Deep Learning Strategies for Medical Image Reconstruction

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Thesis Objective

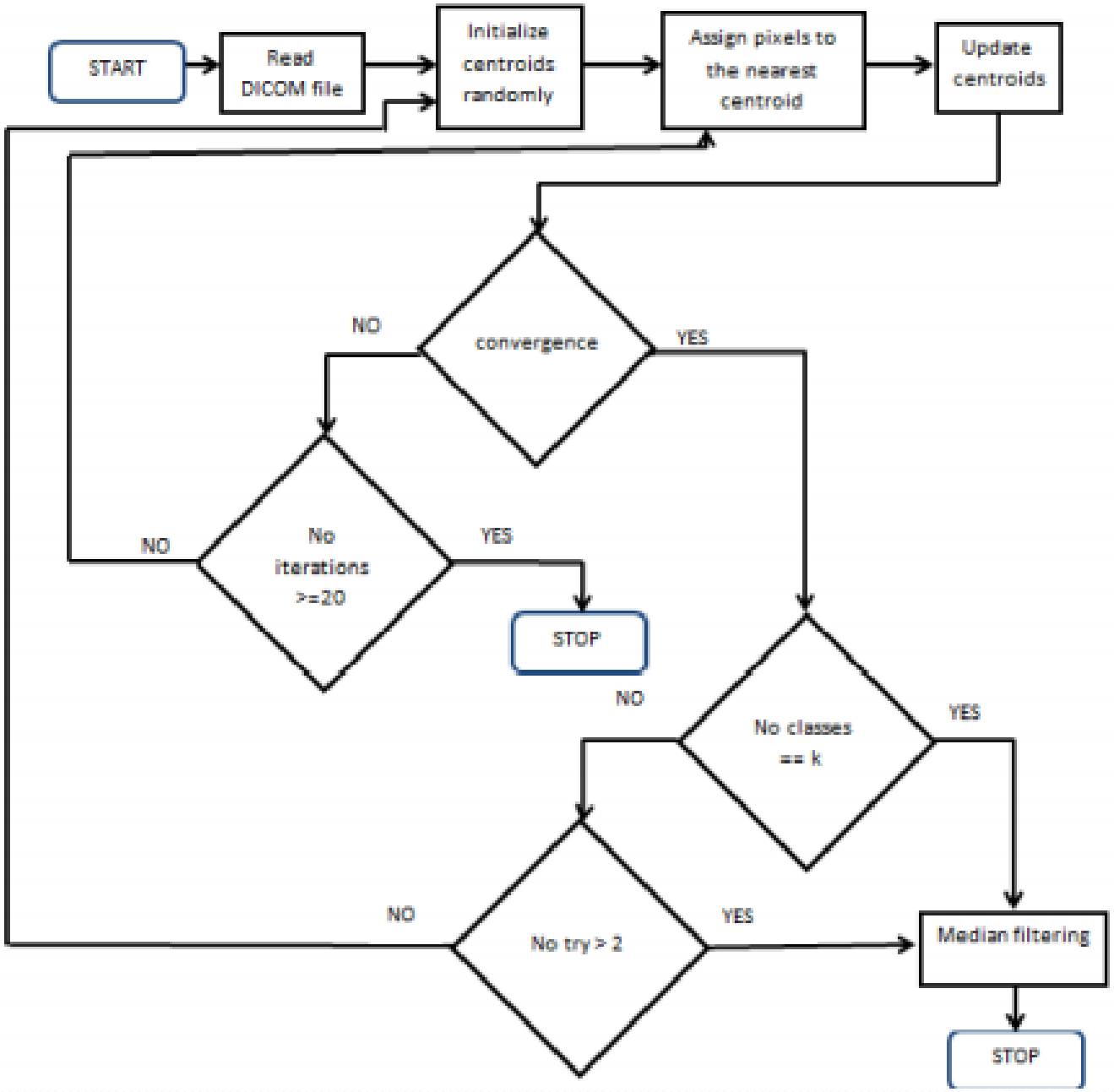
- MRI reconstruction, with the following restrictions:
  - Distorted inputs
  - Small dataset
  - Unlabeled data
  - Qualitative results, simple and fast

Experimental Setup

- Database:
  - fastMRI
  - axial brain scans, T1 and T2 weighted
    - T1: spin-lattice relaxation time, ~3-5 s
    - T2: spin-spin relaxation time, ~260 ms
- Tests done on the whole database and on subsets

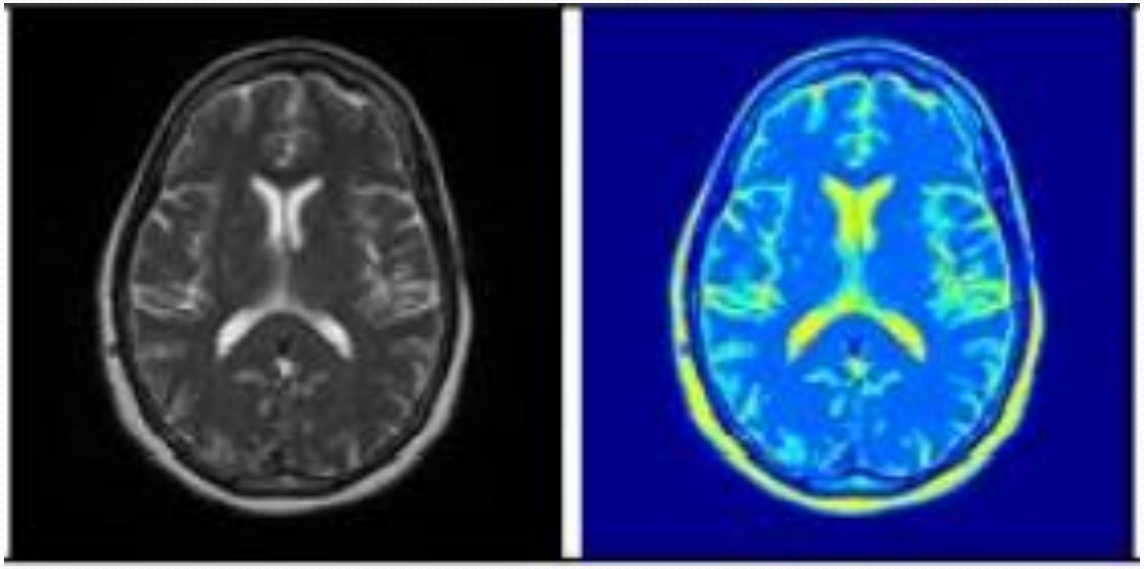
Experimental Setup – MRI segmentation

- K-means algorithm
- on a subset containing 335 scans
- k = 5
  - White matter
  - Gray matter
  - Cerebrospinal fluid
  - Skull
  - background


START
Read DICOM file
Initialize centroids randomly
Assign pixels to the nearest centroid
Update centroids
convergence
NO
YES
No iterations >=20
NO
YES
STOP
No classes == k
NO
YES
No try > 2
NO
YES
Median filtering
STOP

Results – MRI segmentation

- average PSNR = 67 dB
- average SSIM = 0.62



Segmentation results

Experimental Setup – MRI reconstruction

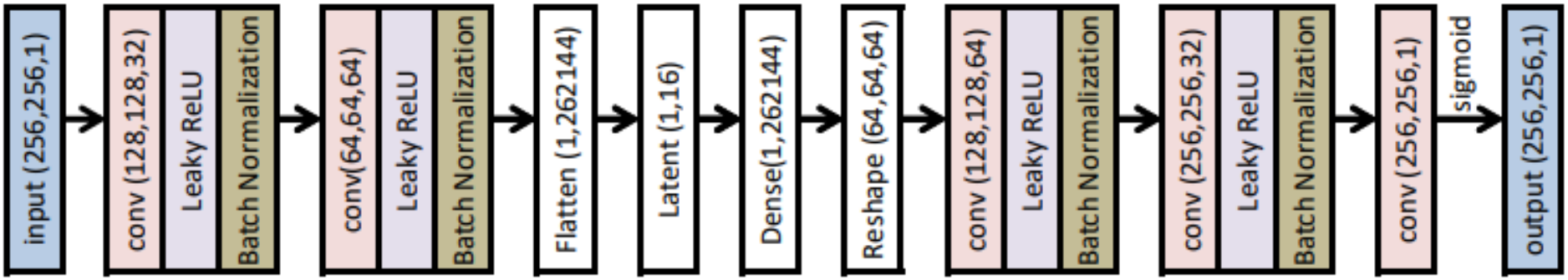
- Database divided into:
  - 80% training samples
  - 20% testing samples
- Variation parameters:
  - Number of epochs:

    {50, 100, 500}
  - Batch size:

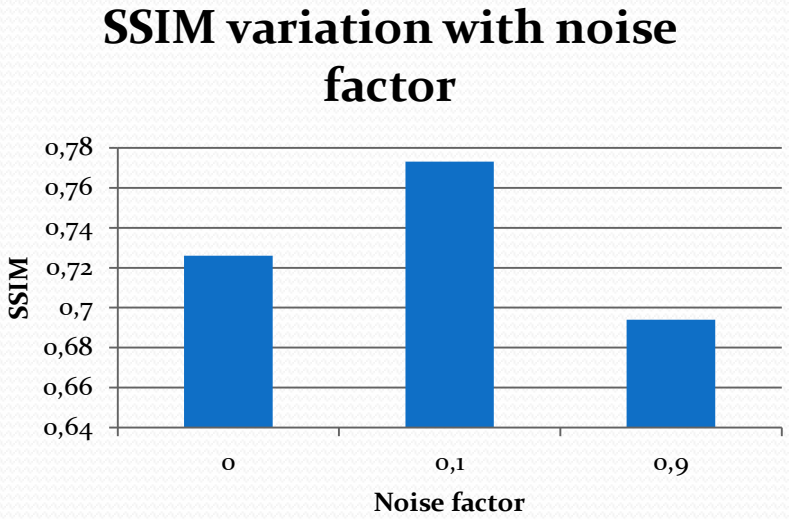
    {2, 4, 32}
  - Noise factor

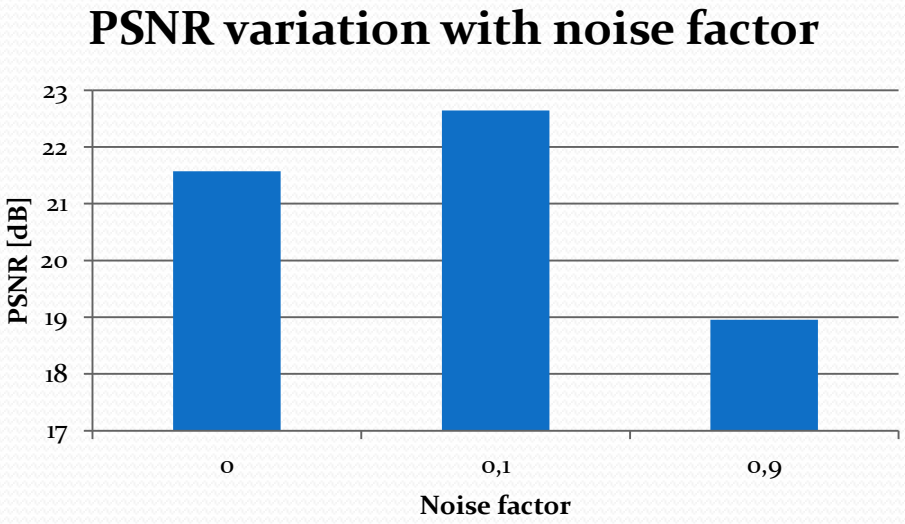
    {0, 0.1, 0.9 }

Experimental Setup – MRI reconstruction

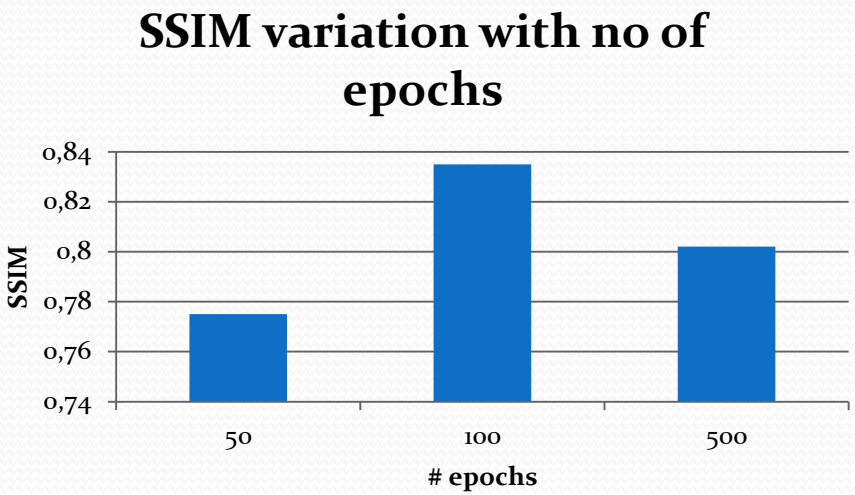


Results – MRI Reconstruction

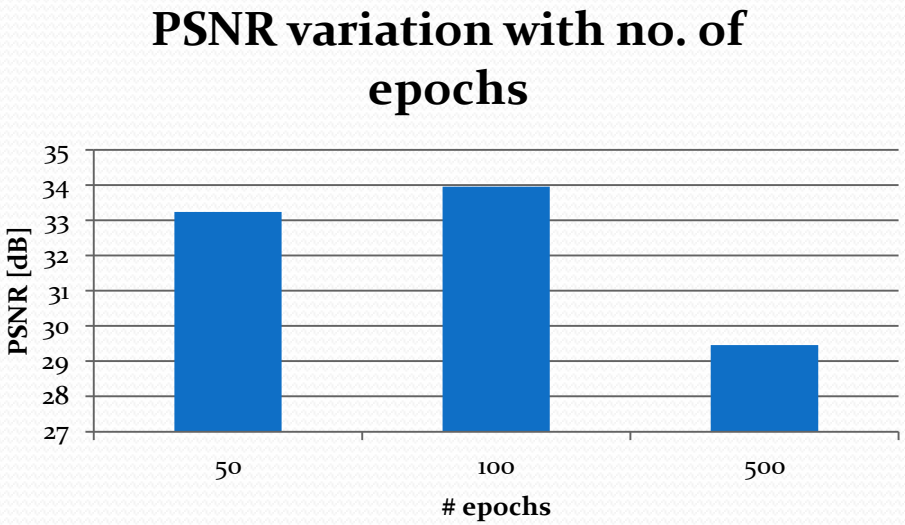




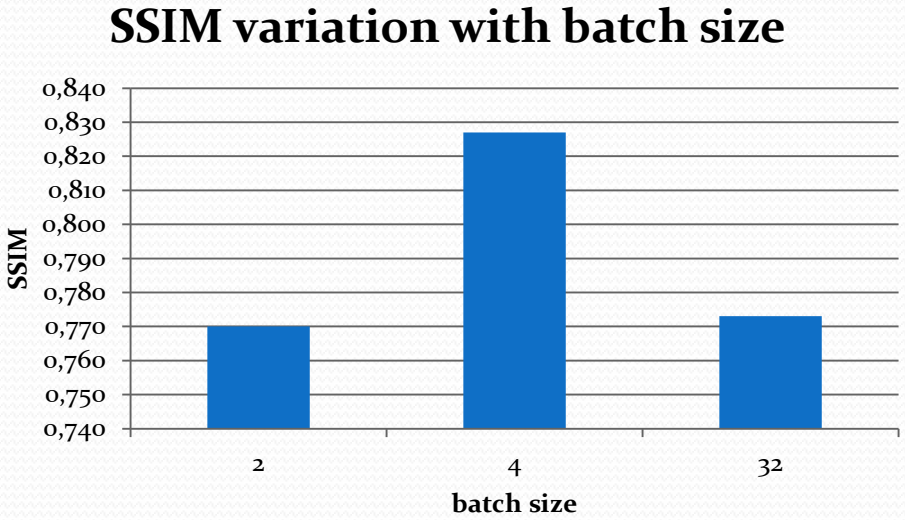
Results – MRI Reconstruction



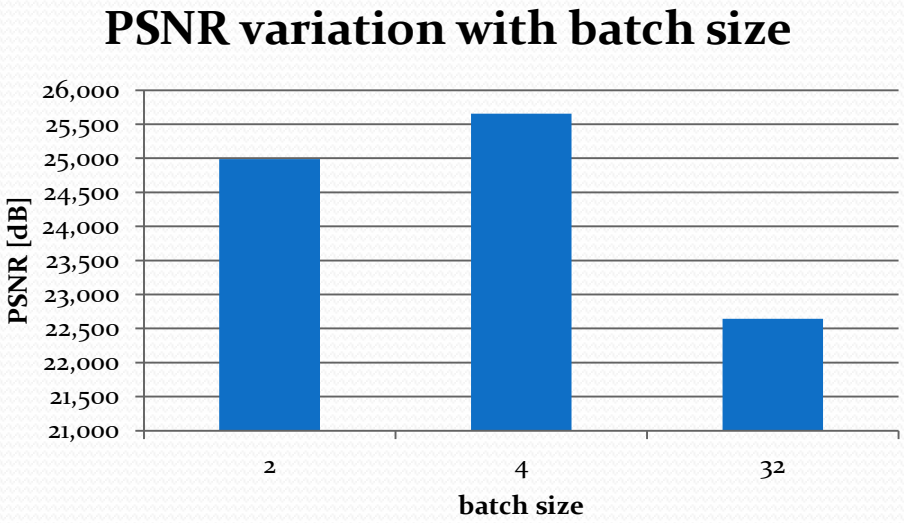
- #epochs low => underfitting
- #epochs high => overfitting



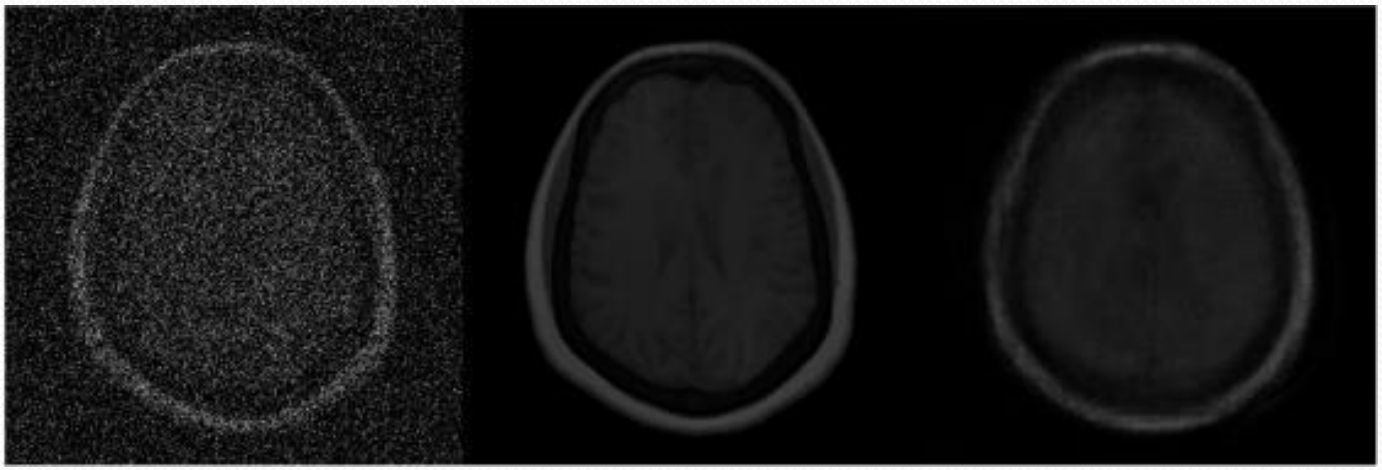
Results – MRI Reconstruction



- quality v.s. computation power



Results – MRI Reconstruction



Reconstruction result for T1 weighted scans

-noise factor = 0.2, Gaussian noise

-batch size = 16

-100 epochs

Results – MRI Reconstruction

training	noise	epochs	batch size	PSNR[dB]	SSIM
subset	0.1, Gaussian	100	2	25.0	0.77
		100	32	22.6	0.77
		200	4	25.7	0.83
	0.9, Gaussian	100	32	19.0	0.69
	Rayleigh	200	4	*18.9*	0.70
whole	0.2, Gaussian	100	4	31.8	0.82
only T1	0.2, Gaussian	100	4	31.8	**0.84**
		50	16	33.2	0.78
		100	16	**34.0**	**0.84**
		500	16	29.5	0.80
segmented scans	0.2, Gaussian	100	16	25.4	*0.56*

Conclusion

- Best results: T1 weighted scans, 100 epochs, batch size = 16
- Similar results for Rayleigh noise and 0.9 Gaussian
- Reconstruction for segmented scans: SSIM decreases

References

- https://github.com/crackwebai1024/denoising-autoencoders-keras-tensorflow
- https://github.com/ShaunCayabyab/k-means.py
- Srinjay Paul. Convolutional denoising autoencoder for images. 2018. Online article available here: https://srinjaypaul.github.io/Convolutional_autoencoders_for_images/
- L. Gondara, "Medical Image Denoising Using Convolutional Denoising Autoencoders," 2016 IEEE 16th International Conference on Data Mining Workshops (ICDMW), Barcelona, 2016
- Ramzi, Z.; Ciuciu, P.; Starck, J.-L. Benchmarking MRI Reconstruction Neural Networks on Large Public Datasets. *Appl. Sci.* 2020, vol *10*, article no 1816

Thank you!

Questions?