Towards Learning-Based Compression of EnMAP Data

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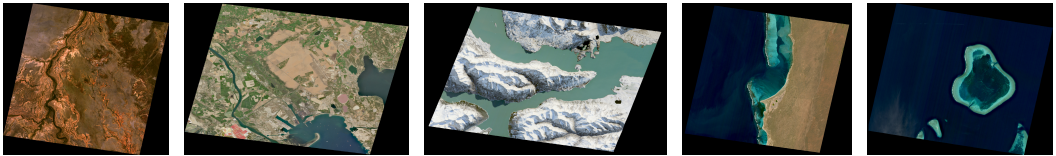


EnMAP data ©DLR [2022/2023]

- 28,758 recorded EnMAP tiles so far ($\geq$ 8 TB) [26.06.2023].
- The development of efficient and effective compression methods is important.
- Deep learning-based compression has recently attracted great attention.

Problem

- Learning-based compression methods require large amounts of training data.
- Existing hyperspectral datasets are not sufficient to train DL compression models.

Proposed Solution

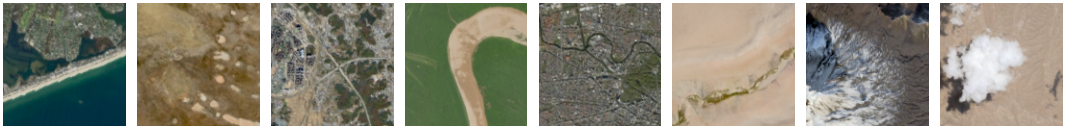
We introduce **HySpecNet-11k** [1] to overcome the limitations of existing datasets.

Dataset	Acquisition	Sensor	GSD	Spectral Range	#Bands	Dataset Size
Indian Pines	1992	AVIRIS	20.0 m	400 – 2500 nm	224	0.02 MP
Kennedy Space Center (KSC)	1996	AVIRIS	18.0 m	400 – 2500 nm	224	0.31 MP
Salinas Scene	1998	AVIRIS	3.7 m	420 – 2450 nm	224	0.11 MP
Pavia Center	2001	ROSIS	1.3 m	430 – 860 nm	102	1.20 MP
Pavia University	2001	ROSIS	1.3 m	430 – 860 nm	103	0.21 MP
Botswana	2001	Hyperion	30.0 m	400 – 2500 nm	242	0.38 MP
Cooke City	2008	HyMap	3.0 m	450 – 2480 nm	126	0.22 MP
ShanDongFeiCheng (SDFC)	2021	HAHS	0.5 m	400 – 1000 nm	63	0.72 MP
HySpecNet-11k (ours)	2022	EnMAP	30.0 m	420 – 2450 nm	224	188.14 MP

[1] M. H. P. Fuchs and B. Demir, "Hyspecnet-11k: A large-scale hyperspectral dataset for benchmarking learning-based hyperspectral image compression methods," in *IEEE International Geoscience and Remote Sensing Symposium*, 2023.

Proposed Solution: The HySpecNet-11k Dataset

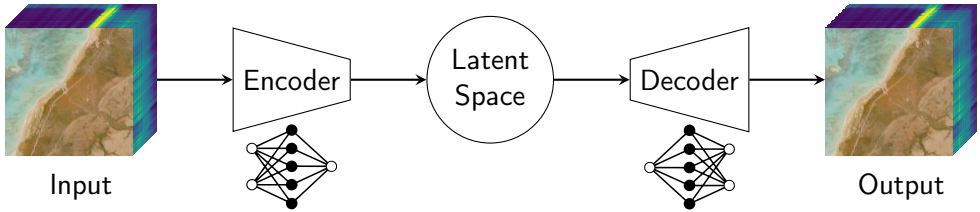
- HySpecNet-11k [1] is based on hyperspectral EnMAP [2] data (L2A product).
- HySpecNet-11k includes:
  - 11,483 image patches;
  - 128×128 pixels;
  - 30 m ground sample distance;
  - 224 spectral bands.
- The dataset can be used for any task that does not require labels.



[1] M. H. P. Fuchs and B. Demir, "Hyspecnet-11k: A large-scale hyperspectral dataset for benchmarking learning-based hyperspectral image compression methods," in *IEEE International Geoscience and Remote Sensing Symposium*, 2023.

[2] L. Guanter, H. Kaufmann, K. Segl, *et al.*, "The enmap spaceborne imaging spectroscopy mission for earth observation," *Remote Sensing*, vol. 7, no. 7, pp. 8830–8857, 2015.

Learning-Based Hyperspectral Image Compression



We benchmark the following hyperspectral compression methods on HySpecNet-11k:

- 1D-Convolutional Autoencoder (1D-CAE) [3];
- Spectral Signals Compressor Network (SSCNet) [4];
- 3D Convolutional Auto-Encoder (3D-CAE) [5].

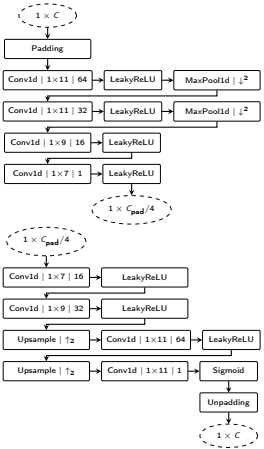
[3] J. Kuester, W. Gross, and W. Middelmann, "1d-convolutional autoencoder based hyperspectral data compression," *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. 43, pp. 15–21, 2021.

[4] R. La Grassa, C. Re, G. Cremonese, *et al.*, "Hyperspectral data compression using fully convolutional autoencoder," *Remote Sensing*, vol. 14, no. 10, p. 2472, 2022.

[5] Y. Chong, L. Chen, and S. Pan, "End-to-end joint spectral–spatial compression and reconstruction of hyperspectral images using a 3d convolutional autoencoder," *Journal of Electronic Imaging*, vol. 30, no. 4, p. 041 403, 2021.

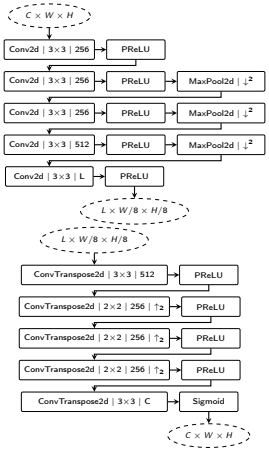
1D-CAE

Spectral Compression



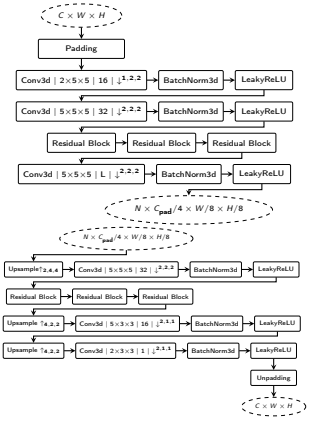
SSCNet

Spatial Compression

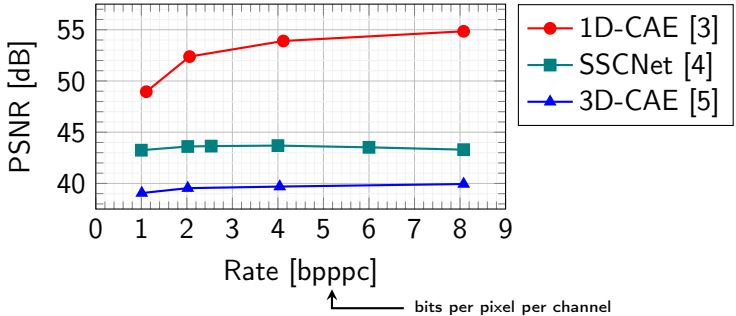


3D-CAE

Spatio-Spectral Compression



Experimental Results



- Spatial compression (SSCNet & 3D-CAE) heavily reduces reconstruction quality.
- Reconstruction quality nearly constant when spatial compression is applied.

[3] J. Kuester, W. Gross, and W. Middelmann, "1d-convolutional autoencoder based hyperspectral data compression," *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. 43, pp. 15–21, 2021.

[4] R. La Grassa, C. Re, G. Cremonese, *et al.*, "Hyperspectral data compression using fully convolutional autoencoder," *Remote Sensing*, vol. 14, no. 10, p. 2472, 2022.

[5] Y. Chong, L. Chen, and S. Pan, "End-to-end joint spectral–spatial compression and reconstruction of hyperspectral images using a 3d convolutional autoencoder," *Journal of Electronic Imaging*, vol. 30, no. 4, p. 041 403, 2021.

Conclusion

- We introduced HySpecNet-11k as the first public EnMAP benchmark dataset.
  - HySpecNet-11k can be used for any unsupervised learning task.
- We benchmarked the SOTA in learning-based hyperspectral image compression.
- We observed that spectral compression is particularly effective for EnMAP data.

Future Works

- We will release further versions of HySpecNet.
- We will work on spatio-spectral compression.
- We will investigate efficient ways to label EnMAP data.

Visit Our Website

Dataset, code and pre-trained weights are publicly available at
`https://hyspecnet.rsim.berlin`

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