IMAGE DENOISING WITH DICTIONARIES

THE UNIVERSITY of ADELAIDE

K-SVD Dictionary Learning

- Algorithm that able to remove the noise to preserve as much the details in the image
- Interest on searching sparse representations of signals, $\boldsymbol{y \cong Dx}$
- D: dictionary matrix, y: sparse coefficient of k-atoms, x: representation coefficient of signal y
- K-SVD steps:

1. Initialise dictionary, D
2. Sparse coding (use Matching Pursuit)
3. Dictionary Update (column-by-column)

Individual and Universal Dictionary

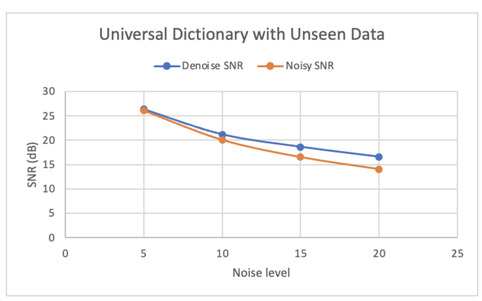
Individual Dictionary

- Break down the image to 8x8 patches over 50 iterations
- Use the dictionary to denoise the same image

Noisy and denoised image with noise level σ=20

Universal Dictionary

- Created one trained dictionary from 15 test images
- Use the trained dictionary to denoise an unseen image



OMP vs FISTA

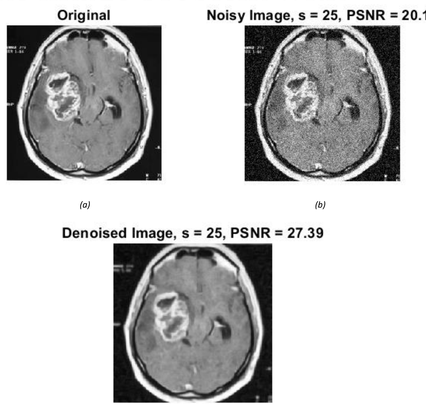
Experiment

- OMP is an iterative algorithm that selects at each step of the column, which most correlate with current residuals
- FISTA
- Dictionary, D = 50, Sparsity, k = 5

		AVERAGE SPARSITY OF COEFFICIENT		TRAINING TIME TO TRAIN DICTIONARY (SECONDS)		OUTPUT SNR ERROR OF THE SIGNAL (DB)	
MATCHING PURSUIT	λ	Generated Data	Unseen Data	Generated Data	Unseen Data	Generated Data	Unseen Data
OMP	-	5	5	7.44	6.32	19.41	7.79
FISTA	0.1	12.16	2.36	125.3	229.8	25.97	16.95
FISTA	0.3	5.60	9.64	100.5	195.9	16.11	7.99
FISTA	0.5	2.84	6.32	102.2	202.2	12.45	5.03
FISTA	0.9	1.29	2.36	100.7	201.1	7.75	1.91

Future Work

- Trained dictionary with much more data to create denser dictionary
- Applied the image problem with FISTA



(Github/brain tumor mri classification)

Conclusion

- K-SVD with OMP performs better than FISTA due to its simplicity and fast convergence to zero
- Universal dictionary is more powerful as it able denoise unseen data. The dictionary could be trained using larger dataset to make more useful for application

References

- L. Shao, R. Yan, X. Li and Y. Liu, "From Heuristic Optimization to Dictionary Learning: A Review and Comprehensive Comparison of Image Denoising Algorithms," in IEEE Transactions on Cybernetics, vol. 44, no. 7, pp. 1001-1013, July 2014, doi: 10.1109/TCYB.2013.2278548.
- M. Elad and M. Aharon, "Image Denoising Via Sparse and Redundant Representations Over Learned Dictionaries," in IEEE Transactions on Image Processing, vol. 15, no. 12, pp. 3736-3745, Dec. 2006, doi: 10.1109/TIP.2006.881969.

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