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Supplemental Document for Progressive Denoising of Monte Carlo Rendered Images

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Abstract

In our paper "Progressive Denoising of Monte Carlo Rendered Images", we propose a progressive denoising technique that aims to denoise only when it is beneficial, reducing its impact at high sample counts, that is based on feeding error estimates, calculated using SURE, to a neural network used to estimate a per-pixel mixing parameter. The network output is further augmented with confidence intervals based on classical statistics, ensuring consistency and guaranteeing its convergence.

This supplementary document provides detailed results for the experiments of ***Section 6*** *of the paper, in particular:*

- ***Comparison with Denoising***
- ***Application to an Existing Denoiser***

CCS Concepts
• ***Computing methodologies*** → ***Image processing; Rendering; Ray tracing;***

1. Comparison with Denoising

We trained multiple U-Net based denoisers [CKS*17], each with a different combination of the input features, and for each of these we trained our method's network (see Section 5.1 and 4.3 of the paper). Tables 1 and 2 detail the results of applying *progressive denoising* to these denoisers over our test dataset (the tables do not cover all sample per pixel inputs for brevity).

For every combination of input features, our method is able to lower the final image error for nearly all of the error metrics and input samples per pixel tested. In cases for which *progressive denoising* does not improve the error, as in the Coffee scene, the difference is marginal. The improvement in terms of SMAPE and FLIP tends to be slighter than RMSE improvement, although for scenes in which the denoisers perform poorly, such as the Crown and Landscape scenes, the former error metrics do improve considerably.

2. Application to an Existing Denoiser

We trained our *progressive denoising* network for use with the pretrained Intel Open Image Denoise (OIDN) denoiser [oid], which achieves substantially higher quality than our own trained denoisers. Table 3 detail our results when applying our method to this denoiser, both with and without auxiliary input features (albedo and normals).

The proposed method is able to improve upon the RMSE of the denoiser's output in most cases, particularly as the sample count increases. When it does not improve upon the error, the difference is once again marginal. The results in terms of the SMAPE and FLIP error metrics are much more mixed in this case, with only marginal differences for most scenes, however substantial improvement is still had in scenes where OIDN is not as performant (the Bistro-Cafe, Crown, Landscape, and San Miguel scenes).

The interactive results viewer, also provided as a supplement to the paper, showcases the images behind the results of Table 3. The scenes referenced here can be found in the cited repositories [Bit16] [Pha20].

References

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			RMSE				SMAPE			FLIP		
			32	128	1024	8192	128	1024	8192	128	1024	8192
BATHROOM2	HDR	den	1.5995	1.5106	1.4431	1.4169	0.0267	0.0208	0.0151	0.0919	0.0692	0.0447
		pro-den	1.5290	0.7606	0.1670	**0.0522**	0.0268	0.0202	0.0141	0.0917	0.0668	0.0411
	HDR, VAR	den	0.7476	0.7034	0.5731	0.4422	0.0257	0.0195	0.0140	0.0894	0.0656	0.0407
		pro-den	0.7081	0.5022	0.1812	0.0523	0.0258	0.0194	**0.0138**	0.0893	0.0648	**0.0398**
	HDR, ALB, NRM	den	0.7951	0.7241	0.6322	0.4906	0.0264	0.0202	0.0146	0.0923	0.0677	0.0438
		pro-den	0.5548	**0.3464**	**0.1419**	0.0532	0.0265	0.0201	0.0144	0.0919	0.0668	0.0426
	HDR, ALB, NRM, VAR	den	0.5937	0.5415	0.4689	0.5007	**0.0249**	0.0193	0.0142	0.0880	0.0645	0.0432
		pro-den	**0.5266**	0.3710	0.1726	0.0523	0.0249	**0.0191**	0.0140	**0.0879**	**0.0639**	0.0421
	mc-render		1.0057	0.5022	0.1744	0.0553	0.1603	0.0940	0.0429	0.2006	0.1295	0.0628
BISTRO-CAFE	HDR	den	0.0632	0.0475	0.0343	0.0287	0.0871	0.0661	0.0443	0.1903	0.1404	0.0880
		pro-den	**0.0602**	0.0389	0.0175	0.0078	0.0865	0.0631	0.0371	0.1885	0.1352	0.0769
	HDR, VAR	den	0.0698	0.0503	0.0289	0.0165	**0.0847**	0.0617	0.0371	0.1859	0.1331	0.0774
		pro-den	0.0606	**0.0377**	0.0174	**0.0077**	0.0853	**0.0616**	**0.0363**	**0.1856**	**0.1320**	**0.0754**
	HDR, ALB, NRM	den	0.0754	0.0603	0.0490	0.0443	0.0949	0.0729	0.0530	0.2104	0.1565	0.1055
		pro-den	0.0648	0.0419	0.0188	0.0082	0.0923	0.0681	0.0411	0.2046	0.1481	0.0866
	HDR, ALB, NRM, VAR	den	0.0766	0.0595	0.0345	0.0215	0.0872	0.0659	0.0416	0.1957	0.1446	0.0866
		pro-den	0.0631	0.0392	**0.0173**	0.0079	0.0856	0.0632	0.0384	0.1922	0.1386	0.0785
	mc-render		0.1140	0.0574	0.0206	0.0080	0.2485	0.1469	0.0598	0.3182	0.1935	0.0856
COFFEE	HDR	den	**0.0111**	0.0072	0.0043	0.0027	0.0260	0.0212	0.0173	0.0889	**0.0661**	**0.0465**
		pro-den	0.0115	0.0074	0.0043	0.0024	0.0259	0.0210	0.0170	**0.0885**	0.0664	0.0485
	HDR, VAR	den	0.0111	**0.0071**	**0.0039**	0.0025	**0.0254**	0.0199	0.0159	0.0893	0.0668	0.0504
		pro-den	0.0116	0.0073	0.0040	**0.0023**	0.0254	0.0198	0.0157	0.0891	0.0671	0.0512
	HDR, ALB, NRM	den	0.0117	0.0077	0.0044	0.0026	0.0278	0.0217	0.0167	0.0934	0.0723	0.0544
		pro-den	0.0123	0.0079	0.0045	0.0025	0.0277	0.0212	0.0162	0.0921	0.0718	0.0553
	HDR, ALB, NRM, VAR	den	0.0118	0.0077	0.0043	0.0025	0.0256	0.0198	0.0157	0.0948	0.0736	0.0567
		pro-den	0.0122	0.0079	0.0043	0.0024	0.0257	**0.0198**	**0.0156**	0.0942	0.0734	0.0571
	mc-render		0.0517	0.0258	0.0090	0.0032	0.1185	0.0682	0.0264	0.1978	0.1129	0.0472
CROWN	HDR	den	0.3263	0.2788	0.2371	0.2212	0.0727	0.0593	0.0459	0.1488	0.1173	0.0876
		pro-den	0.2339	0.1396	0.0440	0.0192	0.0686	0.0501	0.0299	0.1408	0.1047	0.0697
	HDR, VAR	den	0.3677	0.2420	0.1152	0.0461	0.0734	0.0546	0.0343	0.1482	0.1111	0.0748
		pro-den	0.2189	0.1127	**0.0421**	0.0183	**0.0681**	**0.0471**	**0.0265**	**0.1397**	**0.1007**	**0.0658**
	HDR, ALB, NRM	den	0.3682	0.3263	0.2837	0.2609	0.0767	0.0638	0.0505	0.1602	0.1307	0.1014
		pro-den	0.2148	0.1194	0.0481	0.0208	0.0704	0.0500	0.0319	0.1496	0.1105	0.0812
	HDR, ALB, NRM, VAR	den	0.3606	0.2798	0.1388	0.0797	0.0757	0.0591	0.0374	0.1565	0.1216	0.0833
		pro-den	**0.2093**	**0.1125**	0.0426	0.0183	0.0701	0.0489	0.0268	0.1468	0.1066	0.0683
	mc-render		0.2510	0.1215	0.0438	**0.0182**	0.1265	0.0785	0.0355	0.2057	0.1349	0.0659
GLASS-OF-WATER	HDR	den	0.0874	0.0574	0.0289	0.0125	0.0330	0.0252	0.0180	**0.0895**	0.0632	0.0377
		pro-den	**0.0859**	**0.0545**	0.0282	0.0122	0.0329	0.0251	0.0179	0.0896	**0.0631**	**0.0377**
	HDR, VAR	den	0.1030	0.0795	0.0382	0.0166	0.0326	0.0245	0.0164	0.0923	0.0639	0.0383
		pro-den	0.0899	0.0570	**0.0256**	**0.0116**	**0.0324**	**0.0243**	**0.0162**	0.0923	0.0637	0.0380
	HDR, ALB, NRM	den	0.0946	0.0691	0.0331	0.0129	0.0343	0.0258	0.0178	0.0952	0.0668	0.0404
		pro-den	0.0912	0.0583	0.0274	0.0122	0.0341	0.0255	0.0175	0.0950	0.0664	0.0399
	HDR, ALB, NRM, VAR	den	0.1029	0.0766	0.0319	0.0148	0.0330	0.0251	0.0168	0.0901	0.0646	0.0393
		pro-den	0.0957	0.0575	0.0259	0.0118	0.0328	0.0248	0.0165	0.0899	0.0643	0.0390
	mc-render		0.2838	0.1424	0.0500	0.0154	0.1759	0.1209	0.0513	0.2468	0.1610	0.0713

Table 1: Comparison of our approach (pro-den) with the U-Net based denoisers (den) for different input feature combinations and samples per pixel inputs. The best method for each input feature combination is highlighted in green, and the best of all combinations, including the Monte-Carlo rendered image, is highlighted in **boldface**. Continued in Table 1.

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			RMSE				SMAPE			FLIP		
			32	128	1024	8192	128	1024	8192	128	1024	8192
KITCHEN	HDR	den	**0.1148**	0.0797	0.0514	0.0396	0.0308	0.0225	0.0152	0.0942	0.0678	0.0411
		pro-den	0.1150	**0.0785**	**0.0386**	**0.0164**	**0.0307**	0.0225	0.0152	**0.0939**	0.0676	0.0409
	HDR, VAR	den	0.1489	0.1108	0.0745	0.0440	0.0309	0.0220	0.0148	0.0945	0.0671	0.0410
		pro-den	0.1450	0.0980	0.0455	0.0164	0.0308	**0.0220**	**0.0147**	0.0943	**0.0667**	**0.0403**
	HDR, ALB, NRM	den	0.1468	0.1078	0.0760	0.0622	0.0330	0.0237	0.0160	0.1013	0.0722	0.0436
		pro-den	0.1448	0.0946	0.0424	0.0172	0.0328	0.0235	0.0158	0.1009	0.0715	0.0426
	HDR, ALB, NRM, VAR	den	0.1792	0.1209	0.0700	0.0388	0.0314	0.0228	0.0154	0.0965	0.0695	0.0424
		pro-den	0.1721	0.1051	0.0485	0.0166	0.0312	0.0226	0.0152	0.0960	0.0686	0.0411
	mc-render		0.3493	0.1739	0.0606	0.0189	0.1866	0.1153	0.0477	0.2347	0.1468	0.0666
LANDSCAPE	HDR	den	0.0266	0.0191	0.0160	0.0153	0.0926	0.0713	0.0578	0.1872	0.1365	0.1099
		pro-den	0.0218	0.0105	0.0043	0.0018	0.0780	0.0448	0.0216	**0.1668**	0.0928	0.0518
	HDR, VAR	den	0.0221	0.0109	0.0045	0.0023	0.0810	0.0477	0.0228	0.1707	0.0963	0.0516
		pro-den	**0.0212**	**0.0102**	**0.0042**	0.0018	**0.0762**	**0.0434**	0.0192	0.1675	0.0904	0.0456
	HDR, ALB, NRM	den	0.0273	0.0200	0.0172	0.0167	0.1154	0.0980	0.0885	0.2343	0.1945	0.1771
		pro-den	0.0227	0.0112	0.0048	0.0021	0.0887	0.0529	0.0263	0.1921	0.1200	0.0746
	HDR, ALB, NRM, VAR	den	0.0240	0.0142	0.0088	0.0076	0.0946	0.0688	0.0502	0.1975	0.1408	0.1086
		pro-den	0.0218	0.0103	0.0042	0.0018	0.0775	0.0444	0.0214	0.1710	0.0942	0.0530
	mc-render		0.0280	0.0131	0.0047	**0.0018**	0.0915	0.0463	**0.0177**	0.1704	**0.0893**	**0.0420**
LIVING-ROOM-3	HDR	den	0.0133	0.0096	0.0061	0.0041	0.0273	0.0233	0.0194	0.0648	0.0472	0.0306
		pro-den	0.0138	0.0102	0.0064	0.0040	0.0273	0.0232	0.0189	0.0649	0.0472	0.0302
	HDR, VAR	den	0.0129	**0.0092**	0.0061	0.0041	0.0298	0.0266	0.0232	0.0653	0.0478	0.0314
		pro-den	0.0134	0.0097	0.0063	**0.0040**	0.0297	0.0260	0.0217	0.0652	0.0477	0.0307
	HDR, ALB, NRM	den	0.0135	0.0093	0.0062	0.0042	0.0291	0.0232	0.0190	0.0663	0.0469	0.0298
		pro-den	0.0142	0.0101	0.0064	0.0041	0.0290	0.0231	0.0184	0.0663	0.0469	0.0298
	HDR, ALB, NRM, VAR	den	**0.0129**	0.0093	**0.0061**	0.0041	0.0271	0.0223	0.0180	0.0647	**0.0466**	**0.0296**
		pro-den	0.0135	0.0099	0.0062	0.0040	**0.0271**	**0.0222**	**0.0178**	**0.0647**	0.0467	0.0297
	mc-render		0.1117	0.0563	0.0200	0.0061	0.1353	0.0708	0.0257	0.1580	0.0895	0.0400
SANMIGUEL	HDR	den	0.0484	0.0372	0.0285	0.0255	0.1114	0.0765	0.0523	0.3493	0.2380	0.1394
		pro-den	**0.0418**	0.0244	0.0105	0.0046	0.1109	0.0723	0.0435	0.3504	0.2332	0.1242
	HDR, VAR	den	0.0471	0.0295	0.0126	0.0066	0.1107	0.0720	0.0438	0.3474	0.2301	0.1254
		pro-den	0.0419	0.0244	**0.0103**	**0.0045**	0.1110	0.0710	**0.0421**	0.3498	0.2292	**0.1200**
	HDR, ALB, NRM	den	0.0562	0.0470	0.0400	0.0377	0.1095	0.0795	0.0601	0.3351	0.2392	0.1686
		pro-den	0.0448	0.0263	0.0117	0.0051	**0.1077**	0.0727	0.0450	**0.3333**	**0.2276**	0.1344
	HDR, ALB, NRM, VAR	den	0.0488	0.0336	0.0179	0.0111	0.1091	0.0742	0.0501	0.3393	0.2353	0.1505
		pro-den	0.0424	**0.0242**	0.0104	0.0046	0.1083	**0.0706**	0.0429	0.3397	0.2285	0.1279
	mc-render		0.0601	0.0322	0.0124	0.0049	0.2498	0.1475	0.0656	0.4884	0.3006	0.1318
SPACESHIP	HDR	den	**0.0255**	0.0167	0.0079	0.0035	0.0151	0.0107	0.0074	0.0592	0.0420	0.0258
		pro-den	0.0257	0.0166	0.0080	0.0034	0.0152	0.0109	0.0075	0.0591	0.0422	0.0258
	HDR, VAR	den	0.0271	0.0164	0.0082	0.0038	**0.0147**	**0.0104**	0.0067	0.0573	0.0415	0.0256
		pro-den	0.0269	**0.0162**	**0.0075**	0.0034	0.0148	0.0105	**0.0067**	**0.0573**	**0.0413**	**0.0254**
	HDR, ALB, NRM	den	0.0268	0.0177	0.0099	0.0041	0.0163	0.0123	0.0081	0.0673	0.0523	0.0328
		pro-den	0.0270	0.0177	0.0081	0.0034	0.0164	0.0124	0.0080	0.0668	0.0518	0.0322
	HDR, ALB, NRM, VAR	den	0.0279	0.0169	0.0081	0.0039	0.0159	0.0111	0.0073	0.0661	0.0482	0.0323
		pro-den	0.0282	0.0167	0.0077	**0.0033**	0.0159	0.0111	0.0072	0.0657	0.0475	0.0315
	mc-render		0.0753	0.0376	0.0130	0.0041	0.0877	0.0500	0.0204	0.1356	0.0833	0.0389

Table 2: Continuation of Table 1. Comparison of our approach (pro-den) with the U-Net based denoisers (den) for different input feature combinations and samples per pixel inputs. The best method for each input feature combination is highlighted in green, and the best of all combinations, including the Monte-Carlo rendered image, is highlighted in **boldface**.

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			RMSE				SMAPE			FLIP		
			32	128	1024	8192	128	1024	8192	128	1024	8192
BATHROOM2	HDR	oidn	**0.2932**	**0.2045**	0.1232	0.0628	**0.0220**	0.0171	0.0126	**0.0802**	**0.0595**	**0.0393**
		pro-den	0.2933	0.2047	**0.1224**	**0.0513**	0.0221	0.0172	0.0129	0.0803	0.0595	0.0395
	HDR, ALB, NRM	oidn	0.4353	0.3450	0.1635	0.0780	0.0220	**0.0168**	**0.0125**	0.0863	0.0619	0.0398
		pro-den	0.4300	0.3394	0.1566	0.0557	0.0222	0.0169	0.0127	0.0863	0.0620	0.0398
	mc-render		1.0057	0.5022	0.1744	0.0553	0.1603	0.0940	0.0429	0.2006	0.1295	0.0628
BISTRO-CAFE	HDR	oidn	0.0525	0.0375	0.0218	0.0126	0.0764	0.0585	0.0377	0.1731	0.1287	0.0767
		pro-den	0.0515	0.0351	0.0170	0.0076	0.0760	0.0568	0.0340	0.1711	0.1249	0.0709
	HDR, ALB, NRM	oidn	0.0511	0.0372	0.0200	0.0102	**0.0707**	0.0536	0.0345	0.1657	0.1228	0.0737
		pro-den	**0.0504**	**0.0345**	**0.0167**	**0.0076**	0.0707	**0.0532**	**0.0327**	**0.1646**	**0.1204**	**0.0697**
	mc-render		0.1140	0.0574	0.0206	0.0080	0.2485	0.1469	0.0598	0.3182	0.1935	0.0856
COFFEE	HDR	oidn	**0.0118**	**0.0079**	0.0047	0.0028	**0.0219**	**0.0177**	**0.0142**	**0.0867**	**0.0712**	0.0548
		pro-den	0.0122	0.0081	**0.0044**	**0.0024**	0.0221	0.0179	0.0144	0.0868	0.0715	0.0551
	HDR, ALB, NRM	oidn	0.0139	0.0093	0.0054	0.0037	0.0245	0.0190	0.0149	0.0966	0.0752	0.0575
		pro-den	0.0141	0.0093	0.0048	0.0025	0.0246	0.0192	0.0150	0.0965	0.0753	0.0574
	mc-render		0.0517	0.0258	0.0090	0.0032	0.1185	0.0682	0.0264	0.1978	0.1129	**0.0472**
CROWN	HDR	oidn	0.2308	0.1754	0.1277	0.1021	0.0590	0.0467	0.0323	0.1305	0.1035	0.0759
		pro-den	**0.1920**	**0.1027**	**0.0409**	**0.0179**	**0.0573**	**0.0416**	**0.0245**	**0.1268**	**0.0964**	0.0661
	HDR, ALB, NRM	oidn	0.2385	0.1726	0.1219	0.1011	0.0617	0.0481	0.0334	0.1372	0.1073	0.0799
		pro-den	0.2092	0.1060	0.0411	0.0181	0.0610	0.0433	0.0248	0.1345	0.1002	0.0671
	mc-render		0.2510	0.1215	0.0438	0.0182	0.1265	0.0785	0.0355	0.2057	0.1349	**0.0659**
GLASS-OF-WATER	HDR	oidn	**0.0785**	0.0535	0.0295	0.0122	**0.0297**	**0.0235**	0.0160	**0.0853**	**0.0645**	0.0402
		pro-den	0.0787	**0.0517**	**0.0248**	**0.0115**	0.0299	0.0236	**0.0159**	0.0855	0.0645	**0.0401**
	HDR, ALB, NRM	oidn	0.0823	0.0543	0.0269	0.0125	0.0318	0.0242	0.0162	0.0973	0.0682	0.0406
		pro-den	0.0825	0.0537	0.0259	0.0118	0.0322	0.0244	0.0163	0.0989	0.0689	0.0408
	mc-render		0.2838	0.1424	0.0500	0.0154	0.1759	0.1209	0.0513	0.2468	0.1610	0.0713
KITCHEN	HDR	oidn	**0.1003**	**0.0646**	0.0391	0.0185	**0.0261**	0.0198	**0.0137**	0.0854	0.0636	**0.0396**
		pro-den	0.1004	0.0647	**0.0382**	**0.0169**	0.0261	0.0199	0.0138	**0.0854**	**0.0636**	0.0397
	HDR, ALB, NRM	oidn	0.1321	0.0937	0.0467	0.0219	0.0261	**0.0197**	0.0138	0.0931	0.0678	0.0406
		pro-den	0.1288	0.0919	0.0456	0.0178	0.0262	0.0198	0.0139	0.0930	0.0677	0.0404
	mc-render		0.3493	0.1739	0.0606	0.0189	0.1866	0.1153	0.0477	0.2347	0.1468	0.0666
LANDSCAPE	HDR	oidn	0.0230	0.0142	0.0097	0.0086	0.0785	0.0551	0.0367	0.1694	0.1160	0.0791
		pro-den	**0.0207**	**0.0102**	**0.0042**	**0.0018**	**0.0717**	**0.0414**	0.0173	**0.1581**	**0.0873**	0.0422
	HDR, ALB, NRM	oidn	0.0229	0.0128	0.0071	0.0057	0.0771	0.0490	0.0266	0.1695	0.1071	0.0648
		pro-den	0.0216	0.0110	0.0043	0.0018	0.0732	0.0422	**0.0173**	0.1594	0.0875	0.0425
	mc-render		0.0280	0.0131	0.0047	0.0018	0.0915	0.0463	0.0177	0.1704	0.0893	**0.0420**
LIVING-ROOM-3	HDR	oidn	**0.0132**	**0.0091**	**0.0060**	0.0040	**0.0247**	**0.0204**	0.0166	**0.0651**	**0.0484**	**0.0301**
		pro-den	0.0137	0.0100	0.0064	**0.0040**	0.0248	0.0207	0.0168	0.0652	0.0487	0.0303
	HDR, ALB, NRM	oidn	0.0138	0.0092	0.0061	0.0041	0.0256	0.0204	**0.0165**	0.0775	0.0513	0.0324
		pro-den	0.0142	0.0096	0.0063	0.0040	0.0258	0.0206	0.0167	0.0776	0.0514	0.0325
	mc-render		0.1117	0.0563	0.0200	0.0061	0.1353	0.0708	0.0257	0.1580	0.0895	0.0400
SANMIGUEL	HDR	oidn	0.0511	0.0388	0.0269	0.0209	0.1042	0.0669	0.0422	0.3371	0.2164	0.1178
		pro-den	0.0404	0.0231	0.0103	**0.0045**	0.1037	0.0646	0.0385	**0.3366**	**0.2137**	0.1108
	HDR, ALB, NRM	oidn	0.0495	0.0349	0.0212	0.0135	0.0996	0.0600	0.0362	0.3487	0.2172	0.1141
		pro-den	**0.0380**	**0.0219**	**0.0102**	0.0046	**0.0994**	**0.0586**	**0.0340**	0.3482	0.2146	**0.1079**
	mc-render		0.0601	0.0322	0.0124	0.0049	0.2498	0.1475	0.0656	0.4884	0.3006	0.1318
SPACESHIP	HDR	oidn	**0.0222**	0.0143	0.0074	0.0034	**0.0126**	**0.0093**	**0.0062**	**0.0538**	**0.0399**	**0.0239**
		pro-den	0.0223	**0.0143**	0.0074	**0.0034**	0.0127	0.0094	0.0062	0.0539	0.0401	0.0240
	HDR, ALB, NRM	oidn	0.0223	0.0149	**0.0074**	0.0036	0.0139	0.0100	0.0065	0.0590	0.0418	0.0258
		pro-den	0.0226	0.0152	0.0075	0.0035	0.0141	0.0101	0.0065	0.0592	0.0419	0.0259
	mc-render		0.0753	0.0376	0.0130	0.0041	0.0877	0.0500	0.0204	0.1356	0.0833	0.0389

Table 3: Comparison of our method (pro-den) applied to a high-quality existing denoiser, Intel Open Image Denoise (oidn) [oid]. The best method for each input feature combination is highlighted in green, and the best of all combinations, including the Monte-Carlo rendered image, is highlighted in **boldface**.

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