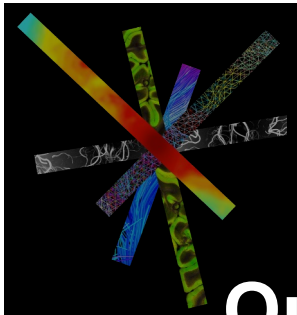
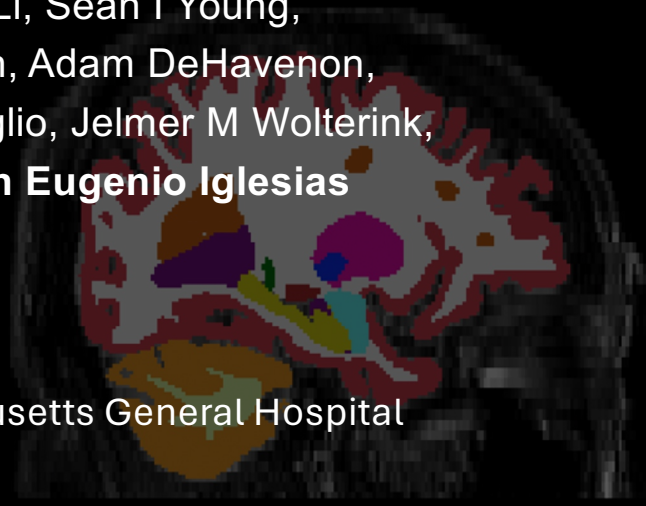




Quantifying White Matter Hyperintensity and Brain Volumes in Heterogeneous Clinical and Low-Field Portable MRI

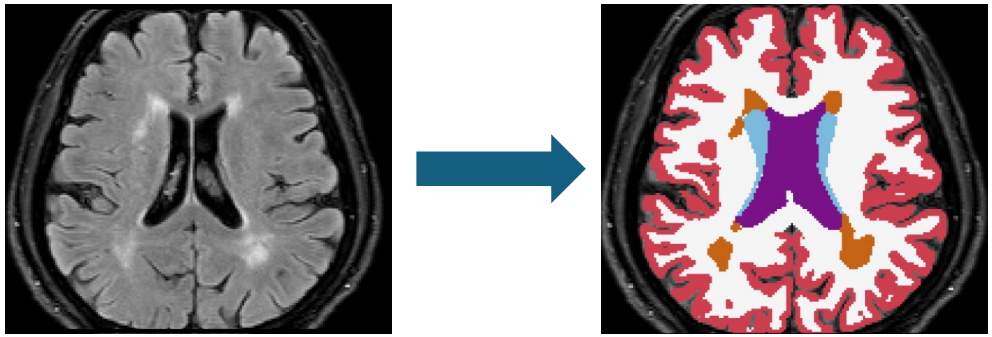
Pablo Laso, Stefano Cerri, Annabel Sorby-Adams, Jennifer Guo, Farrah Mateen, Philipp Goebl, Jiaming Wu, Peirong Liu, Hongwei Bran Li, Sean I Young, Benjamin Billot, Oula Puonti, Gordon Sze, Sam Payabavash, Adam DeHavenon, Kevin N Sheth, Matthew S Rosen, John Kirsch, Nicola Strisciuglio, Jelmer M Wolterink, Arman Eshaghi, Frederik Barkhof, W Taylor Kimberly, **Juan Eugenio Iglesias**

Presenter: Hongwei Bran Li

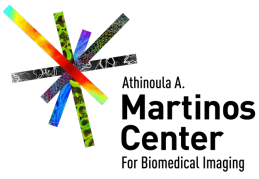
Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital

Introduction

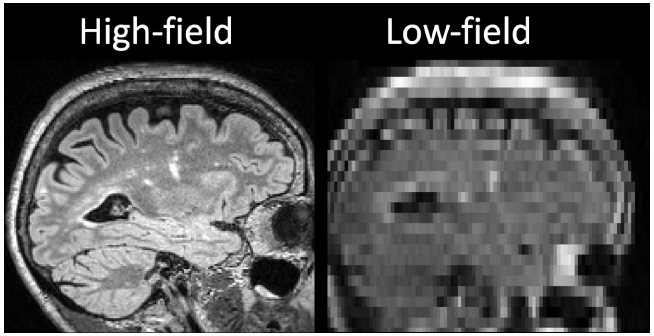
- Brain atrophy and white matter hyperintensity (WMH) in brain MRIs are key biomarkers to determine brain injuries in diseases like multiple sclerosis.
- Automated quantification of brain structures and WMH across **heterogeneous** MRIs is urgently needed



Existing Segmentation Methods



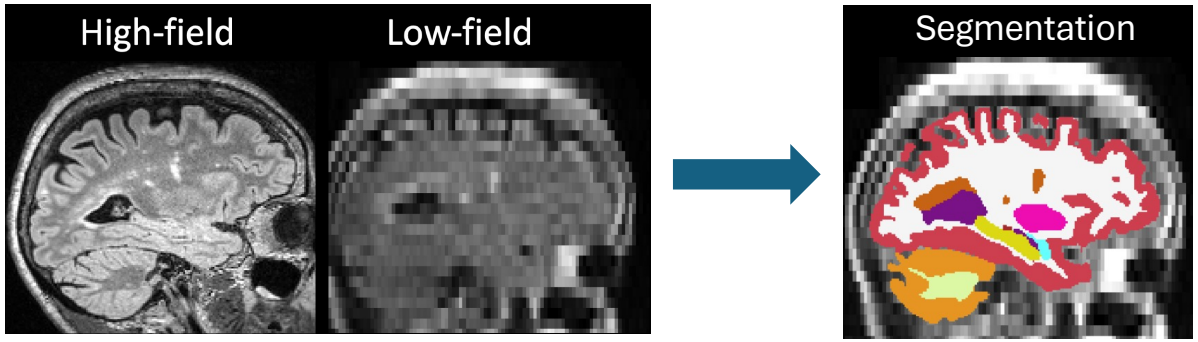
- LST [1]: An unsupervised method to segment WMHs
- Supervised deep learning [2] based on expert annotations.
- SAMSEG[3]: A contrastive-adaptive method using parametric Bayesian modelling.



[1] Schmidt, Paul, et al. "An automated tool for detection of FLAIR-hyperintense white-matter lesions in multiple sclerosis." Neuroimage 59.4 (2012)
[2] Roy, Abhijit Guha, et al. "QuickNAT: A fully convolutional network for quick and accurate segmentation of neuroanatomy." NeuroImage 186 (2019)
[3] Cerri, Stefano, et al. "A contrast-adaptive method for simultaneous whole-brain and lesion segmentation in multiple sclerosis." Neuroimage 225 (2021).

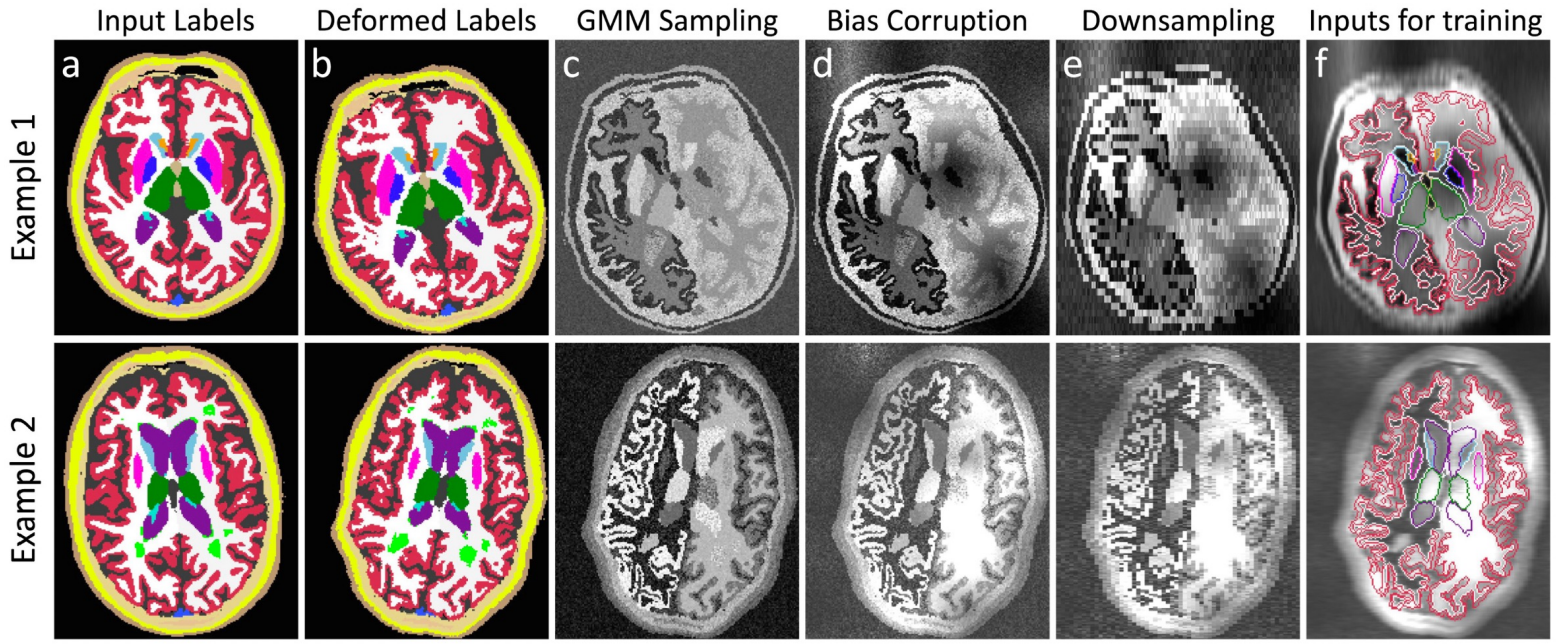
Our Method's Features

- Does not require retraining when deployed in clinical routine
- Uses a composite loss to improve sensitivity and specificity
- Adapts to low-field portable MRI
- Uses multi-task learning for enhanced robustness.



Our Method: WMH-SynSeg

- Learning from synthetic data by random contrasts [4]



Generation process of synthetic data

[4] Billot, Benjamin, et al. "SynthSeg: Segmentation of brain MRI scans of any contrast and resolution without retraining." Medical image analysis (2022)

Our Method - WMH-SynSeg

- Training on synthetic data
  - 3D U-Net [5] architecture with five levels, 64 feature maps per level, and group normalization, taking 160^3 voxel cubes.
  - a tailored loss function with equal weight on cross-entropy, Dice scores, average L1 error for T1w intensities, and L1 error for bias field.
- Testing on real data
  - Test-time augmentation with flipping for robustness.

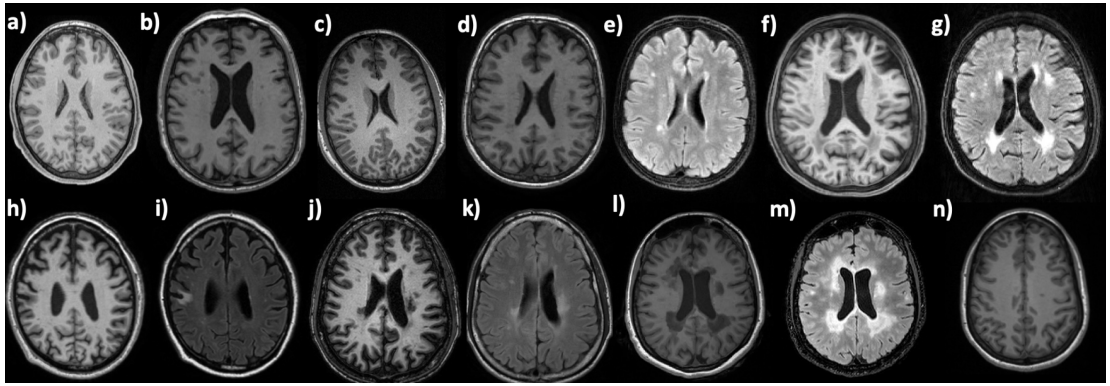
[5] Ronneberger, Olaf, Philipp Fischer, and Thomas Brox. "U-net: Convolutional networks for biomedical image segmentation." MICCAI 2015

Experiment

- Training and testing on nine diverse brain MRI datasets

Dataset	HCP	ADNI	GE3T	Singapore	Utrecht	ISBI	FLI-IAM	ADHD	MGH
Train	897	1148	15	15	-	-	-	-	-
Test	-	-	5	5	20	15	15	20	12
WMHs	✗	✗	✓	✓	✓	✓	✓	✗	✗

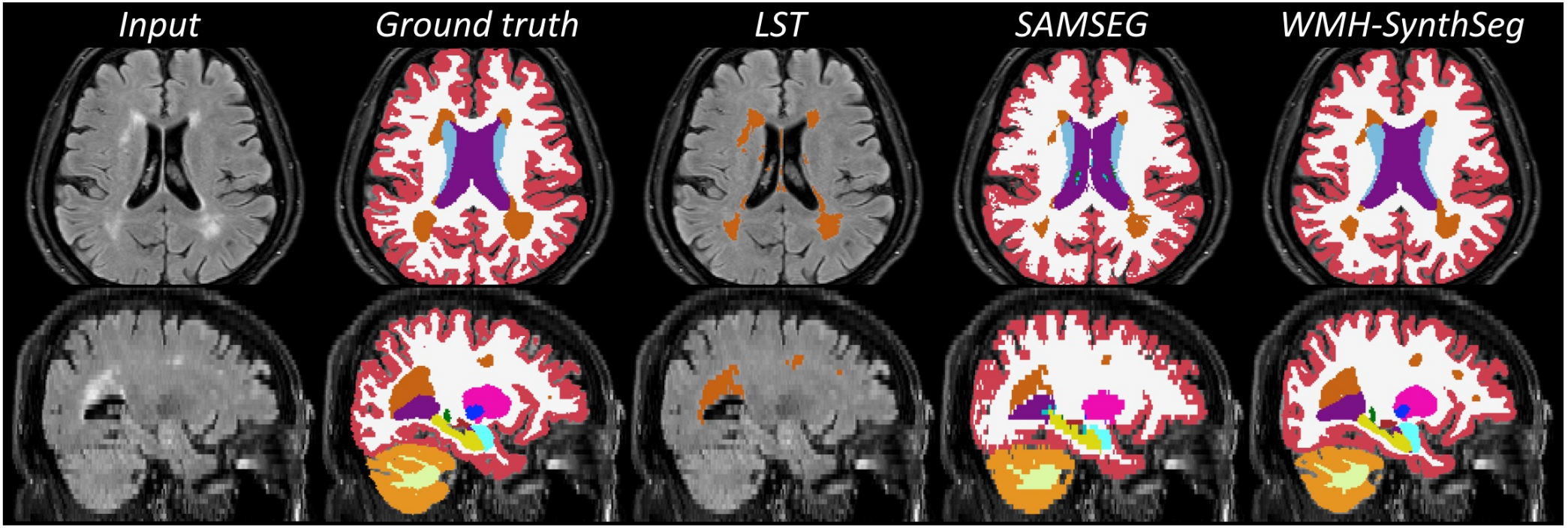
- Evaluation metrics
  - Dice scores
  - Correlation between volumetric measurement from high-field and low-field scans



Sample images

Results

- Qualitative comparison



Results

- Quantitative comparison

Method	T1w		FLAIR	
	Anat	WMH	Anat	WMH
LST (LPA)	N/A	N/A	N/A	0.57
SAMSEG	0.81	0.46	0.72	0.56
WMH-SynthSeg (NoWMH-noCE-noMTL)	0.83	0.47	0.76	0.53
WMH-SynthSeg (NoWMH)	**0.85**	0.47	0.78	0.54
WMH-SynthSeg (full)	**0.85**	**0.55**	**0.79**	**0.62**

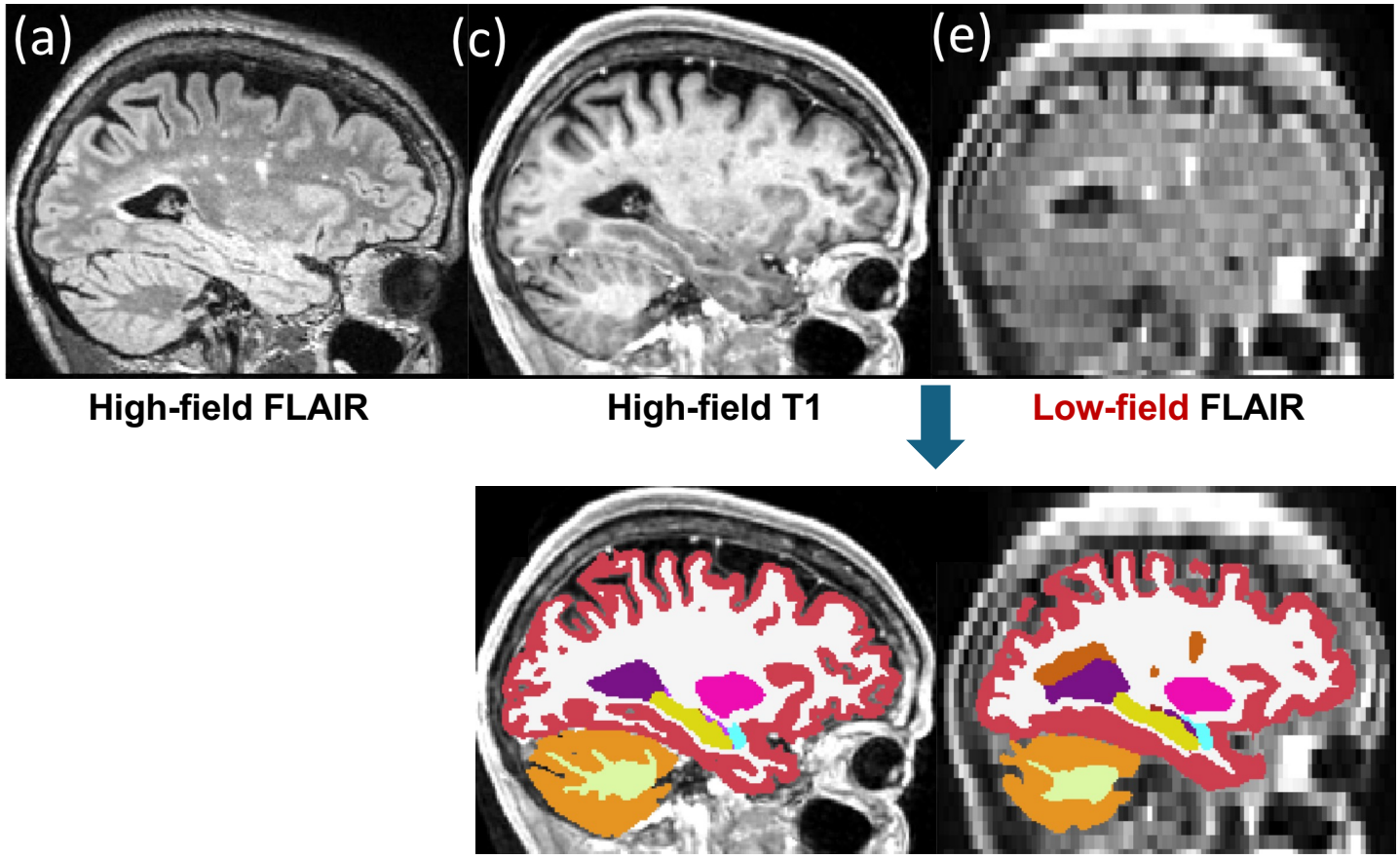
→ **Highest Dice score for brain structures and WMHs are achieved.**

Method	T1w		FLAIR	
	Hippo	WMH	Hippo	WMH
LST (LPA)	N/A	N/A	N/A	-0.33
SAMSEG	0.71	0.63	0.69	0.64
WMH-SynthSeg (full)	**0.89**	**0.75**	**0.86**	**0.85**

→ **High correlations between volumetric measurements from high-field and low-field MRIs in an in-house MS cohort are observed.**

Results

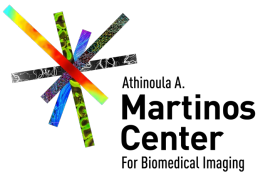
- Segmentation on low-field portable MRI without retraining



Summary

- **WMH-SynSeg** is a highly robust segmentation tool that simultaneously segments 30 brain structures and WMHs.
- Future work will include realistic modeling of WMH and evaluation on pMRI from larger cohorts. W.
- **WMH-SynthSeg** is publicly available and has potential in analyzing portable MRI acquired in medically underserved areas.

Using only one line for segmentation in FreeSurfer! 😊



Thank you!
Any questions?