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IN VIVO IMAGING

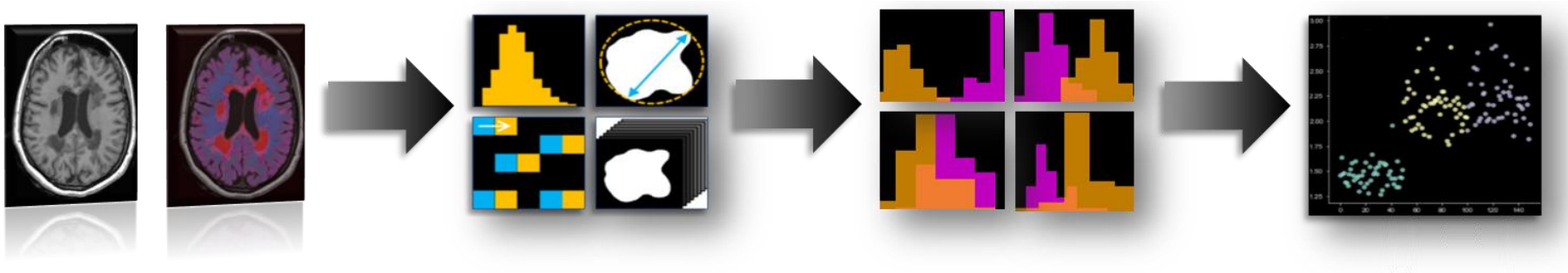
precision medicine
Maastricht University

CycleGANs for FLAIR brain scans synthesis from conventional T1w MRI and qMRI

Elizaveta Lavrova, Henry Woodruff, Emilie Lommers, Pierre Maquet, Eric Salmon, Philippe Lambin, Christophe Phillips

Quantitative Magnetic Resonance Imaging in Neurodegeneration
Virtual conference
28.10.2022

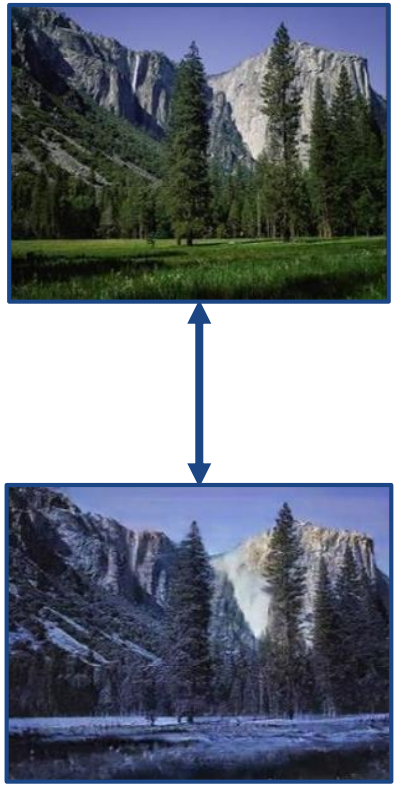
Problem identification



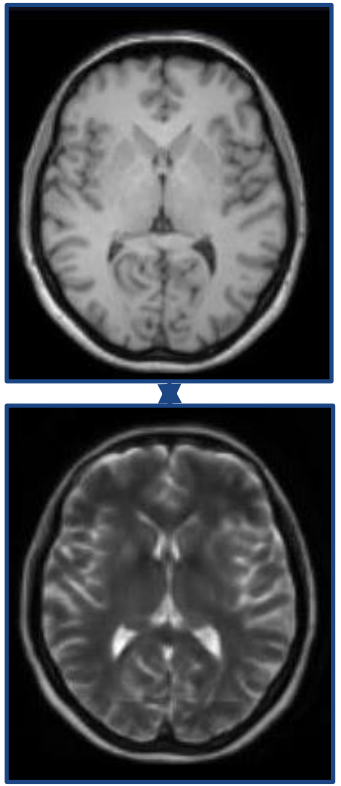
MS – multiple sclerosis
NC – normal controls
WM – white matter
WMH – white matter hyperintensity

Lavrova E, Lommers E, Woodruff HC, Chatterjee A, Maquet P, Salmon E, Lambin P, Phillips C. Exploratory Radiomic Analysis of Conventional vs. Quantitative Brain MRI: Toward Automatic Diagnosis of Early Multiple Sclerosis. Front Neurosci. 2021 Aug 5;15:679941. doi: 10.3389/fnins.2021.679941. PMID: 34421515; PMCID: PMC8374240.

Aim

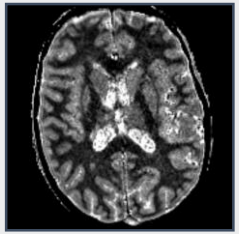


	White matter hyperintensity (WMH) automated and manual segmentation requires conventional T1w/FLAIR data
State of the art solution	Deep learning-based synthetic data
Challenge	If pathological info is not visible on the source image, it might not be transferred to the target domain
Hypothesis	FLAIR scans for multiple sclerosis (MS) patients can be synthesized with cycle-consistent generative adversarial networks (CycleGANs) from qMRI maps without loss of diagnostic information

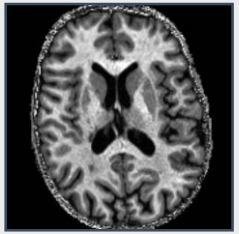


Materials

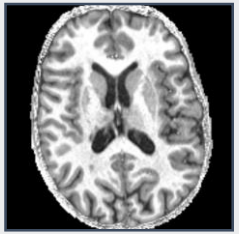
qMRI maps (hMRI toolbox*)



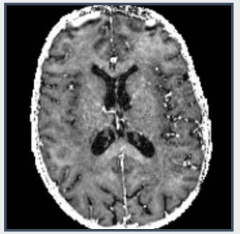
Proton density (PD)



Magnetization transfer saturation (MTs)

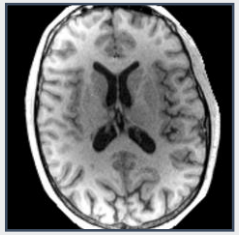


Inversed T1 (R1)

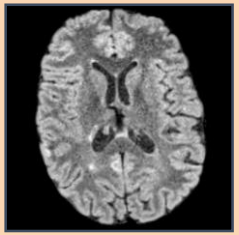


Inversed effective T2 (R2*)

Conventional MRI



T1w (1st echo)



FLAIR (SPM** co-registration)

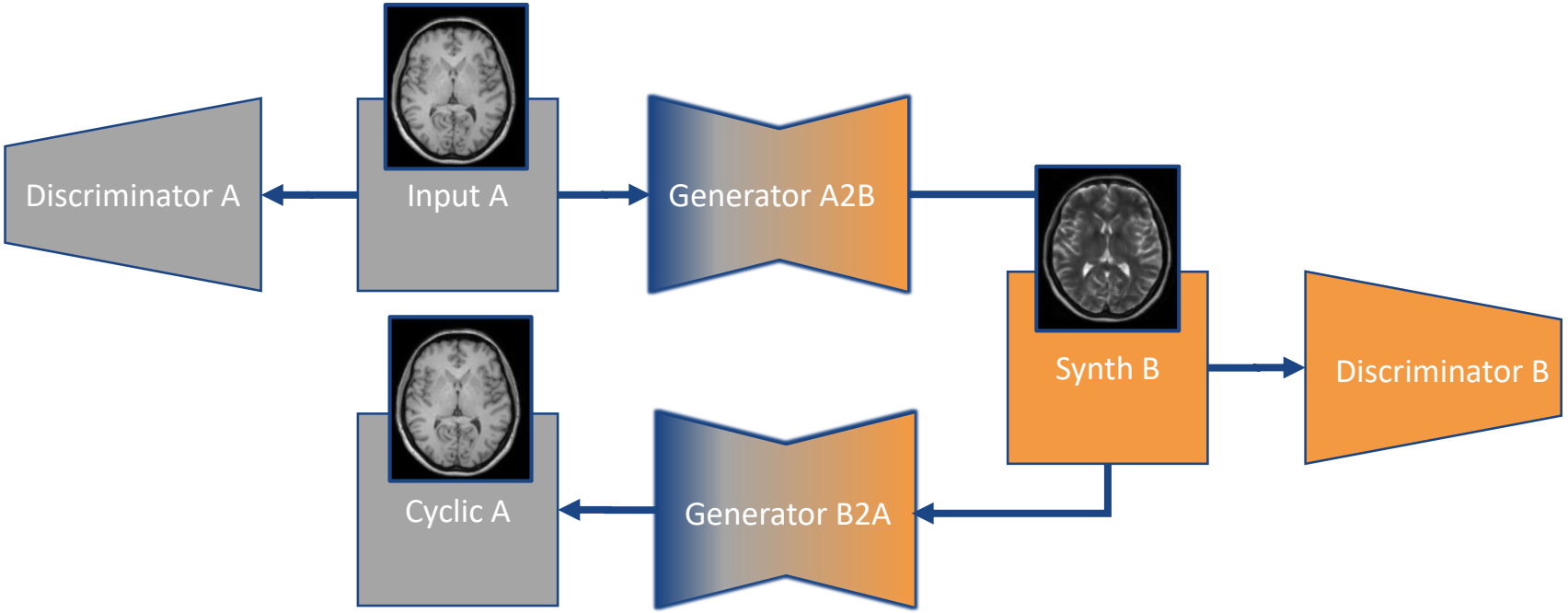
Source domain

Target domain

CRC Liege, Belgium
3T MRI (1×1×1 mm^3)
Siemens Prisma & Allegra
36 MS patients (relapsing-remitting & progressive)

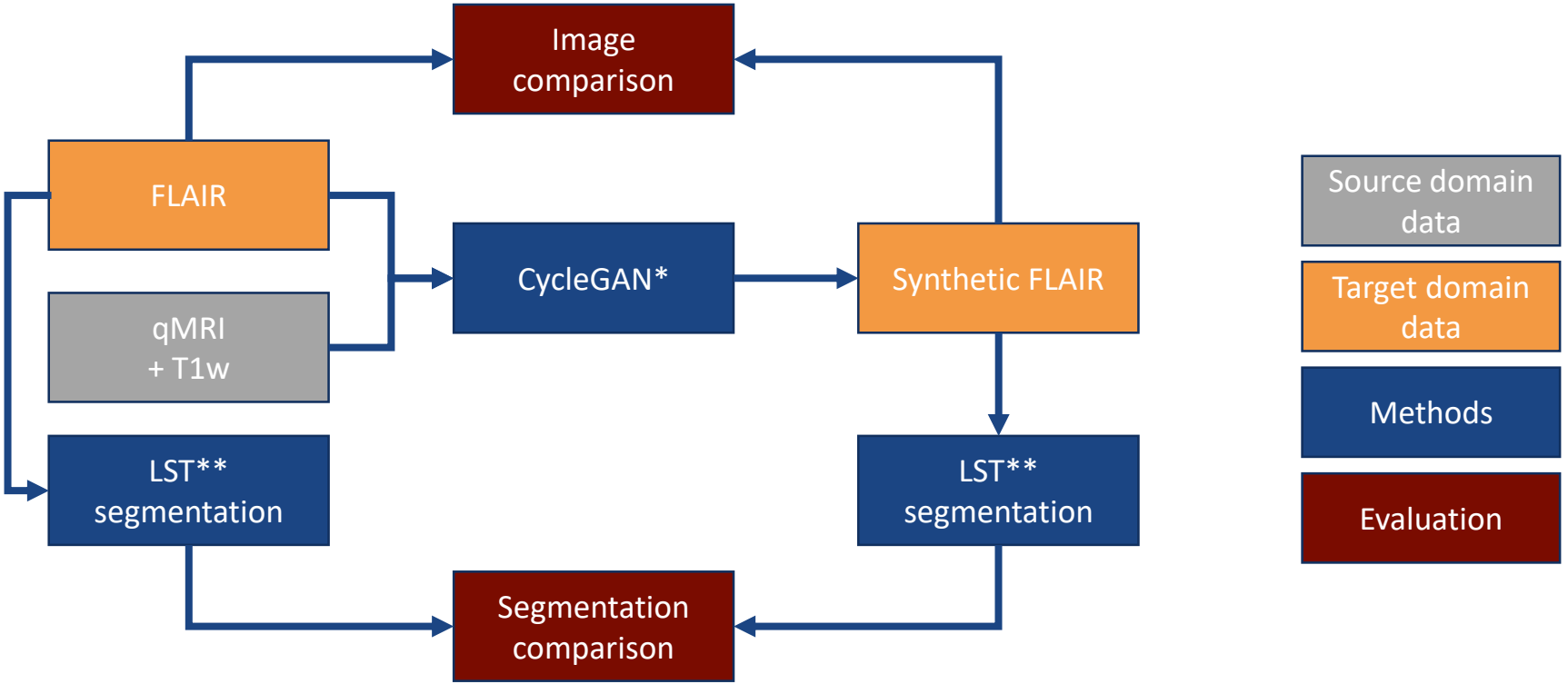
- Tabelow, K., Balteau, E., Ashburner, J., Callaghan, M. F., Draganski, B., Helms, G., ... & Mohammadi, S. (2019). hMRI–A toolbox for quantitative MRI in neuroscience and clinical research. Neuroimage, 194, 191-210.
- **http://www.fil.ion.ucl.ac.uk/spm

Methods: CycleGAN



Zhu, J. Y., Park, T., Isola, P., & Efros, A. A. (2017). Unpaired image-to-image translation using cycle-consistent adversarial networks. In Proceedings of the IEEE international conference on computer vision (pp. 2223-2232).

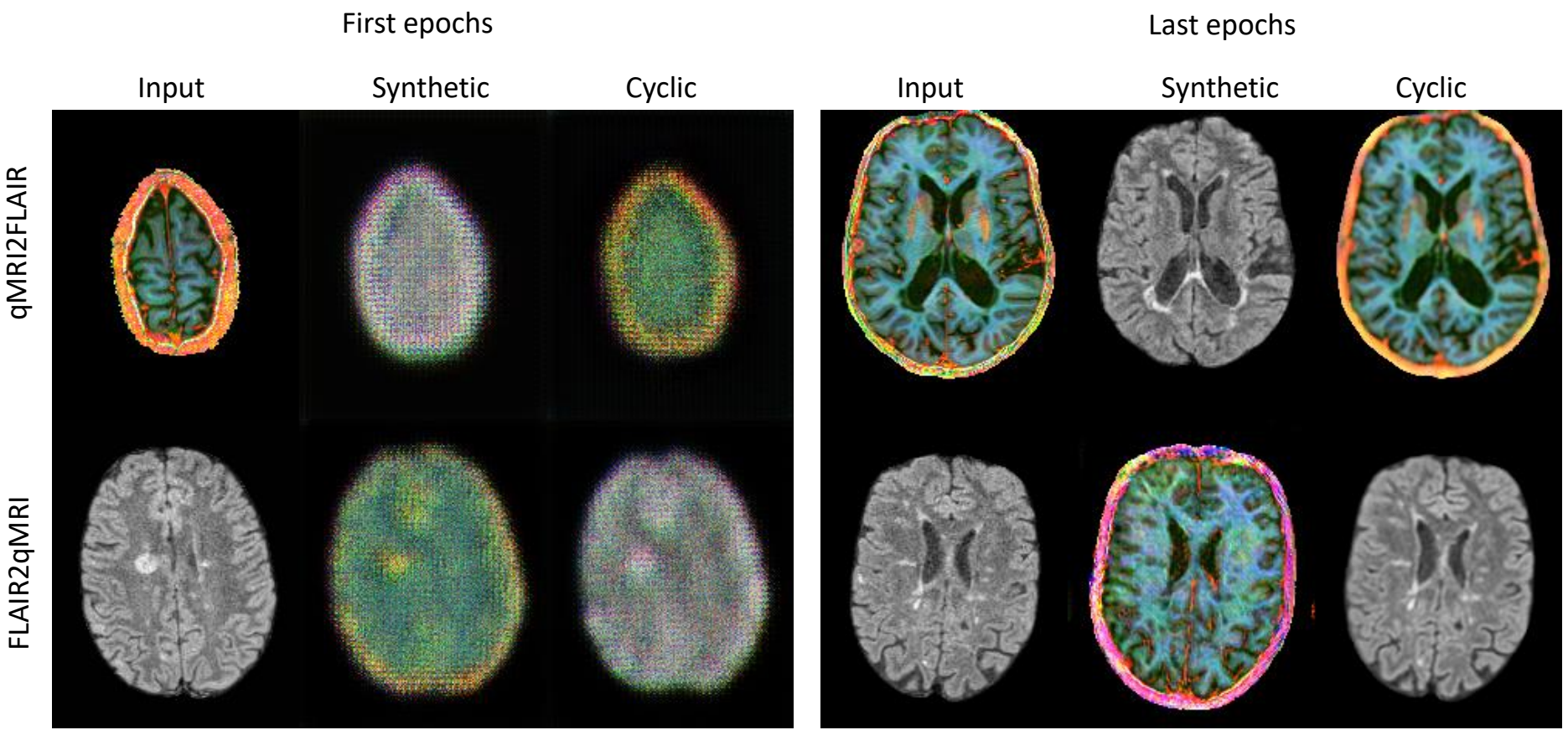
Methods: Pipeline



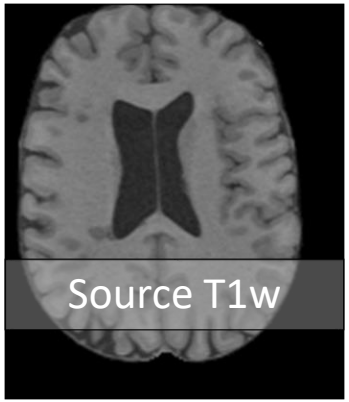
* Welander, P., Karlsson, S., & Eklund, A. (2018). Generative adversarial networks for image-to-image translation on multi-contrast mr images-a comparison of cyclegan and unit. arXiv preprint arXiv:1806.07777.

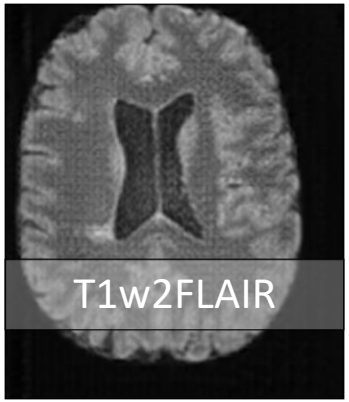
** Schmidt, P., Gaser, C., Arsic, M., Buck, D., Forschler, A., Berthele, A., et al. (2012). An automated tool for detection of FLAIR-hyperintense white-matter lesions in Multiple Sclerosis. Neuroimage 59, 3774–3783. doi: 10.1016/j.neuroimage.2011. 11.032.

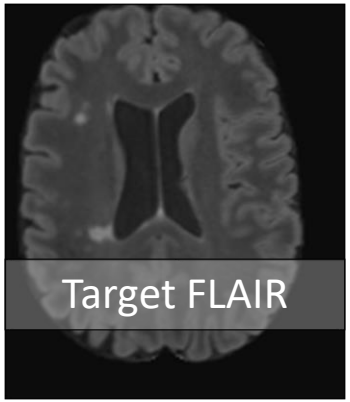
Results

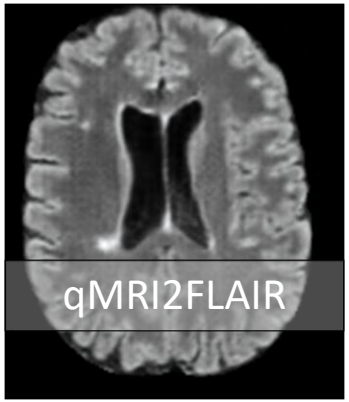

First epochs
Last epochs
Input
Synthetic
Cyclic
Input
Synthetic
Cyclic
qMRI2FLAIR
FLAIR2qMRI

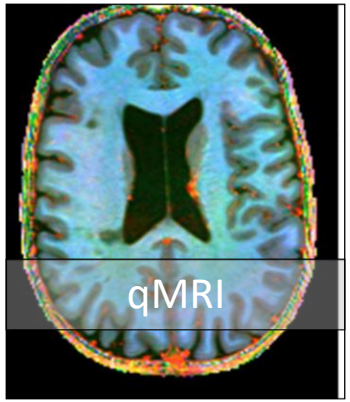
Results











	SSIM (↑)	FSIM (↑)	LL RMSE (↓), mm³	LL ICC (↑)
T1w2FLAIR	0.31 (±0.05)	0.59 (±0.02)	2806.53	0.50
qMRI2FLAIR	**0.42 (±0.04)**	**0.62 (±0.03)**	**1745.49**	**0.78**

LL – lesion load,
SSIM – structural similarity index, FSIM – feature-based similarity index,
RMSE – root mean square error, ICC – intra-class correlation coefficient

Conclusion

CycleGAN is a suitable technique for cross-modality synthesis

qMRI preserves pathological information besides style transfer

Technique should be validated on larger datasets, different pathologies and MR sequences

Technique can be applied in retrospective studies + for cost reduction and data augmentation and imputation purposes

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ACKNOWLEDGEMENTS

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Dr Christophe Phillips

THANK YOU FOR YOUR ATTENTION!

elizaveta.lavrova@uliege.be

Supplementary

qMRI maps generation	https://hmri-group.github.io/hMRI-toolbox/
Data co-registration	https://www.fil.ion.ucl.ac.uk/spm/
WMH segmentation	https://www.applied-statistics.de/lst.html
Data generation	https://github.com/simontomaskarlsson/GAN-MRI