

Spectra without Spectra: Learning Spectral Reconstruction from Real-World RGB Data with Sparse Supervision

Supplemental Material

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1. Training and Evaluation Datasets

In previous deep learning based methods, the datasets that were used for training and evaluation were synthetically simulated from hyperspectral images. Table 1 provides an overview of the datasets utilized in several prior methods.

2. Filter Response

2.1. RGB Filter Response

In order to compute the filter response functions f_k for the camera used in the dataset, we utilized the color chart patches under the 93 illuminations in the lab images in BeyondRGB. We optimized the filters by minimizing the error between the median value of all color chart patches in HS space and in the camera RGB space:

$$\min_{f_k} \left\{ \sum_{P \in \text{dataset}} \left\| \text{med}_{(x,y) \in P} (f_k(\lambda) S(x, y; \lambda)) - \text{med}_{(x,y) \in P} (I_k(x, y)) \right\|_1 \right\}. \quad (1)$$

Where P is a single patch in a color chart in an image. There are 18 color patches which aren't grayscale in each color chart, under 93 different illuminations, resulting in $18 \times 93 = 1674$ data pairs, for $3 \times 31 = 93$ unknowns. We normalized the filters so that the green channel's maximum value is equal to one. A figure of the filters can be found in figure 1.

2.2. Multispectral Filter Responses

In figure 2 we present the response function in the multispectral (MS) sensor in the BeyondRGB dataset, as published in [10]. The MS filters are wide and have overlapping regions as opposed to HS data.

3. Results

In table 2 we present full results on the supervised method trained on ARAD 1K with different scales of shot noise. From the table it is clear that changing the noise scale doesn't have a large impact on the results on X-Rite ColorChecker Classic indicating that there is a fundamental gap between synthetic data and real-camera data.

In figure 3 we show the HS reconstruction on two samples from the BeyondRGB dataset from the lab (clb/RED_red/55_mix64 and clb/BBLUE_yellow/71_mix79). In figure 4 we show the HS reconstruction on two samples from

Method	Datasets	Method Type
Lips-SpecFormer [17]	CAVE [25], NTIRE2020 [3], NTIRE2022 [4]	Supervised
MST ++ [5]	NTIRE2022 [4]	Supervised
SSFDF [8]	CAVE [25], Harvard [7]	Supervised
DRCR [13]	NTIRE2018 [2], NTIRE2020 [3], NTIRE2022 [4]	Supervised
WHANet [19]	NTIRE2022 [4], CAVE [25], Harvard [7], Curprite (remote sensing dataset) [19]	Supervised
GMSR [20]	NTIRE2020 [3], CAVE [25], Harvard [7]	Supervised
RepCPSI [21]	NTIRE2018 [2], NTIRE2020 [3], CAVE [25]	Supervised
LSA-Net [27]	CAVE [25]	Supervised
NeSR [24]	NTIRE2018 [2], NTIRE2020 [3], CAVE [25]	Supervised
HSACS [12]	NTIRE2018 [2], CAVE [25], Harvard [7]	Supervised
[28]	NTIRE2018 [2], CAVE [25], Harvard [7]	Supervised
[15]	ICVL [1]	Supervised
AWAN [11]	NTIRE2018 [2], NTIRE2020 [3]	Supervised
HSCNN+ [16]	NTIRE2018 [2]	Supervised
[18]	NTIRE2018 [2]	Supervised
HSCNN [23]	ICVL [1]	Supervised
[9]	NTIRE2020 [3]	Supervised+ Unsupervised
DSR-Net [6]	CAVE [25], Harvard [7]	Unsupervised
MFormer [14]	NTIRE2020 [3], CAVE [25], Harvard [7]	Unsupervised
[26]	ICVL [1]	Unsupervised
[29]	ICVL [1], NTIRE2020 [3], HOTAC [22] (unaligned videos of HS and RGB data)	Unsupervised

Table 1. HS datasets used in spectral reconstruction methods for training and evaluation

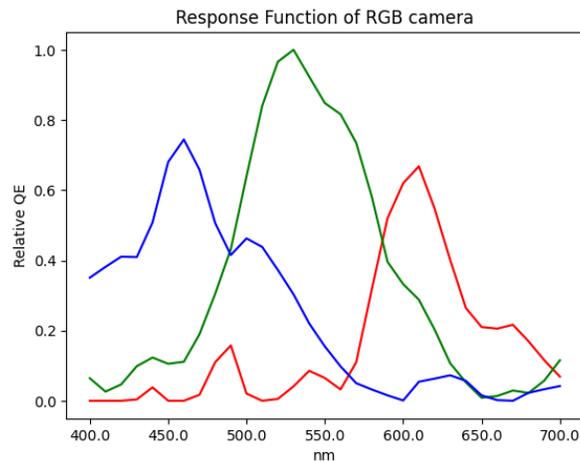


Figure 1. Response function of Samsung Galaxy S21 Plus based on color chart data.

the BeyondRGB dataset from natural environments- one of an indoor scene (outdoor/205) and one of an outdoor scene (outdoor/327).

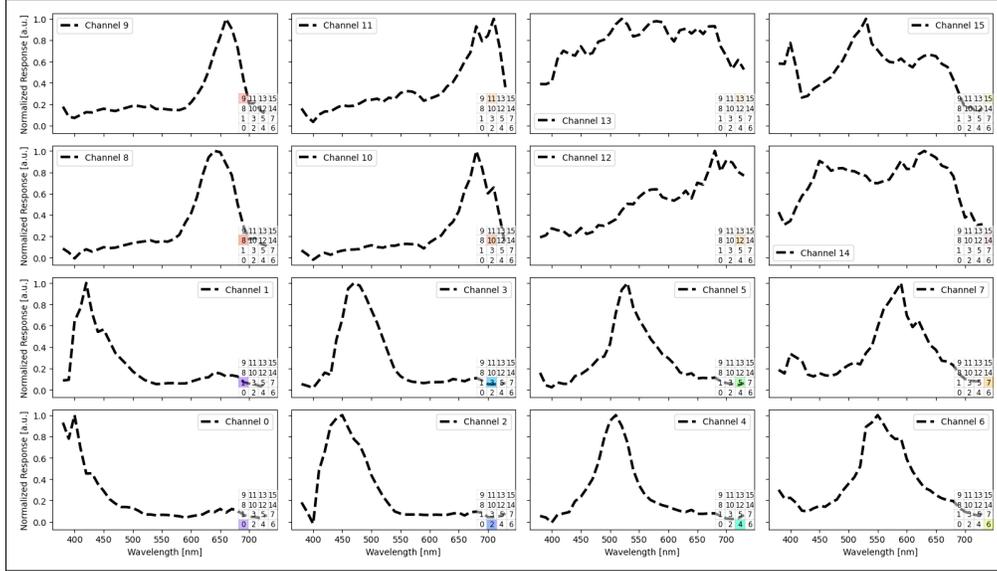


Figure 2. Normalized response function of the MS sensor in the BeyondRGB dataset.

Method	Validation set	X-Rite ColorChecker Classic
ARAD npe=10	4.81	19.2
ARAD npe=100	3.83	18.91
ARAD npe=1000	3.35	19.07
ARAD no shot noise	2.84	19.23
Ours	-	5.52

Table 2. Results with supervised learning on synthetic data, compared to the results with a network trained in a mixed-supervised manner on the color chart patches. Different shot-noise levels were used to try and best capture the noise in BeyondRGB. All errors are measured in SAM.

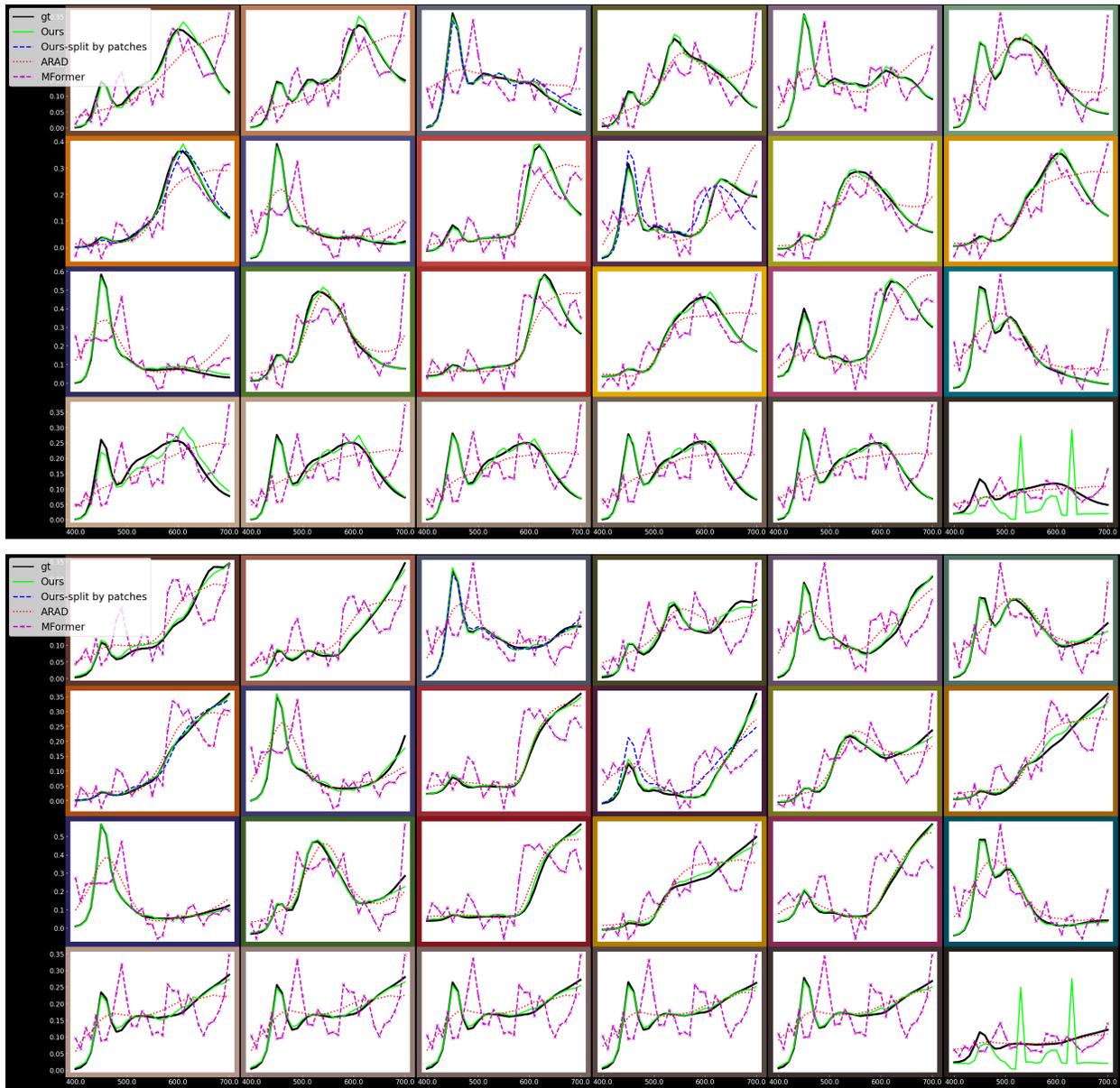


Figure 3. Reconstruction on the on the X-Rite ColorChecker Classic from two images from the lab. The values shown are the mean of the reconstruction on the patch. For the network trained with the patches split we only show results on the patches from the test set: (0, 2), (1, 0), (1, 4).

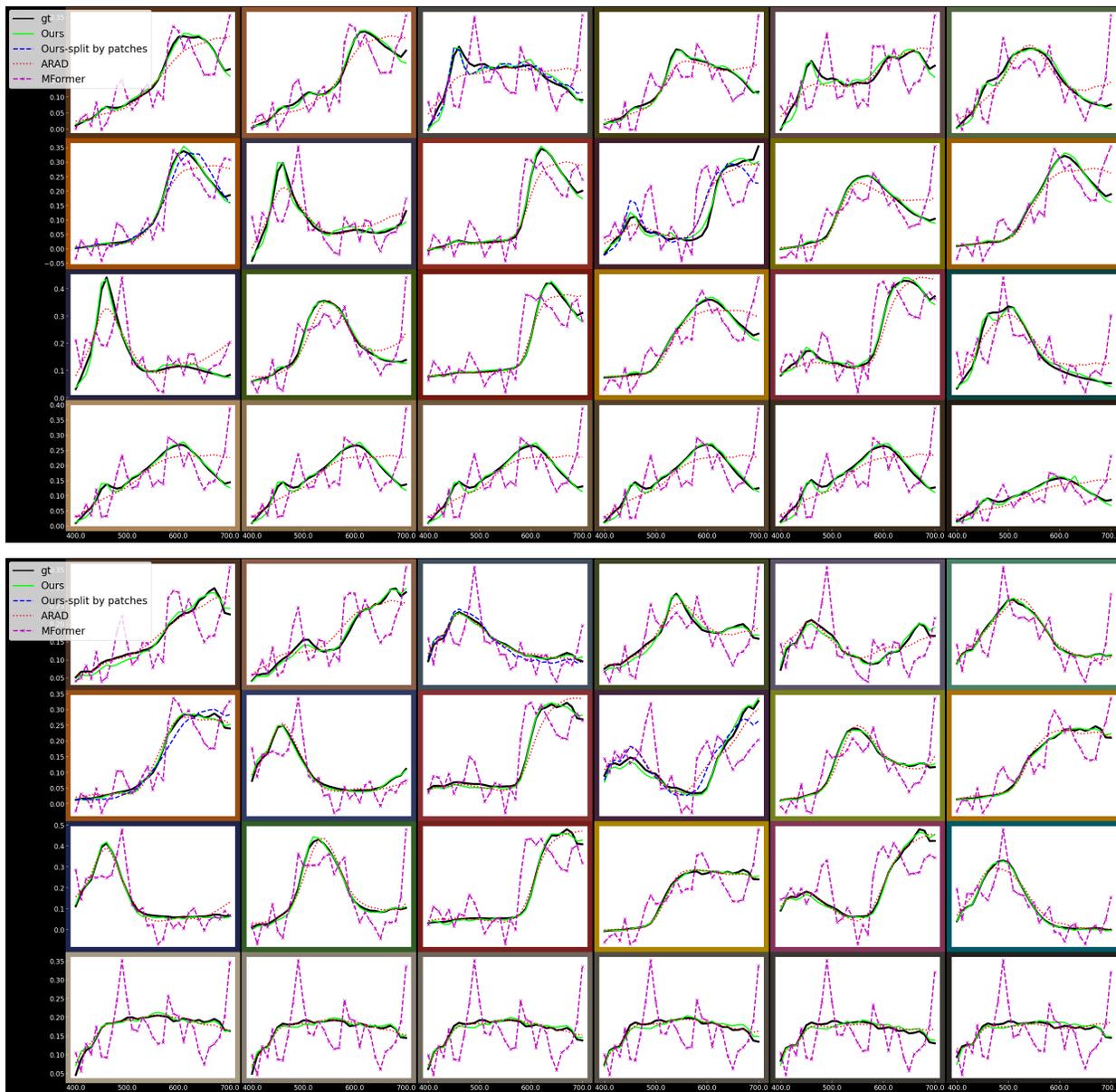


Figure 4. Reconstruction on the on the X-Rite ColorChecker Classic, top: indoor image, bottom: outdoor image. The values shown are the mean of the reconstruction on the patch. For the network trained with the patches split we only show results on the patches from the test set: (0, 2), (1, 0), (1, 4).

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