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Hyperspectral remote sensing data compression with neural networks

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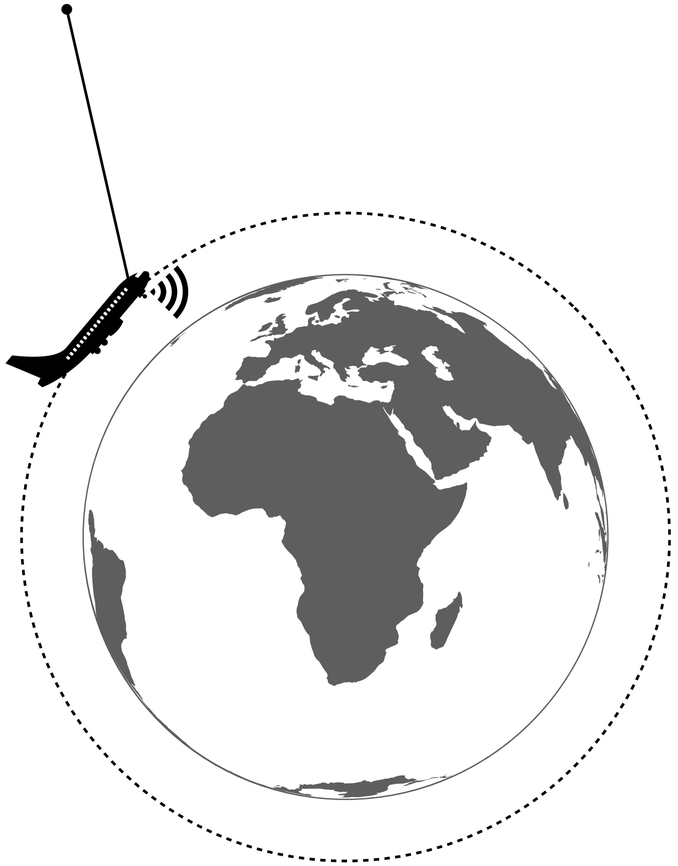
Data Compression Conference (DCC) 2022

This presentation

1. Machine Learning compression of remote sensing images
2. Proposed method
3. Experimental results
4. Discussion and significance



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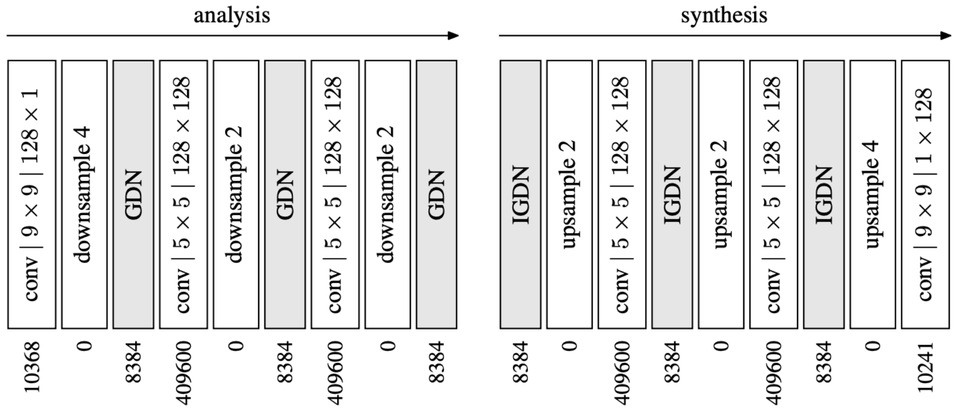
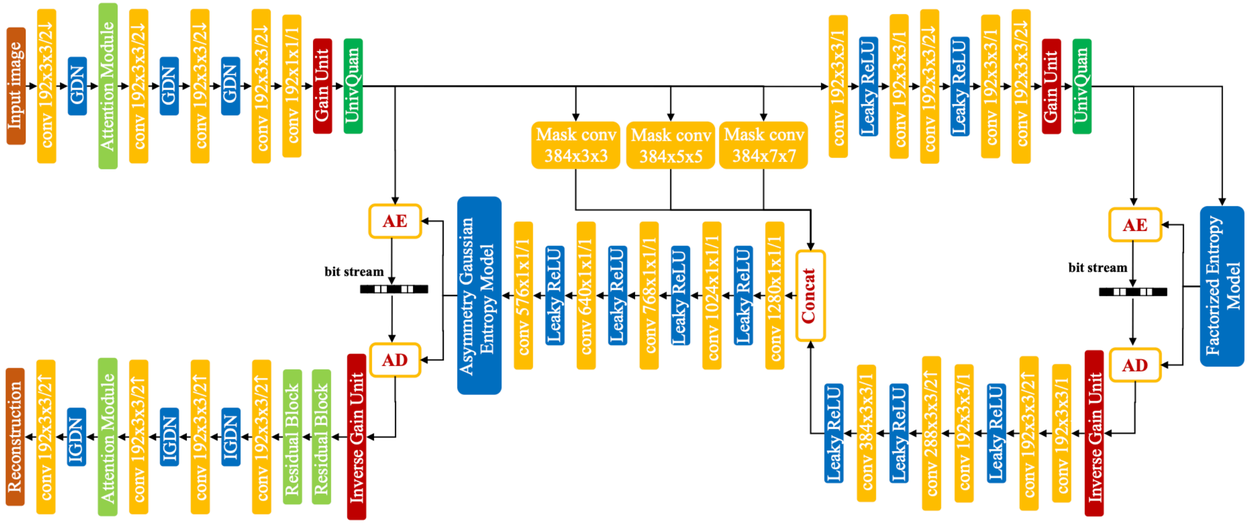
Machine Learning compression of remote sensing images

Machine Learning image compression

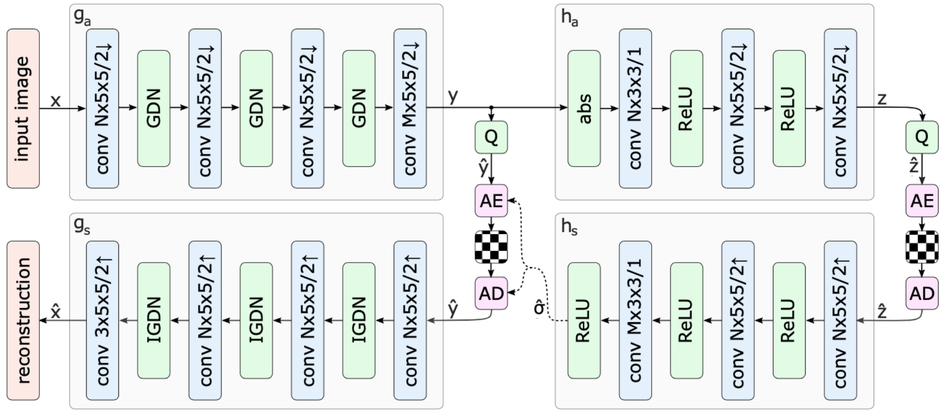
A very active field of research



J. Ballé, V. Laparra, E. Simoncelli (2017)



Z. Cui, J. Wang, S. Gao, T. Guo, Y. Feng, B. Bai (2021)



J. Ballé, D. Minnen, S. Singh, S. J. Hwang, N. Johnston (2018)

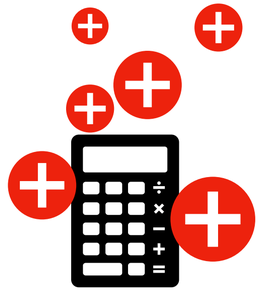
Increasingly complex designs

Machine Learning image compression

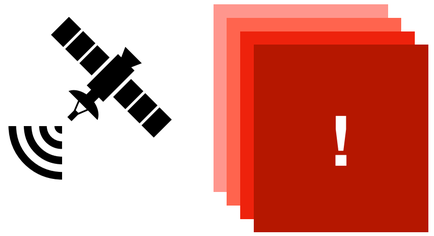
Three key points

1. Almost entirely focused on natural images

2. These systems are computationally costly



3. Computational complexity grows superlinearly with the number of input channels



Machine Learning image compression

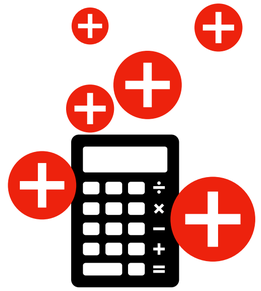
Challenges with remote sensing data

1. **Almost entirely focused on natural images**

   Little development on the subject

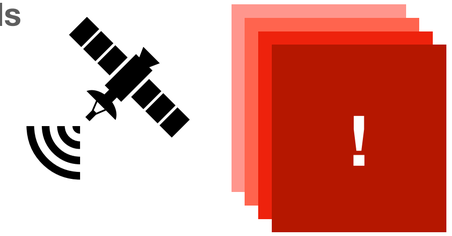
2. **These systems are computationally costly**

   Remote sensing is ususally carried out on low-power platforms



3. **Computational complexity grows superlinearly with the number of input channels**

   Remote sensing images are typically hyperspectral, with many channels



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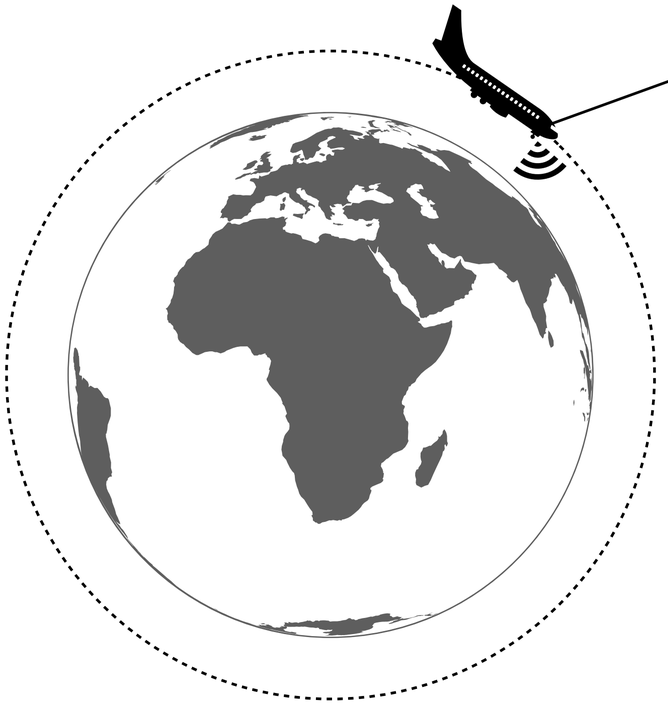

2 Proposed method

3 Experimental results

4 Discussion and significance

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Proposed method

Proposed method

Three key features

Band-by-band

Spectral partition

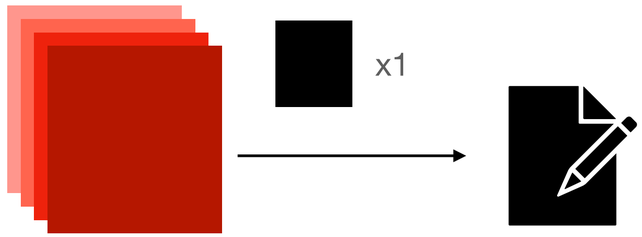
Small encoders

Proposed method

Band-by-band

Band-by-band

Processing the image channel-by-channel allows us to use smaller networks and keep encoding time essentially linear with respect to the number of channels.



Spectral partition

Small encoders

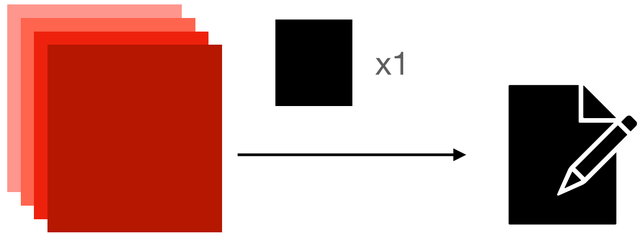
What about spectral correlation?

Proposed method

Spectral partition

Band-by-band

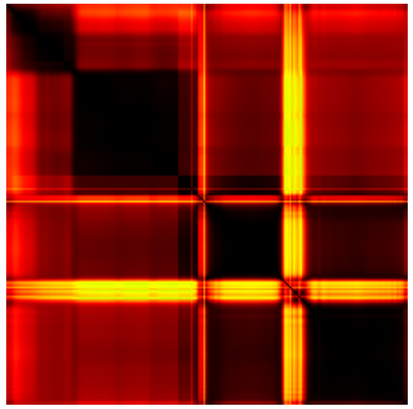
Processing the image channel-by-channel allows us to use smaller networks and keep processing complexity linear with respect to the number of channels.



Spectral partition

Typically hyperspectral images have very high similarity along the spectrum, particularly between adjacent channels, which often comes in **clusters**, as opposed to a mere continuous gradient.

We trained one independent model for each such interval of bands, which allows our models to be focused on a specific distribution, so they can improve performance thanks to high specialisation.



Small encoders

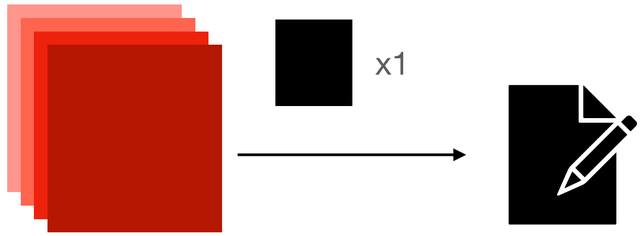
Aren't neural-network codecs very complex anyway?

Proposed method

Small encoders

Band-by-band

Processing the image channel-by-channel allows us to use smaller networks and keep processing complexity linear with respect to the number of channels.



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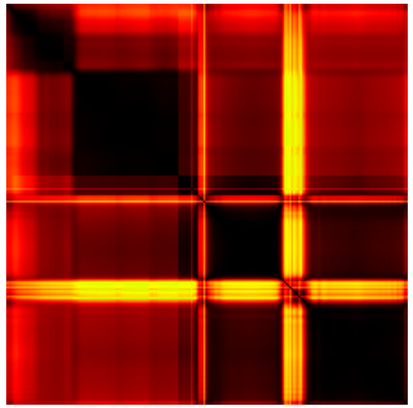
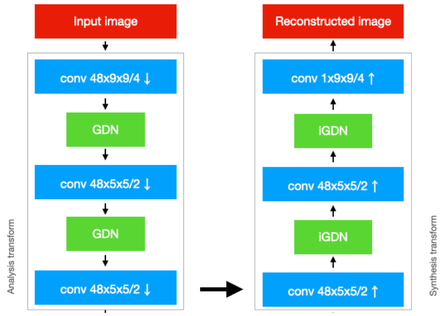


Small encoders

To keep complexity low, and thanks to the high specialisation of our models, we can competitively use small networks (in terms of the number of parameters and operations) to compress those images.



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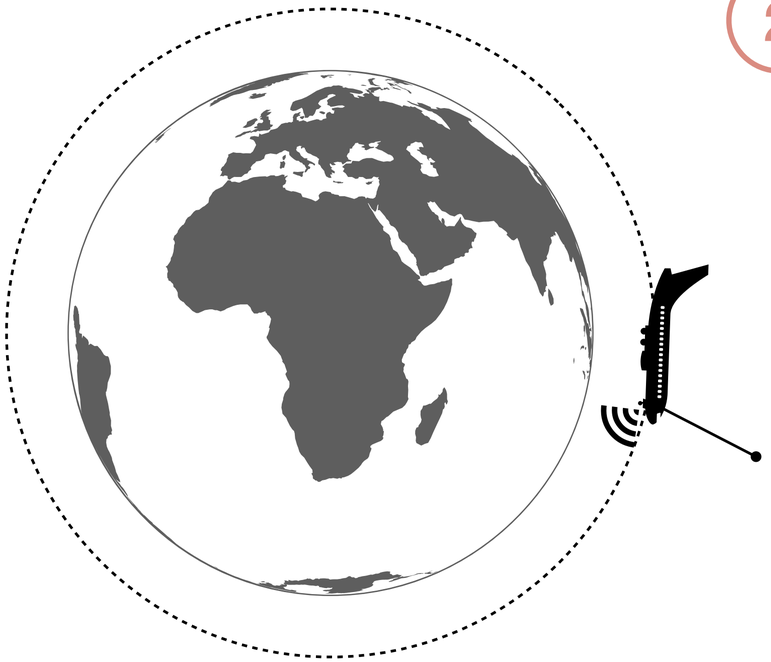

3 Experimental results

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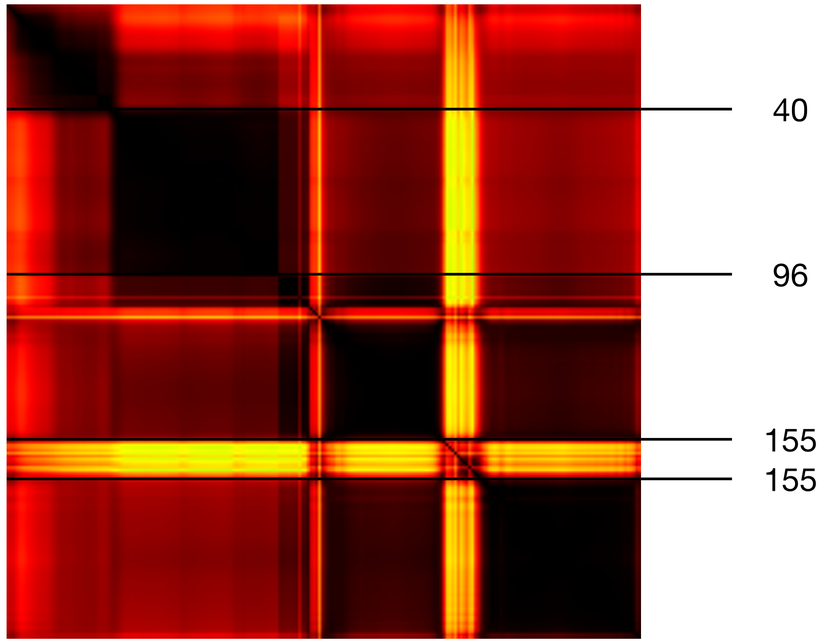
Experimental results

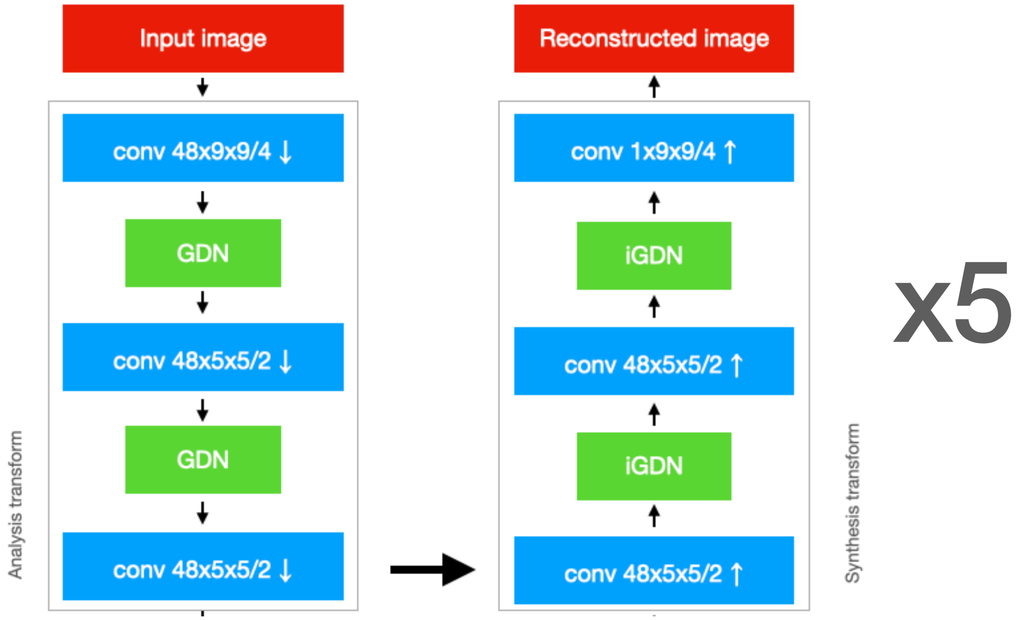
Experimental results

Setup

1 Intervals in AVIRIS images

We identified 5 high-correlation band intervals in AVIRIS images, shown below



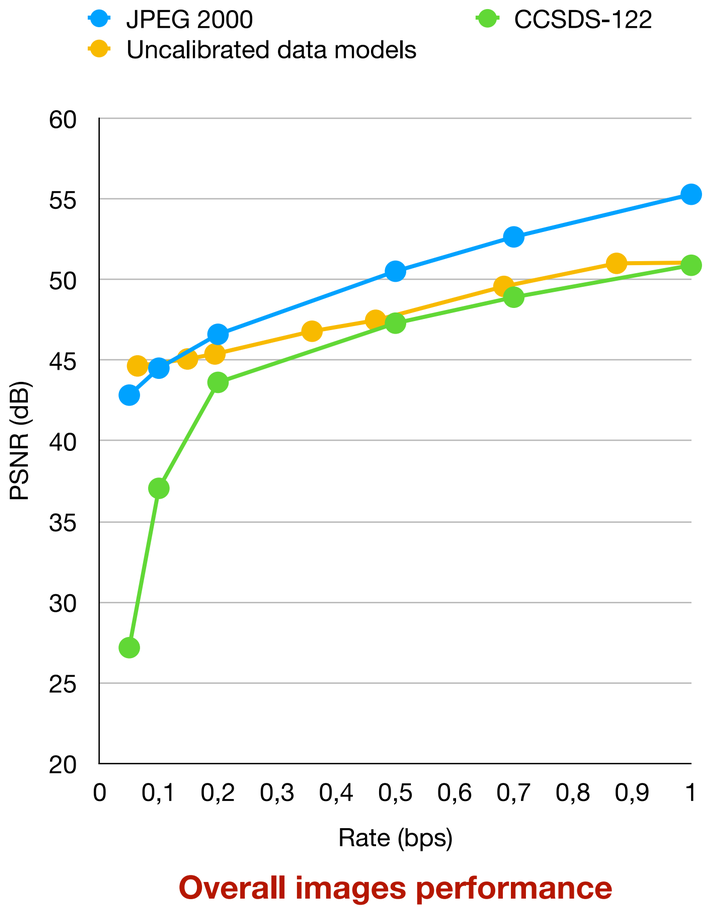


2 Models

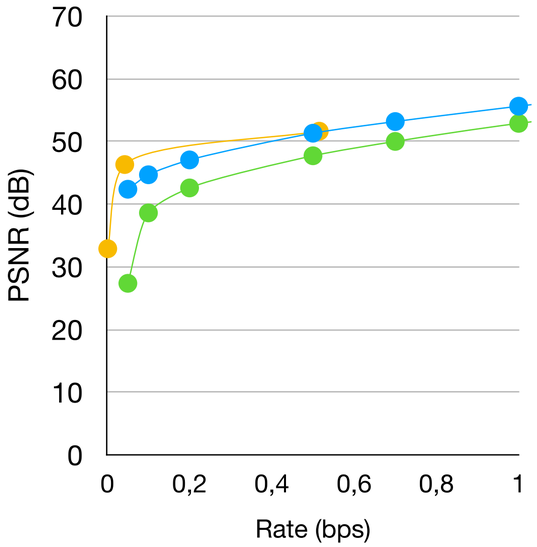
We used a proven architecture by Ballé *et al.* with just 48 filters. One instance of this architecture (model) was trained for each of the intervals, 5 in total.

Experimental results

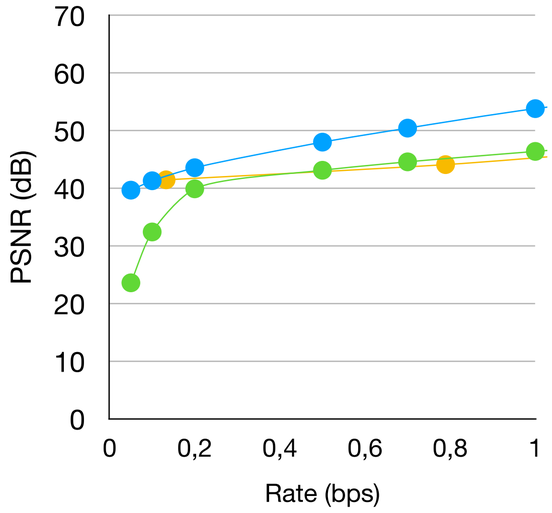
Performance



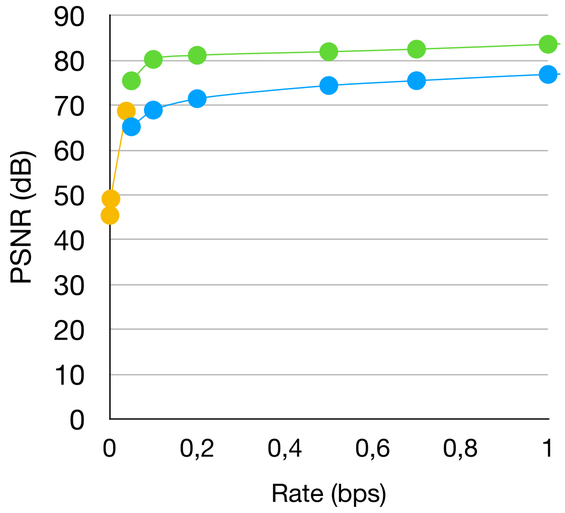
Overall images performance



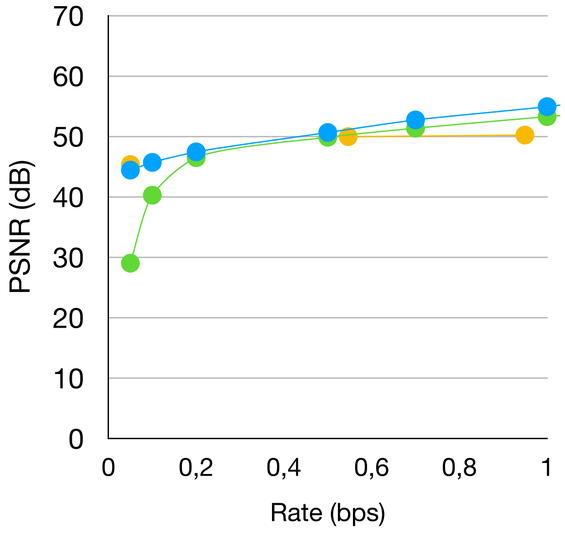
Interval 1 (1-40)



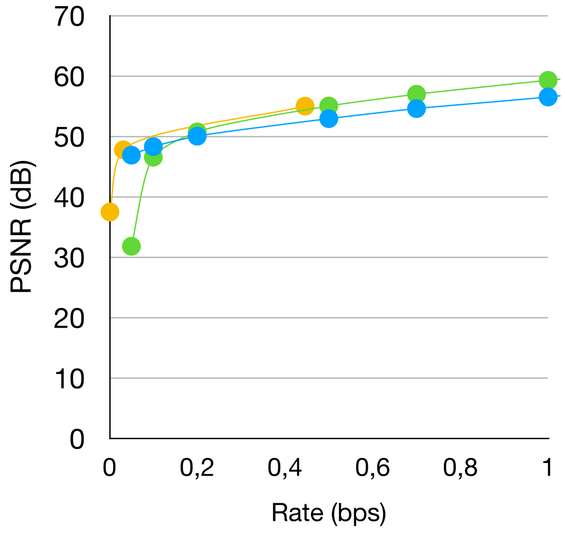
Interval 2 (41-96)



Interval 4 (156-165)



Interval 3 (97-155)



Interval 5 (166-224)

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Discussion and significance

Discussion and significance

What have we learned?

1. These methods can be used effectively and competitively

2. First contibution for ML compression of hyperspectral image (i.e. >100 bands)

3. Baseline for further development and analysis

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