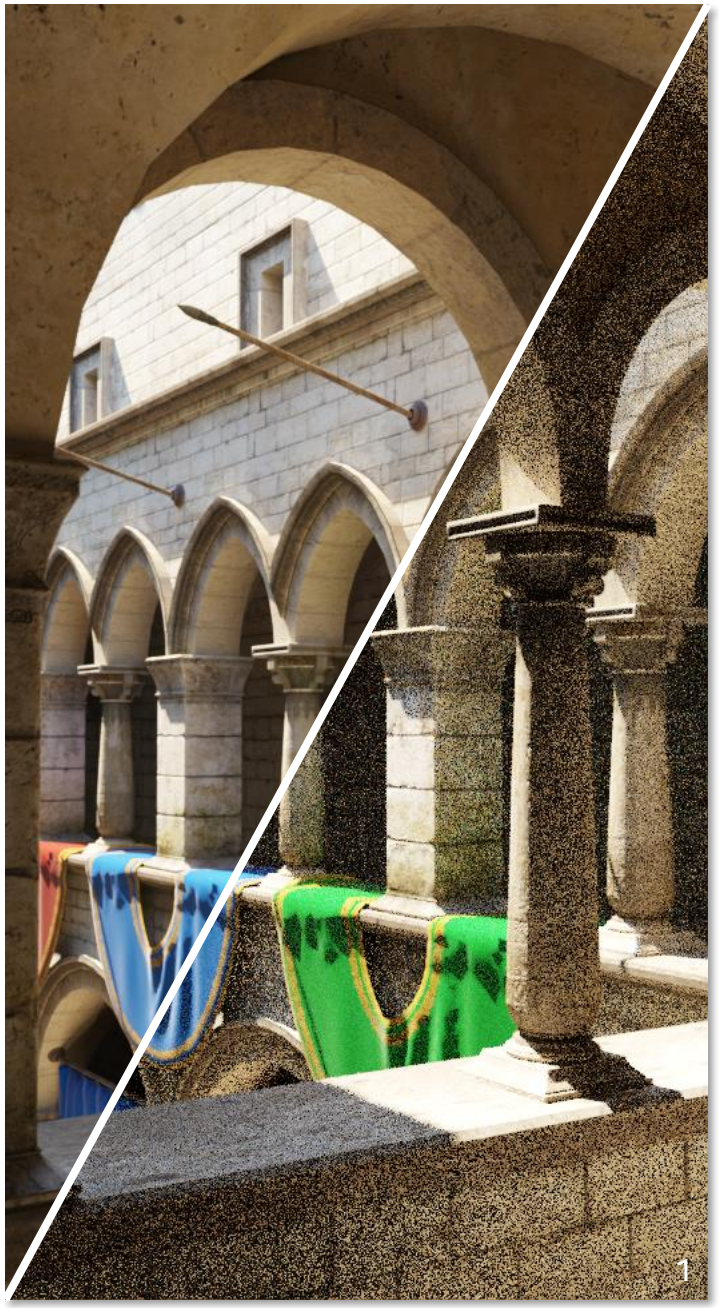

The Junk Shop by Alex Treviño. Original Concept by Anaïs Maamar.

# Intel® Open Image Denoise: Overview

## High-Quality, Deep Learning Based Monte-Carlo Image Denoising Filters

- Final frame and baked lightmap denoising
- Suitable for interactive and offline rendering
- User-trainable with the included training toolkit
- Windows*, macOS*, Linux* support
- Supported hardware:
  - x86 CPUs, Apple M1* support
- Open Source under Apache* 2.0 license

www.openimagedenoise.org




[1]Scene courtesy of Frank Meinl, downloaded from Morgan McGuire's Computer Graphics Archive.

# Intel® Open Image Denoise: Workflow

## High-Quality, Deep Learning Based Monte-Carlo Image Denoising Filters

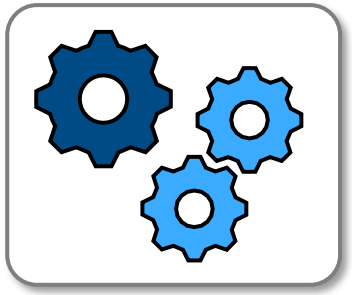
Renderer: Feature Buffers

Color

Albedo
(optional)

Normal
(optional)

Intel Open Image Denoise



Denoised result

[1]Scene by Christophe Seux.

# Intel® Open Image Denoise: Features

## High-Quality, Deep Learning Based Monte-Carlo Image Denoising Filters

- Multiple input buffers
  - Color buffer
  - Optional auxiliary feature buffers
    - Albedo
    - Normal
- LDR and HDR images
  - Robust HDR support
  - Handles fireflies without special pre-filtering
- Individual network training
  - Customized to a specific renderer or set of scenes


Low sample count:
16 spp
Rendered with Corona Renderer. Scene by Evermotion (“15th Anniversary Collection”).
corona


Rendered with Corona Renderer. Scene by Evermotion (“15th Anniversary Collection”).


Rendered with Corona Renderer. Scene by Evermotion (“15th Anniversary Collection”).


Low sample count:
64 spp
Blender Institute: Agent 327 Barbershop (CC-BY-ND)
blender™

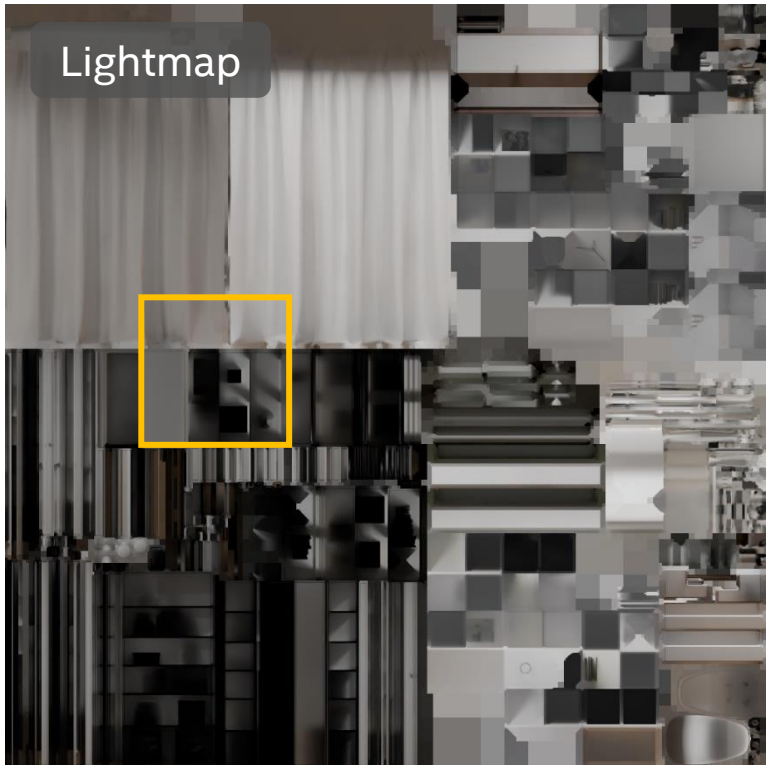

Low sample count:
64 spp (denoised)
intel
Open Image
Denoise
blender™
Blender Institute: Agent 327 Barbershop (CC-BY-ND)

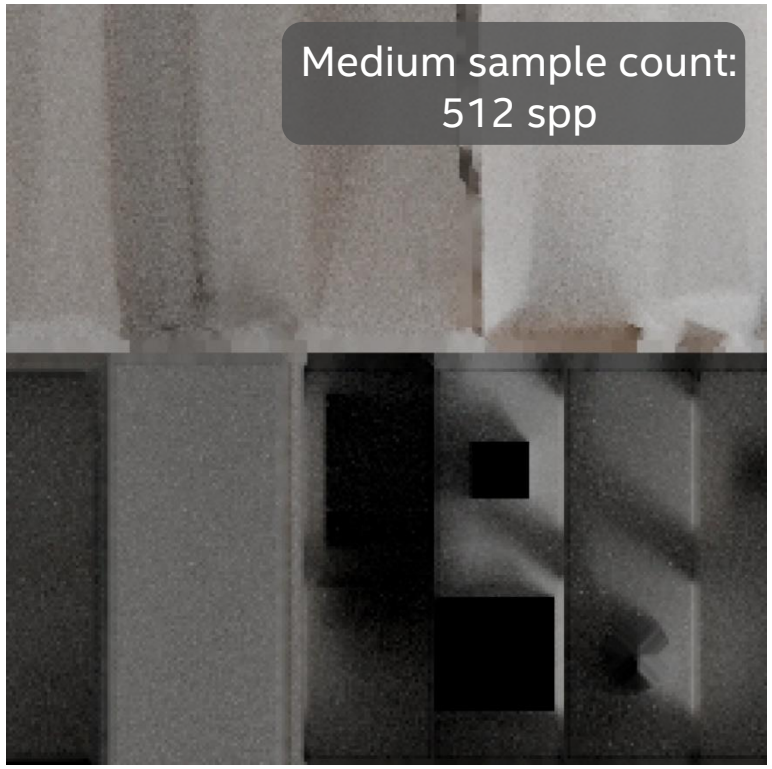

Ground truth:
16K spp
Low sample count:
64 spp (denoised)
Blender Institute: Agent 327 Barbershop (CC-BY-ND)
intel
Open Image
Denoise
blender™

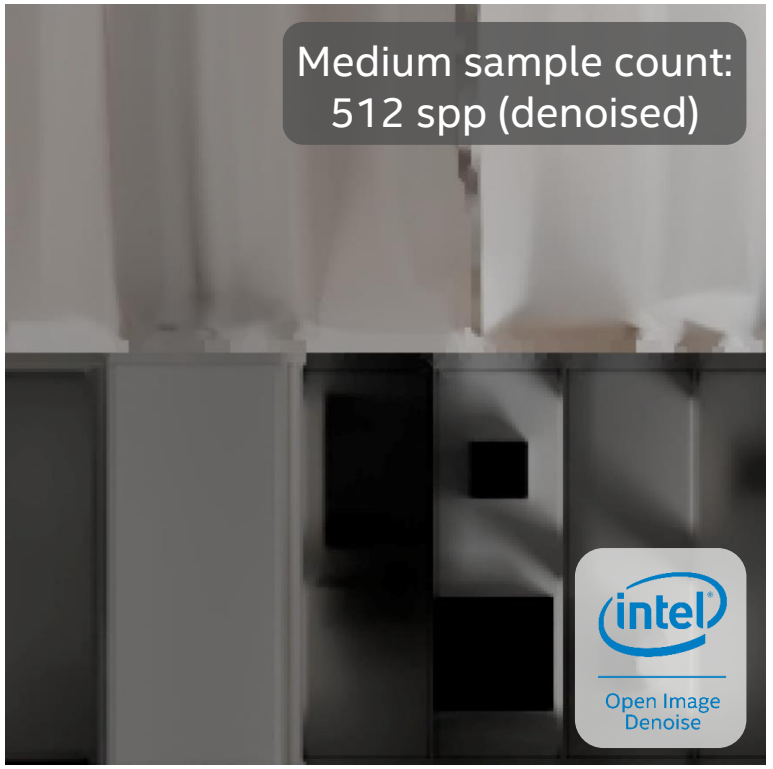

Blender Institute: Agent 327 Barbershop (CC-BY-ND)

# Intel® Open Image Denoise: In Games

## High-Quality, Deep Learning Based Monte-Carlo Image Denoising Filters




- Lightmaps store direct and indirect illumination in textures
- Need to be recalculated (via path tracing) when the scene or lighting changes
- Low sample counts lead to noise resulting in blotchy artefacts in final renders


Medium sample count lightmap:
512 spp
Unity's ArchViz Demo
unity


Medium sample count lightmap:
512 spp (denoised)
intel
Open Image
Denoise
unity
Unity's ArchViz Demo


Medium sample count lightmap:
512 spp
Medium sample count lightmap:
512 spp (denoised)
Open Image
Denoise
unity
Unity's ArchViz Demo

# Intel® Open Image Denoise: Integrations

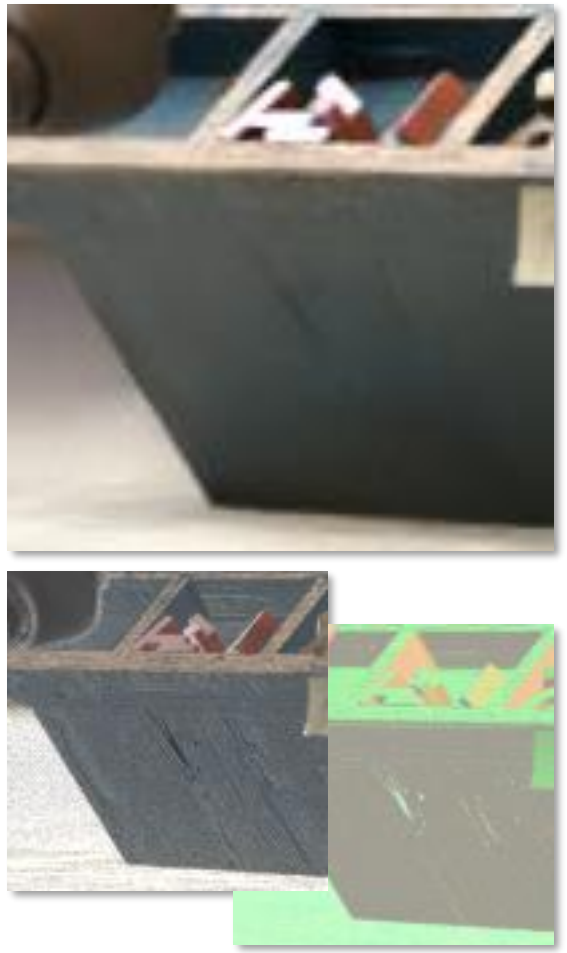
## High-Quality, Deep Learning Based Monte-Carlo Image Denoising Filters

# Intel® Open Image Denoise: Upcoming Features

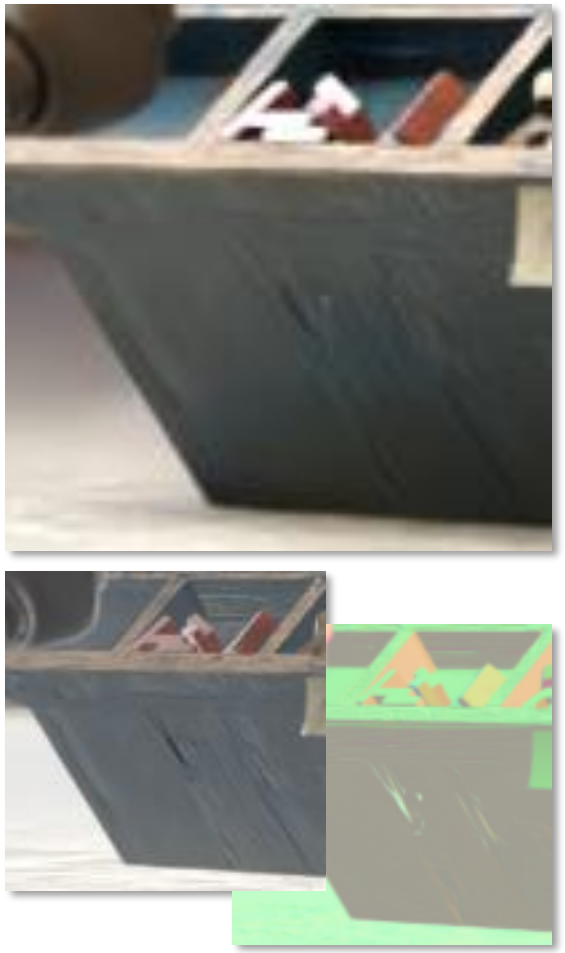
## High-Quality, Deep Learning Based Monte-Carlo Image Denoising Filters

- Auxiliary feature buffer denoising as an optional prefiltering step
- Improved quality when using clean/denoised auxiliary buffers
- Temporally coherent denoising for animations
- XPU Support

Noisy Features



Denoised Features



Embree



Open Image Denoise

Open VKL



OSPRay

*Data courtesy Bentley*, Disney*  *Other names and brands may be claimed as the property of others

# Intel® Open VKL: Overview

## High-Performance, Feature-Rich Volume Traversal Library

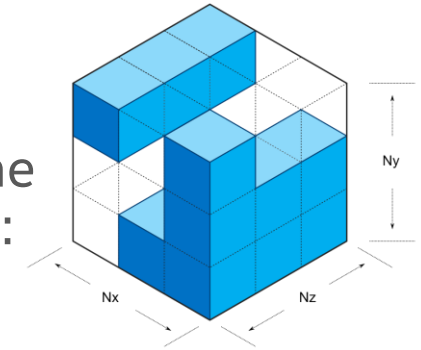
- Highly-optimized volume sampling and traversal kernel library
- Support for latest CPUs and ISAs (e.g. Intel® AVX-512)
- Windows*, macOS* 10.x, Linux* support
- API for easy integration into applications
- Open Source under Apache* 2.0 license

  www.openvkl.org

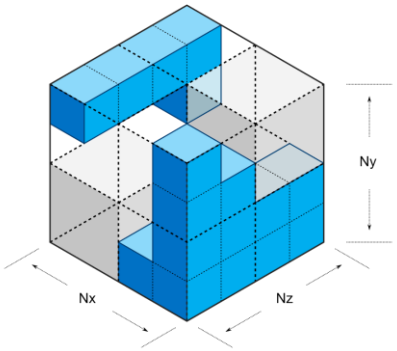
# Intel® Open VKL: Features

## High-Performance, Feature-Rich Volume Traversal Library

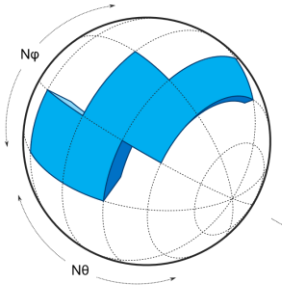
Volume types:

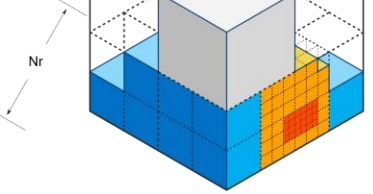



Structured



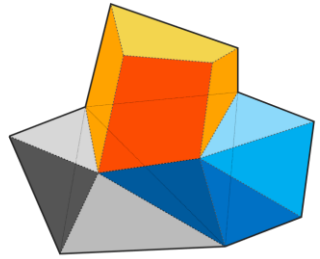

VDB (Sparse Structured)



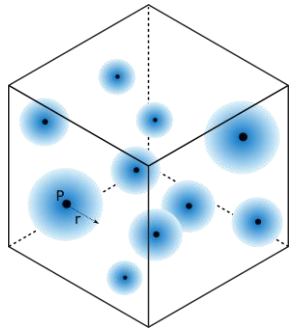




Spherical Structured

Adaptive Mesh Refinement



Unstructured




Particle

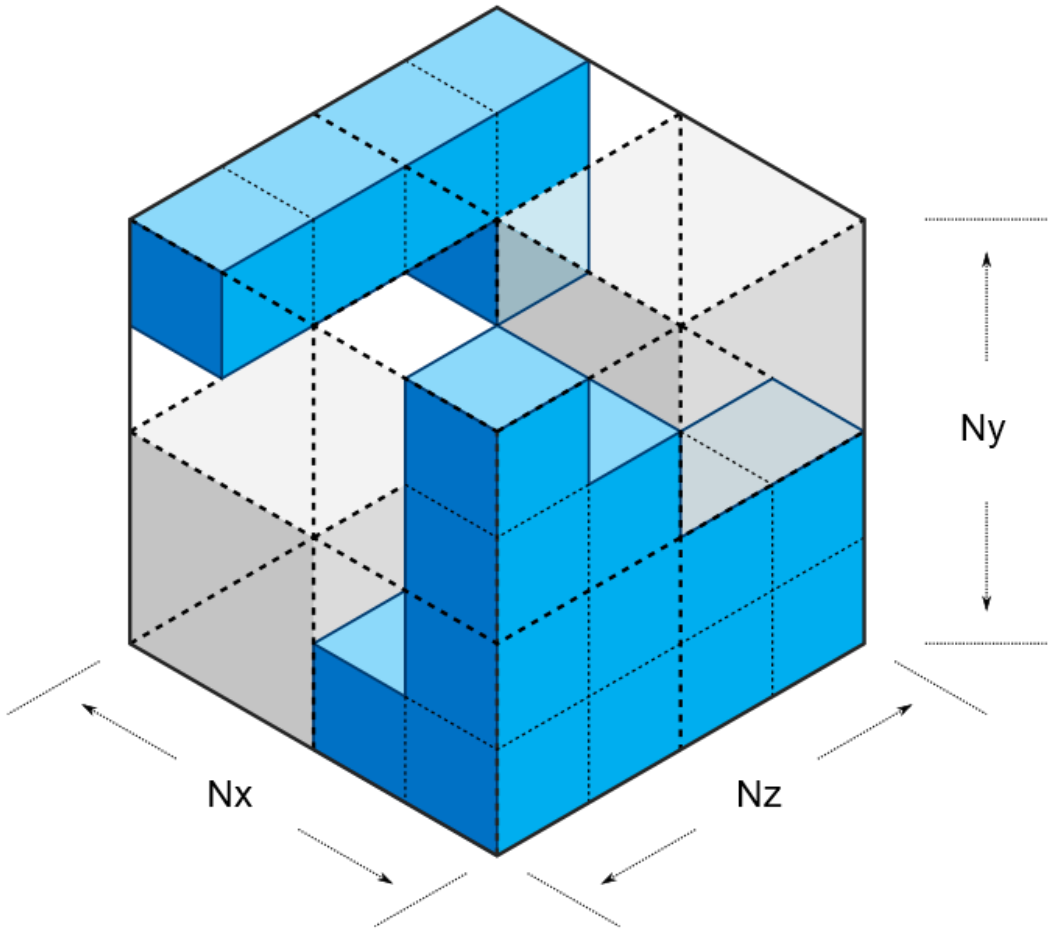
APIs:

- Sampling
- Gradient computation
- Ray-based interval iteration
- Implicit Isosurfacing
- Volume Observers

# Intel® Open VKL: OpenVDB Support

## High-Performance, Feature-Rich Volume Traversal Library

- VDB Volumes – Sparse Grids
  - Fast Access
  - Efficient Use of Memory
  - Load .vdb files Directly



# Intel® Open VKL: Motion Blur

## High-Performance, Feature-Rich Volume Traversal Library

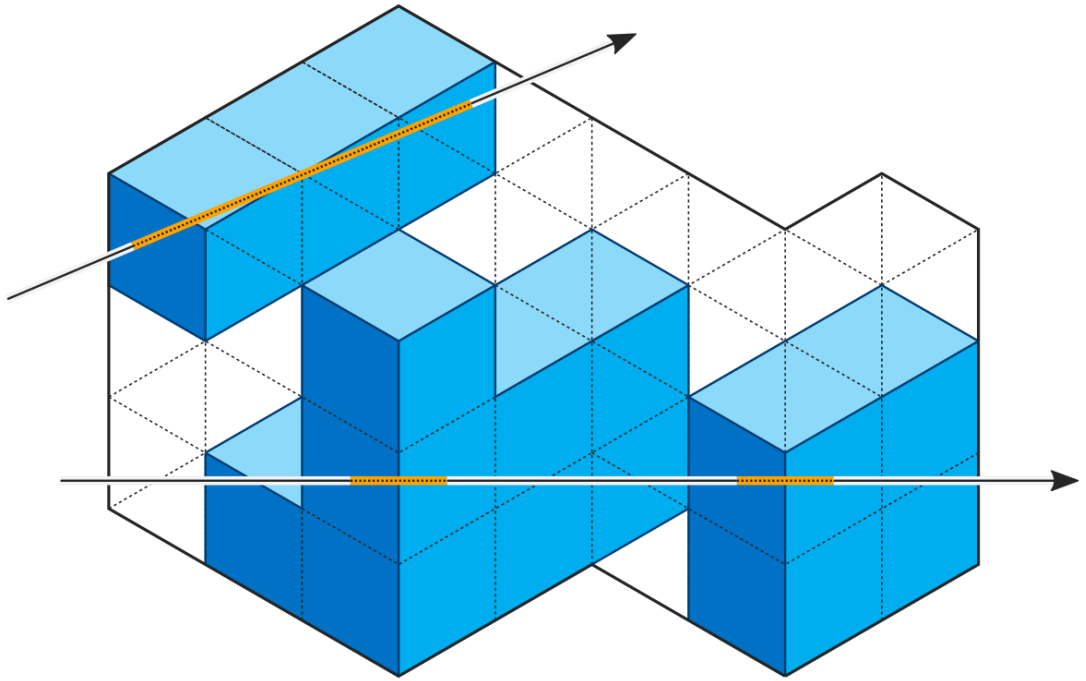
- Direct Support for Motion Blur
  - Optimal Performance with Structured Temporal Data
  - Flexibility and Memory Savings with Unstructured Temporal Data

**Sampling** | **Gradient computation** | Ray-based interval iteration | Implicit Isosurfacing | Volume Observers

# Intel® Open VKL: Iterators

## High-Performance, Feature-Rich Volume Traversal Library

- Ray-Based Interval Iteration allowing iteration over meaningful intervals
  - Value Ranges per Interval for Tracking Methods
  - Step Sizes per Interval for Ray Marching Methods

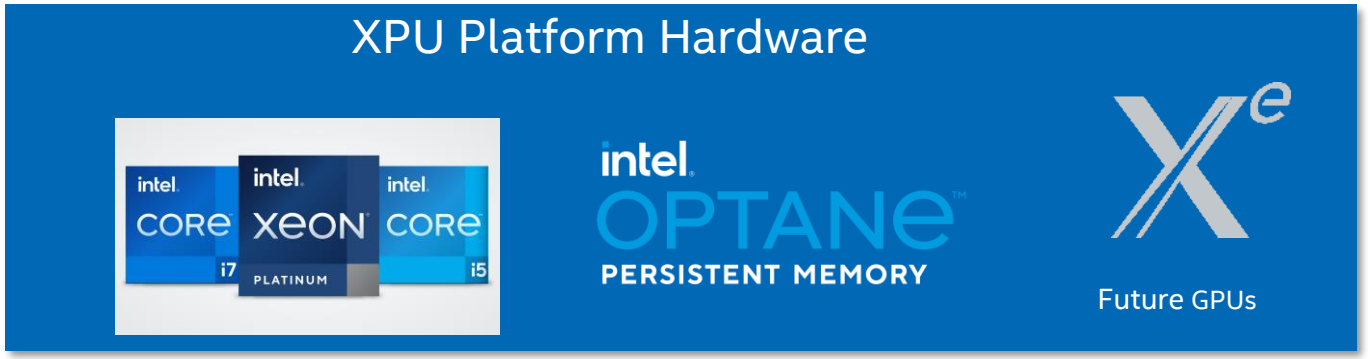


Sampling | Gradient computation | **Ray-based interval iteration** | Implicit Isosurfacing | Volume Observers

# Intel® Open VKL: Upcoming Features

**High-Performance, Feature-Rich Volume Traversal Library**

- Motion Blur Sampling API Extended to VDB Volumes
- Version 1.0 Release
- XPU support



Embree



Open Image Denoise



Open VKL

OSPRay

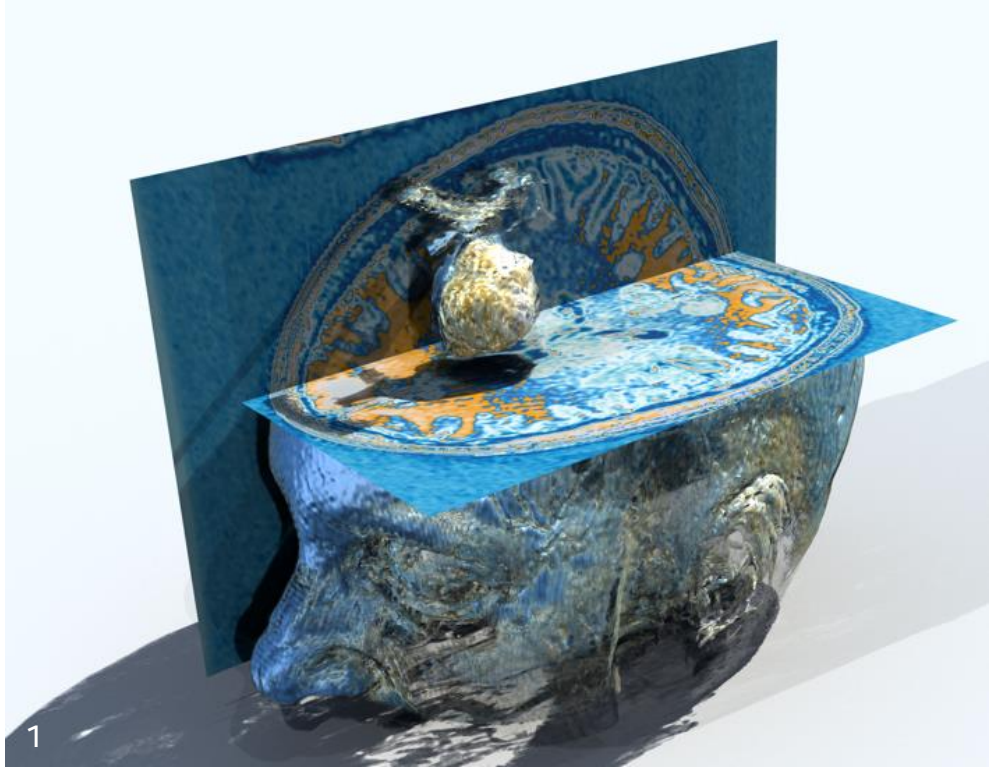
*Data courtesy Bentley*, Disney* *Other names and brands may be claimed as the property of others

# Intel® OSPRay: Overview

## An Open Scalable Portable Ray Tracing Library

- Integrates our low-level libraries into a full rendering library for scalable CPU ray tracing
- Renderers ranging from fast visualization to photoreal path tracing
- **Scalable** from laptops up to multi-node supercomputers
- Windows*, macOS*, Linux* support
- Open Source under Apache* 2.0 license

  www.ospray.org





[1]Data courtesy Kitware. Visualization Dave Demarle, Carson Brownlee
[2]Villa scene by Florent Boyer and Skylight map courtesy by Nolan Goodnight.
[3]Modern Hall scene from Blendswap by NewSee21035.
[4]Landscape scene by Jan-Walter Schliep, Burak Kahraman, and Timm Dapper from Laubwerk.

# Intel® OSPRay: Scalability

## Scalable, interactive rendering of large data sets


- Interactive (~10FPS) of a gravitational waves simulation (36TB)
- Multi-node setup (1x Intel® Xeon® E5 v4 Dual Socket + 4x Intel® Xeon Phi™ 7230 Processors)

# Intel® OSPRay: Usage in Scientific Visualization

## Scalable, interactive rendering of large data sets

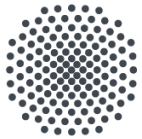
Computer Graphics Charles University

& Chaos Research


Northern Illinois University

UNIVERSITY OF CAMBRIDGE





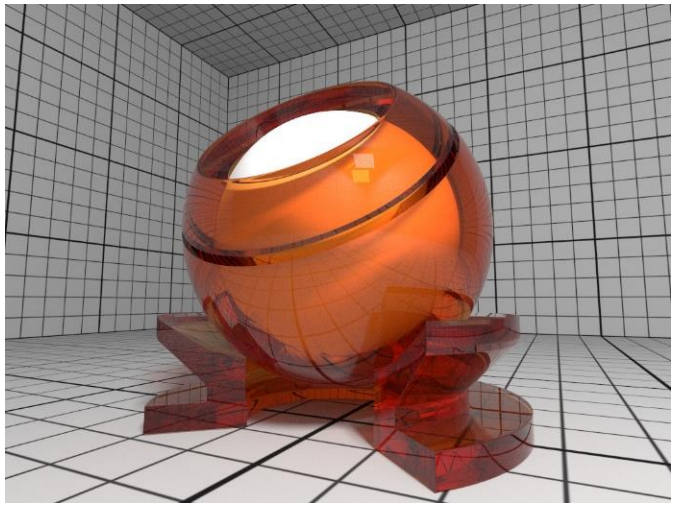
University of Stuttgart
Germany

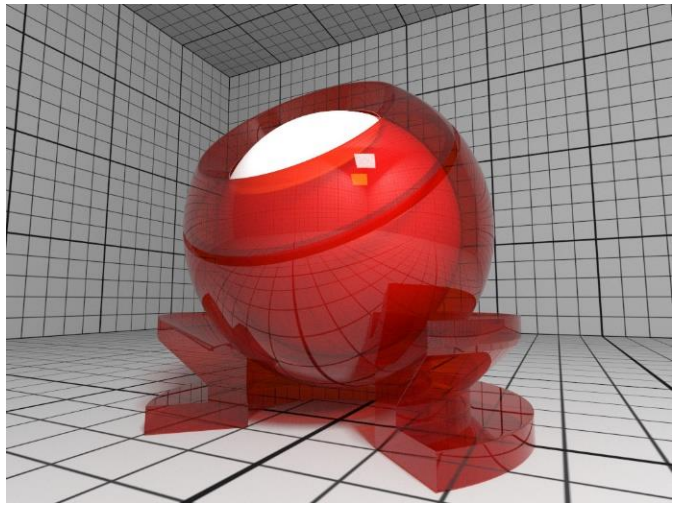
TACC

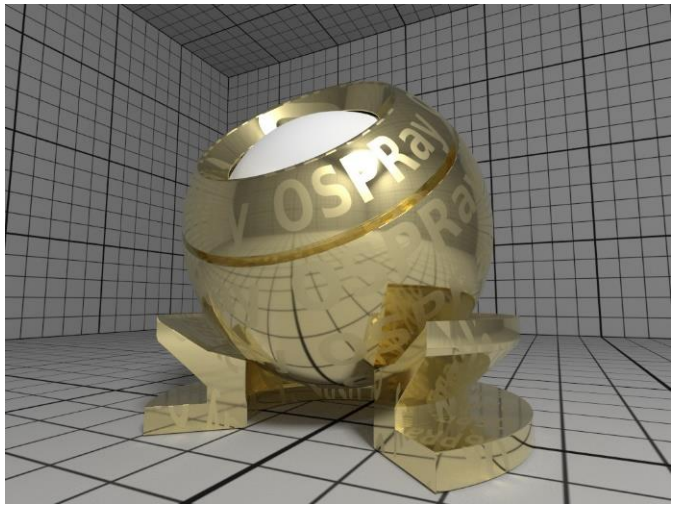

THE UNIVERSITY OF TENNESSEE KNOXVILLE

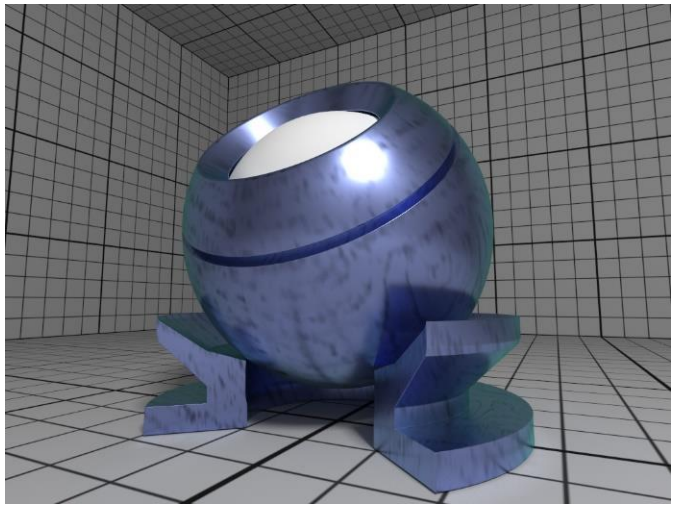
# Intel® OSPRay: Path Tracer and Realistic Materials

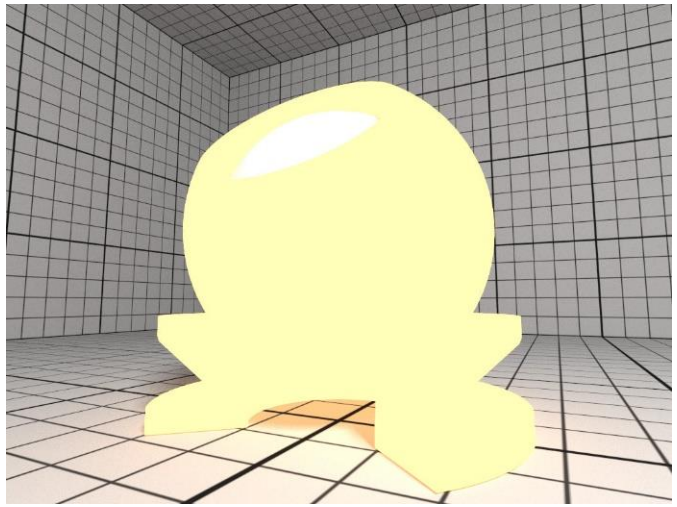
## Scalable, interactive rendering of large data sets







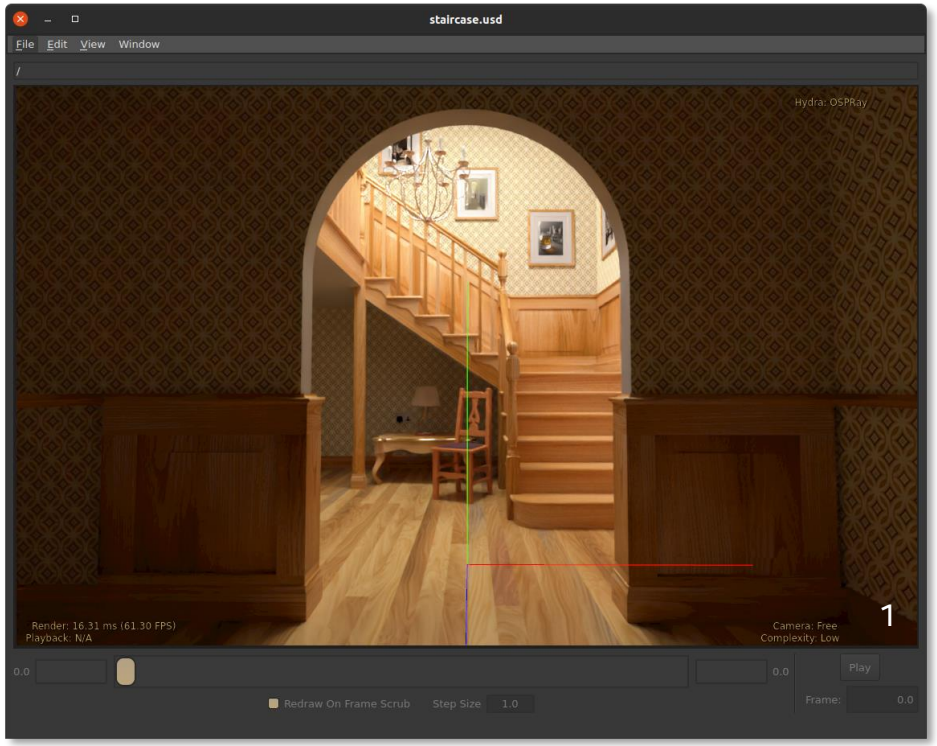




# Intel® Hydra for OSPRay

## An OSPRay Hydra plugin for the USD ecosystem

- Allows rendering/exploring USD scenes using OSPRay
- Multiple render modes for fast pre-vis or photo realistic path tracing
- Supports:
  - **USDLux** light sources
  - **USDPreviewSurface** material
  - **Ptex** textures
  - **instancing**
- Open Source under Apache* 2.0 license [https://github.com/ospray/hdospray](https://github.com/ospray/hdospray)




[1]The Wooden Staircase scene from Blendswap by Wig42.

USD OSPRay Open Image Denoise Embree

Landscape scene by Jan-Walter Schliep, Burak Kahraman, and Timm Dapper from Laubwerk. Rendered with Hydra for OSPRay.

# Intel® OSPRay Studio

## Interactive visualization application

- File Importer – obj/mtl, glTF, vdb, structured and unstructured volume formats
- GUI scene builder/editor for materials, lights, camera editor, and camera path control
- Extensible via plugins
- Used for various Intel® oneAPI Rendering Toolkit demos
- Open Source under Apache* 2.0 license https://github.com/ospray/ospray_studio


Car Model by Bentley Motors Limited. Rendered with OSPRay Studio.

Moana Island Scene and Disney Cloud by Disney Animation. Rendered with OSPRay.


intel

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