





Open Image Denoise Open Source Denoising for Ray Tracing Attila T. Áfra

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Overview

Algorithm Quality & Performance API Roadmap & Conclusion



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Usage of Denoising Today

- Noise is inevitable with Monte Carlo ray/path tracing
- Rendering fully converged, noise-free images is often too expensive
- Denoising partially converged images is getting more and more popular
- The movie industry is already using denoising to reduce rendering times
 - About 2-10x overall speed improvement
 - Negligible image quality loss
- Denoising is crucial for real-time ray tracing (e.g. games)
 - Typically ~1 sample per pixels → extremely noisy
 - Enables fully dynamic ray traced shadows, reflections, AO, and global illumination

Open Image Denoise

- Denoising library for images rendered with ray tracing
- Provides a high-quality deep learning based denoising filter
- Suitable for both interactive preview and final-frame rendering
- Runs on any modern Intel[®] Architecture CPU (SSE4.1 → AVX-512)
- Windows (64-bit), macOS, Linux
- Clean, minimalist C/C++ API and library design
 - Straightforward application integration (in hours)
 - Depends only on the Intel[®] TBB library
- Free and Open Source under Apache 2.0 license
 - http://openimagedenoise.github.com

Intel[®] Rendering Framework

- Open Image Denoise is a stand-alone library...
- ... but is a component of the Intel[®] Rendering Framework
 - A collection of open source libraries developed by Intel for advanced rendering and visualization



General Visualization / Rendering Stack



Open Image Denoise Features

- Multiple input buffers
 - Color buffer
 - Optional auxiliary/feature buffers
 - Albedo
 - Normal
- LDR and HDR images
 - Robust HDR support
 - Handles fireflies without pre-filtering
- Hardware-agnostic API (CPUs and more)
- Supports querying denoising progress and cancellation



Example: Input and Output Buffers

Color





Normal (optional)





Denoised Color

Scene by Evermotion.

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Denoising Algorithm

- Open Image Denoise currently uses a single denoising algorithm
- Convolutional neural network (CNN) based
- Direct-predicting autoencoder [Chaitanya et al. 2017]
 - Variant of the U-Net architecture [Ronneberger et al. 2015]
- Good balance between quality and performance
 - Quality suitable for final-frame rendering
 - Interactive performance on many-core CPUs
- The library ships with a set of pre-trained models
- Inference implemented using the open source Intel[®] MKL-DNN library

Denoising Pipeline





Denoising Pipeline





(intel)

Denoising CNN



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Example: Crytek Sponza (16 spp) – Original

Scene courtesy of Frank Meinl, downloaded from Morgan McGuire's Computer Graphics Archiv

Example: Crytek Sponza (16 spp) – Denoised

Scene courtesy of Frank Meinl, downloaded from Morgan McGuire's Computer Graphics Archiv

Example: Amazon Lumberyard Bistro (16 spp) – Original

Scene created by Amazon Lumberyard, released publicly in the NVIDIA Open Research Content Archive collection.

Example: Amazon Lumberyard Bistro (16 spp) – Denoised

Scene created by Amazon Lumberyard, released publicly in the NVIDIA Open Research Content Archive collection.

Example: Corona Academy Interior (4 spp) – Original

Rendered with Corona Renderer. Scene provided by Chaos Czech a.s. www.corona-renderer.com



Example: Corona Academy Interior (4 spp) – Denoised

Rendered with Corona Renderer. Scene provided by Chaos Czech a.s. www.corona-renderer.com



Example: Corona Academy Exterior (4 spp) – Original

Rendered with Corona Renderer. Scene provided by Chaos Czech a.s. www.corona-renderer.com



Example: Corona Academy Exterior (4 spp) – Denoised

Rendered with Corona Renderer. Scene provided by Chaos Czech a.s. www.corona-renderer.com



Example: Moana Island Scene (8 spp) – Original



Rendered with Intel® OSPRay. Publicly available dataset courtesy of Walt Disney Animation Studios.

Example: Moana Island Scene (8 spp) – Original



Rendered with Intel® OSPRay. Publicly available dataset courtesy of Walt Disney Animation Studios.

Example: Moana Island Scene (8 spp) – Denoised



Rendered with Intel® OSPRay. Publicly available dataset courtesy of Walt Disney Animation Studios.



Denoising Performance

CPU: 2 × Intel[®] Xeon[®] Platinum 8180

2 × 28 cores, 2.50 GHz, AVX-512



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Open Image Denoise API Overview

- Very similar to the Embree API
- C and C++ (wrapper) version
- Object oriented
- Reference counted
- Device concept
- Compact and easy to use
- For details visit: https://openimagedenoise.github.io/documentation.html



Example: Filter Creation

- Images can be denoised using a filter object
- Changes must be committed (oidnCommitFilter), which typically triggers JIT code generation

// Include Open Image Denoise headers
#include <OpenImageDenoise/oidn.h>

```
int main()
```

// Create an Open Image Denoise device OIDNDevice device = oidnNewDevice(OIDN_DEVICE_TYPE_DEFAULT); oidnCommitDevice(device);

// Create a denoising filter
OIDNFilter filter = oidnNewFilter(device, "RT");

```
// Set filter parameters
... later slide ...
```

// Commit changes
oidnCommitFilter(filter);

```
// Filter the image
oidnExecuteFilter(filter);
```

// Cleanup

}

oidnReleaseFilter(filter); oidnReleaseDevice(device);

Example: Filter Parameters

- Buffers have to be attached to the filter
- Shared buffers of flexible layout (offset + strides) supported

// Set input color buffer

// Set input albedo buffer (optional)

// Set input normal buffer (optional)
oidnSetSharedFilterImage(filter, "normal", normalPtr,
 OIDN_FORMAT_FLOAT3, width, height, 0, 0, 0);

// Set output color buffer

// Set other filter parametres
oidnSetFilter1b(filter, "hdr", true); // image is HDR



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Roadmap & Conclusion



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Roadmap

- Next version (coming very soon!):
 - Higher denoising quality with no performance impact (as shown in this talk)
 - Significantly lower memory consumption (especially for high resolutions)

- Later versions:
 - Support for more auxiliary/feature buffers (e.g. depth)
 - Temporal coherence
 - Possibly other, more specialized denoising filters/algorithms
 - ... what else do you need?

Conclusion

- Open Image Denoise is an open source denoising library for ray tracing
- Suitable for both interactive and final-frame rendering
- Runs on almost any CPU (only SSE4.1 support is required)
- Takes advantage of AVX2 and AVX-512 instruction sets
- Simple, clean API
- Easy integration into renderers
- Under active development



Questions?

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