Accurate Spectral Super-resolution from Single RGB Image Using Multi-scale CNN

Yiqi Yan[1], Lei Zhang[1], Jun Li[2], Wei Wei[1], Yanning Zhang[1]

[1] *Northwestern Polytechnical University*

[2] *Sun Yat-Sen University*

Introduction

- **Single image spectral super-resolution** aims at producing a high-resolution hyperspectral image directly from the RGB observation. The main challenge is to accurately reconstruct a high-dimensional continuous spectrum from three discrete intensity values at each pixel.
- **Multi-scale deep convolutional neural network** jointly encodes the local and non-local image information through symmetrically downsampling and upsampling the intermediate feature maps in a cascading paradigm, and improves the reconstruction accuracy.
- Experimental results on the latest and largest hyperspectral dataset demonstrate the effectiveness of the proposed method.

Method

Basic Building Blocks

- **Double convolution (Double Conv) block** consists of two 3×3 convolutions. Each of them is followed by batch normalization, leaky ReLU and dropout.
- **Downsample block** contains a regular max-pooling layer. It reduces the spatial size of the feature map and enlarges the receptive field of the network.
- **Upsample block** We use the pixel shuffle operation (subpixel convolution), which is good at alleviating the checkboard artifacts.

Network Architecture Our method is inspired by the well known U-Net architecture for image segmentation. The network follows the encoder-decoder pattern.

- **Encoder** Each downsampling step consists of a "Double Conv" with a downsample block. The spatial size is progressively reduced, and the number of features is doubled at each step.
- **Dncoder** Every step consists of an upsampling operation followed by a "Double Conv" block, recovering the spatial size while halving the number of features.
- **Skip connections** The corresponding feature maps of the encoder and decoder are concatenated.

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Comparison experiments

Competing Methods Spline interpolation (serves as baseline), dictionary learning and sparse coding [2, 1], and another deep learning method [3].

Dataset The NTIRE2018 challenge on spectral reconstruction from RGB images (in conjunction with CVPR2018) provides 256 high-resolution hyperspectral images (1392×1300) and 5 independent images for testing. During training, patches of size 64×64 are extracted. During testing, we directly feed the whole image to the network and get the estimated hyperspectral image in one single forward pass.

Evaluation For evaluating **pixel-level reconstruction error**, we follow [1] to use absolute and relative root-mean-square error (RMSE and rRMSE). Note that There are two formulas for RMSE and rRMSE respectively. Besides, we also use use spectral angle mapper (SAM) to measure the **spectral similarity**.

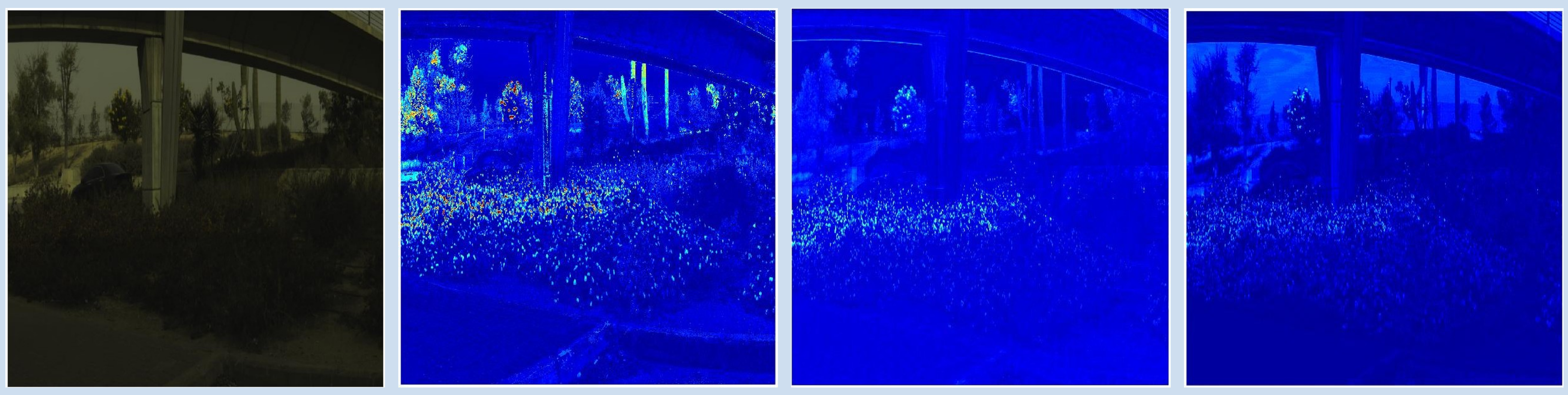
Quantitative Results

The table shows the average evaluation results on the test set. For the complete table, please refer to Table.2 in our paper.

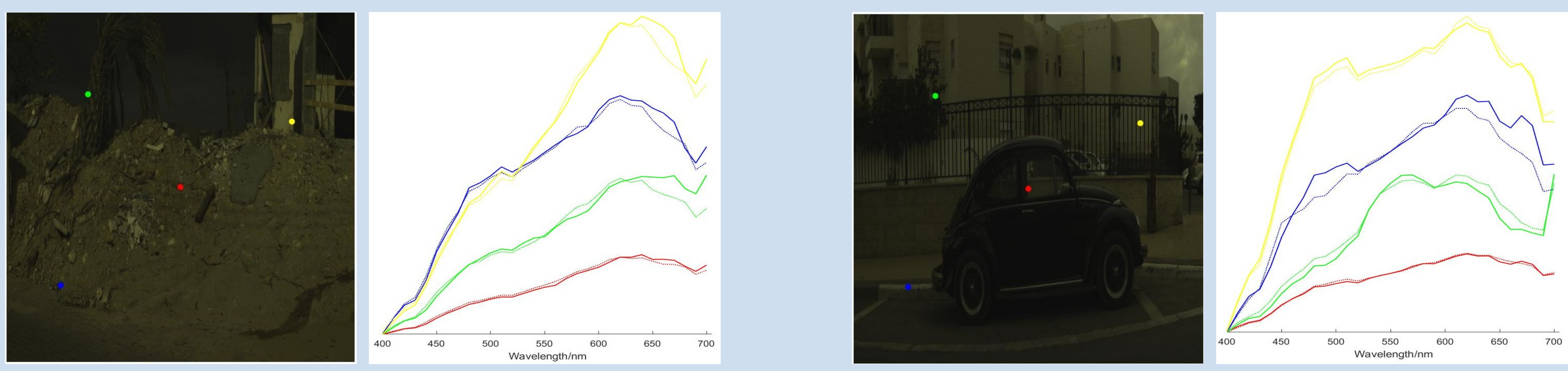
	$RMSE_1$	$RMSE_2$	$rRMSE_1$	$rRMSE_2$	SAM (degree)
Interpolation	1.9454	3.2500	0.0610	0.1038	3.6813
[2]	1.6154	2.6061	0.0656	0.0844	3.6457
[1]	1.2988	1.8936	0.0570	0.0610	3.2985
[3]	0.7584	**1.2445**	0.0262	**0.0407**	1.5523
Out method	**0.7177**	1.2899	**0.0233**	0.0414	**1.4673**

Visual Results

Absolute reconstruction error From left to right: RGB rendition, [1], [3], and our method. More images are available in our paper.



Spectral reconstruction Sample results of spectral reconstruction by our method. The corresponding pixel locations are indicated by different colors. More images are available in our paper.



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