User Guide

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Based on our research paper "COS2A: Conversion from Sentinel-2 to AVIRIS Hyperspectral Data Using Interpretable Algorithm With Spectral-Spatial Duality", we provide a demo file for researchers to investigate our theory and algorithm. Specifically, two models are included:

- The journal model (i.e., COS2A) [1].
- The universal model, which has the same deep learning (DE) part and convex optimization (CO) part [2] as COS2A but is trained by a more general dataset (details are introduced in Section 2).

1 Prerequisites

The demo code of COS2A is conducted under Ubuntu 24.04.2 LTS with NVIDIA RTX 3090 GPU, and the software environments are itemized as below:

- Python: 3.12.4
- torch: 2.7.0+cu126
- torchvision: 0.22.0+cu126
- tensorboard: 2.19.0
- scipy: 1.15.2
- MATLAB: 2023b

2 Details of the training data used in universal model

To enhance the model generalizability, we construct a more comprehensive dataset that includes both real and simulated AVIRIS/Sentinel-2 pairs across multiple regions of the USA. The details are summarized as follows:

1) Western USA (2019)

- **522** real AVIRIS/Sentinel-2 data pairs are collected.
- **522** simulated Sentinel-2 images are generated by uniformly downsampling the real AVIRIS data.

2) Hawaii, USA (2018–2019)

- 100 real AVIRIS/Sentinel-2 pairs are collected. AVIRIS is collected in 2018 and Sentinel-2 in 2019, due to the reduced availability of temporally aligned data pairs. Besides, due to misalignment issues, only **38** pairs are retained for use.
- **100** simulated Sentinel-2 images generated by uniformly downsampling the real AVIRIS data.

3) Data offered in [3, Table 1]

- **568** real AVIRIS images and the corresponding simulated Sentinel-2 images are generated by uniformly downsampling the real AVIRIS data.

4) Cuprite Mining Site, NV, USA

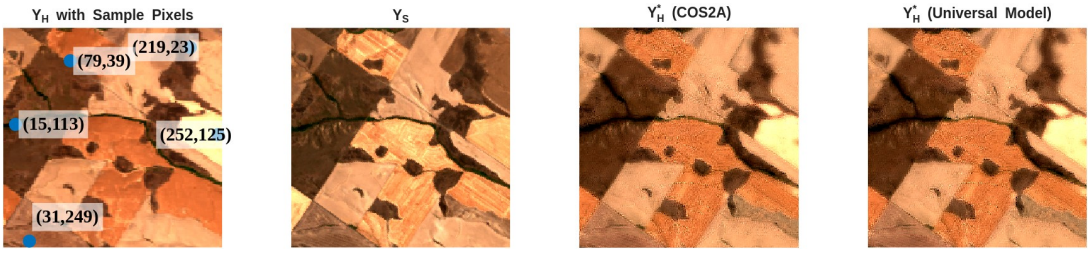
- The image was randomly cropped into **20** overlapping 256×256 patches since the image size is limited (512×614 pixels), and the corresponding simulated Sentinel-2 images are generated by uniformly downsampling the real AVIRIS data.

3 Run the demo code

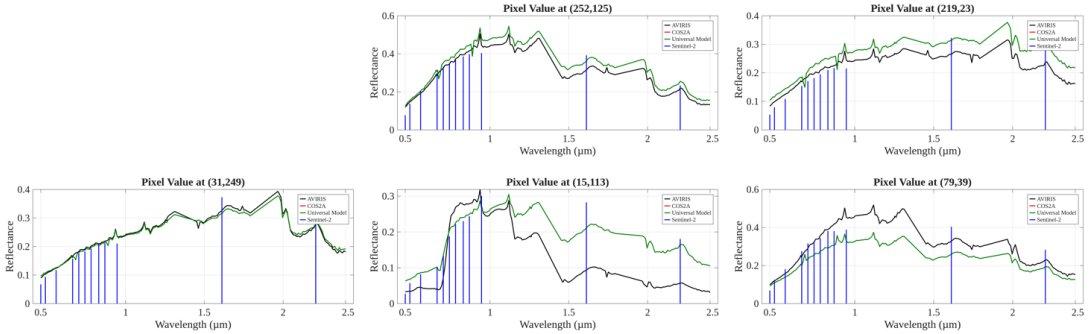
- Open MATLAB in the environment that has installed PyTorch. Then, run "`main.m`" to get the results of COS2A and the universal model in the real data.

  The results are presented in six figures:

  – One figure shows the real AVIRIS image, its counterpart real Sentinel-2 image, and the reconstructed AVIRIS images obtained from COS2A and the universal model, respectively, as shown below.



  – Five figures respectively illustrate the spectral signatures of selected five representative pixels with high spectral diversity, as shown below.



- To evaluate COS2A/universal model on your own data, place the data file in the "`data`" folder and add its filename (without the `.mat` extension) to the "`data_list.txt`". Then, update line 12 in "`main.m`" to select the corresponding scene index (e.g., 1 for the first entry, 2 for the second, etc.).

- If you want to replace the DE result in the COS2A framework, place your DE result file in the "`DE_result`" folder. Comment out line 21 and modify line 22 in "`main.m`" to load your DE result instead.

4 Model Training

- We also provide the training code in the "`train`" folder for retraining the deep unfolding network in COS2A with your own dataset.

- The motivation for releasing the training code is to enable users to train a country-specific model using your own regional datasets.

- To train the network on your own dataset, place your dataset under the "`train/dataset/`" directory. All data are stored as `.mat` files containing paired MSI Y_S and HSI Y_H tensors, and organize them into the subfolders
(i.e., "`train/dataset/Train_Spec`" and "`train/dataset/Valid_Spec`").

- For the real data training settings, the deep unfolding network in COS2A framework is optimized in an end-to-end manner by minimizing an outlier-robust ℓ_1 loss function. A total of 20000 overlapped 64×64 patches with data augmentation (random flips and rotations) are cropped for training and validation. The model is trained for 100 epochs with a batch size of 8 and a learning rate of 0.0001.
- To start training, open a terminal and run "`python train_COS2A.py`". Model checkpoints and logs are automatically saved during training.

5 Reference

[1] C.-H. Lin, J.-T. Chen, Z.-C. Leng, and J.-T. Lin, "COS2A: Conversion from Sentinel-2 to AVIRIS hyperspectral data using interpretable algorithm with spectral-spatial duality," *IEEE Transactions on Geoscience and Remote Sensing*, 2025.

[2] C.-H. Lin, F. Ma, C.-Y. Chi, and C.-H. Hsieh, "A convex optimization-based coupled nonnegative matrix factorization algorithm for hyperspectral and multispectral data fusion," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 56, no. 3, pp. 1652–1667, Nov. 2017.

[3] C.-C. Hsu, C.-H. Lin, C.-H. Kao, and Y.-C. Lin, "DCSN: Deep compressed sensinging network for efficient hyperspectral data transmission of miniaturized satellite," *IEEE Transactions on Geoscience and Remote Sensinging*, vol. 59, no. 9, pp. 7773–7789, Sep. 2021.