Reconstructing Reflection Maps using a Stacked-CNN for Mixed Reality Rendering

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APPENDIX

We demonstrate how it is beneficial to use each level in the SCNN as opposed to mathematically convolving from the low roughness prediction in Figure 1 and Figure 2. The contrast of the low roughness RM prediction is not high enough to produce a strong highlight as the roughness increases. This can result in flat looking shading, or specular highlights in the wrong direction. This artefact is captured using the angular error metric, where the primary light direction has shifted.

For the user study, we tested the perceived image quality between our method and the baseline technique based the related work. This was done for a total of two images, ten of which indoor and ten outdoor scenes, with varying lighting conditions. Users were asked to rank the image on a 5-likert scale when comparing with the ground truth. The results are summarized in Table 1 for indoor and outdoor images. To test for statistical significance we performed Wilcoxon Signed Ranks tests. The output of the statistical tests are summarized in Table 2, for both indoor and outdoor scenes.

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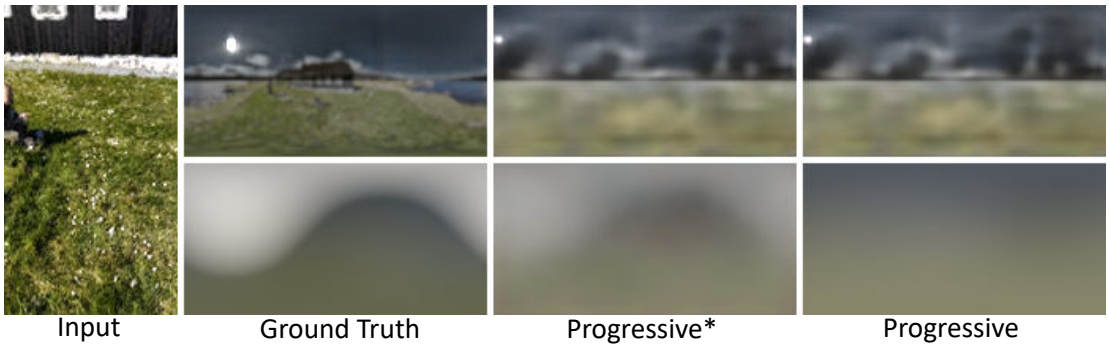

Fig. 1: The input image, its ground truth and predicted environment maps (top) and their corresponding diffuse maps (bottom). This illustrates the benefit of using each CNN in the stack directly for higher accuracy predictions (*"progressive*"*) as opposed to mathematically convolving from the prediction (*"progressive"*).

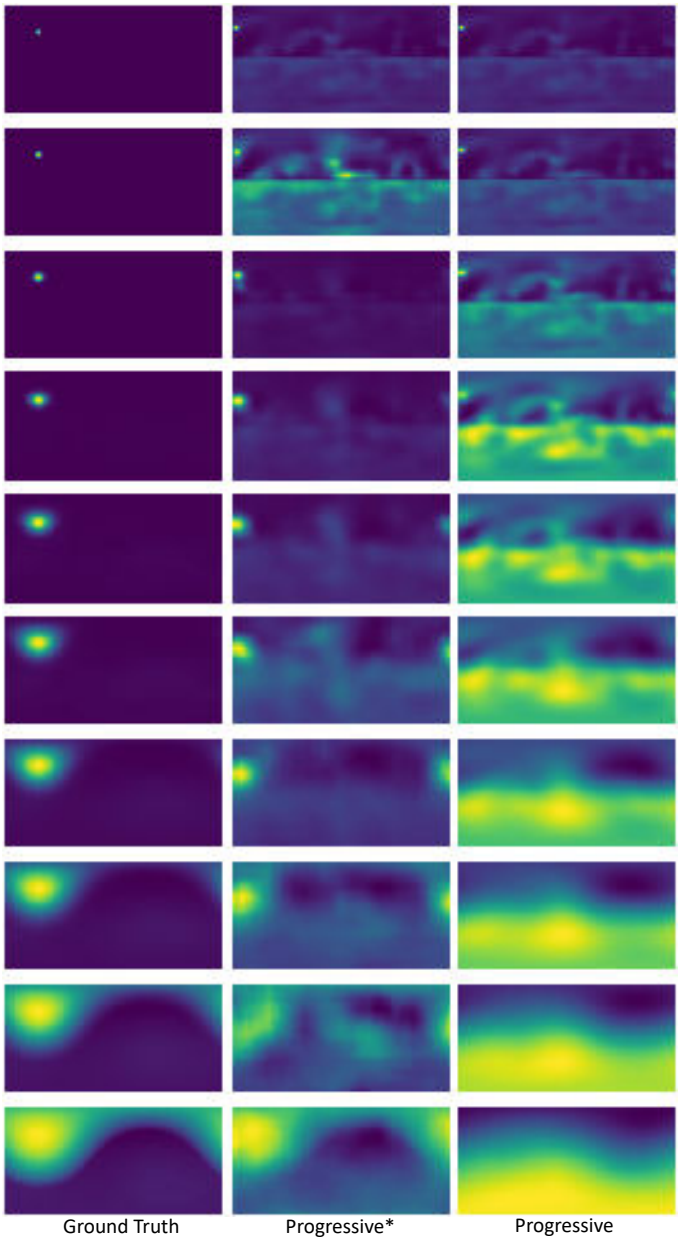

Fig. 2: Heatmap representation of the images from Figure 1. From low roughness (top row) to high roughness (bottom row). This illustrates how the light in the low roughness prediction is not bright enough to make a strong highlight in the correct direction when mathematically convolving.

		Q1		Q2		Q3		Q4	
INDOOR		RM	EM	RM	EM	RM	EM	RM	EM
	i0	4(1)	3(2)	3(1)	2(0.5)	4(0.5)	3(2)	4(1.5)	4(0.5)
	i1	5(1)	4(1)	4(1)	3(1)	5(1)	4(2.5)	4(1.5)	4(1)
	i2	4(0.5)	4(1)	3(1.5)	2(0.5)	3(2)	4(1.5)	4(1)	4(1.5)
	i3	4(1.5)	3(2)	4(1.5)	1(1)	3(2)	1(1)	4(1)	4(1.5)
	i4	4(0.75)	3(1.75)	4(1)	1.5(1)	4(1.75)	3(1)	4(1.75)	3.5(1.75)
	i5	5(2.5)	4(1.5)	1.5(1.75)	2(1)	3(2)	1.5(1)	4(1)	3.5(2)
	i6	4(1.75)	3(1.75)	3(1.75)	2(0.75)	1.5(2.5)	1.5(2.5)	3(1)	2.5(2)
	i7	3(1)	3(1)	2.5(1.25)	2(1.25)	3(1.25)	2(0.25)	4(1)	2.5(2.25)
	i8	4(1)	3(1.25)	3(1.25)	2(1.25)	1.5(1.25)	2(2)	4(1)	3.5(1.25)
	i9	4(1.5)	3(1)	3(1.25)	2(1)	3(1.25)	2(1.25)	4(1.25)	3.5(1.25)
OUTDOOR	i0	4(1.25)	4(1)	2.5(1.5)	4(1)	3.5(1.5)	3.5(3)	4(1)	3.5(1.5)
	i1	4(1.5)	2.5(1.25)	2.5(1.25)	2(0.25)	2(1.25)	2(0.25)	4(0.25)	4(1)
	i2	2.5(1.25)	3(2)	3(1.5)	1.5(2.25)	2.5(2.25)	1(1)	4(0.25)	3.5(1.25)
	i3	4(1)	2(1.5)	4(1)	2(1)	1.5(2)	1(0.25)	4(1.25)	4(1.5)
	i4	4(1)	4(0.5)	3(2.25)	3(1.25)	1.5(2)	2(2)	4(0.25)	4(1.5)
	i5	2.5(1.25)	2.5(1.25)	2(1)	2(1)	2(0.25)	2(0.25)	2.5(1.25)	4(1)
	i6	4(1)	4(1)	2(2)	2(0.5)	3(1)	3(1.5)	3(1.5)	4(1.5)
	i7	4(1)	4(1)	3(1.5)	2(0.5)	4(1)	3(2.5)	4(1)	4(0.5)
	i8	3(0.5)	4(1)	2(2.5)	3(1)	3(1)	3(1)	4(1)	4(1)
	i9	3(1.6)	4(1.5)	2(1)	2(1.5)	2(1)	2(2)	3(2)	4(1)

TABLE 1: Summarized results of indoor and outdoor user studies split by image. Results are presented as Median (Interquartile range).

	INDOOR					OUTDOOR				
	Q1	Q2	Q3	Q4	Distance	Q1	Q2	Q3	Q4	Distance
i0	Z=-2.517 **p=0.012**	Z=-3.494 **p<0.001**	Z=-3.217 **p=0.002**	Z=-1.567 p=0.12	Z=-2.564 **p=0.01**	Z=-1.890 p=0.059	Z=-.707 p=0.48	Z=-.791 p=0.43	Z=-1.730 p=0.08	Z=-2.387 **p=0.017**
i1	Z=-2.840 **p=0.005**	Z=-2.952 **p=0.003**	Z=-2.157 **p=0.031**	Z=-1.508 p=0.132	Z=-.059 p=0.953	Z=-2.588 **p=0.01**	Z=-2.584 **p=0.01**	Z=-1.732 p=0.08	Z=-.707 p=0.48	Z=-1.399 p=0.17
i2	Z=-1.184 p=0.236	Z=-1.467 p=0.14	Z=-.522 p=0.601	Z=-1.724 p=0.085	Z=-1.069 p=0.285	Z=-1.292 p=0.2	Z=-.172 p=0.86	Z=-2.877 **p=0.004**	Z=-1.897 p=0.057	Z=-.673 p=0.50
i3	Z=-2.144 **p=0.032**	Z=-3.564 **p<0.001**	Z=-3.281 p=0.001	Z=-1.006 p=0.314	Z=-2.747 **p=0.006**	Z=-2.724 **p=0.006**	Z=-3.247 **p=0.001**	Z=-2.969 **p=0.003**	Z=-.104 p=0.91	Z=-.314 p=0.75
i4	Z=-2.879 **p=0.004**	Z=-3.598 **p<0.001**	Z=-2.840 **p=0.005**	Z=-2.145 **p=0.032**	Z=-3.511 p<0.001	Z=-1.155 p=0.25	Z=-1.611 p=0.10	Z=-.378 p=0.70	Z=-.187 p=0.85	Z=-.354 p=0.72
i5	Z=-.836 p=0.403	Z=-3.578 **p<0.001**	Z=-2.309 **p=0.021**	Z=-2.648 **p=0.008**	Z=-3.081 **p=0.002**	Z=-.108 p=0.91	Z=-.577 p=0.563	.000d p=1.000	Z=-2.041 **p=0.041**	Z=-1.251 p=0.21
i6	Z=-2.495 **p=0.013**	Z=-3.286 **p=0.001**	Z=-.905 p=0.366	Z=-1.716 p=0.087	Z=-2.162 **p=0.031**	Z=-1.721 p=0.085	Z=-2.130 **p=0.033**	Z=-2.859 **p=0.004**	Z=-1.611 p=0.107	Z=-.768 p=0.442
i7	Z=-3.111 **p=0.002**	Z=-2.959 **p=0.003**	Z=-3.082 **p=0.002**	Z=-.929 p=0.353	Z=-1.192 p=0.233	Z=-2.041 **p=0.04**	Z=-2.271 **p=0.02**	Z=-2.736 **p=0.006**	Z=-.412 p=0.68	Z=-.403 p=0.68
i8	Z=-3.418 **p=0.001**	Z=-2.309 **p=0.021**	Z=-1.318 p=0.187	Z=-2.724 **p=0.006**	Z=-2.174 **p=0.03**	Z=-.647 p=0.51	Z=-1.265 p=0.20	Z=-1.414 p=0.15	Z=-1.165 p=0.244	Z=-1.100 p=0.271
i9	Z=-1.706 p=0.088	Z=-1.698 p=0.09	Z=-2.640 **p=0.008**	Z=-2.352 **p=0.019**	Z=-.155 p=0.87	Z=-2.233 **p=0.025**	Z=-1.414 p=0.157	Z=-.425 p=0.67	Z=-2.724 **p=0.006**	Z=-.503 p=0.615

TABLE 2: Statistical results from the indoor and outdoor user studies, split by image. p values in bold indicate statistical significance.