

Histological validation and reconstruction

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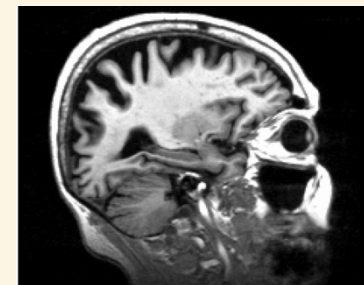
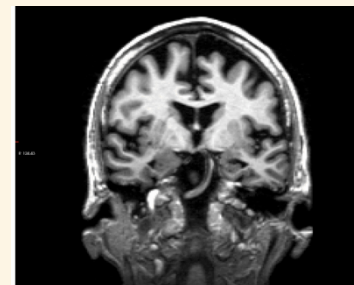


Probabilistic atlases combining *in vivo* and *ex vivo* MRI

Each has its own advantages

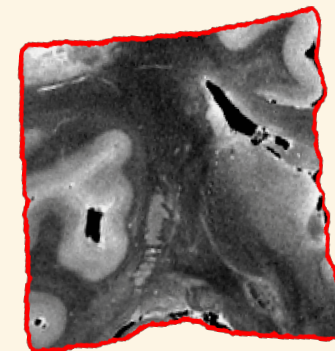
- *In vivo*:

- Complete FOV.
- Faster to label.
- Negligible geometric distortions.



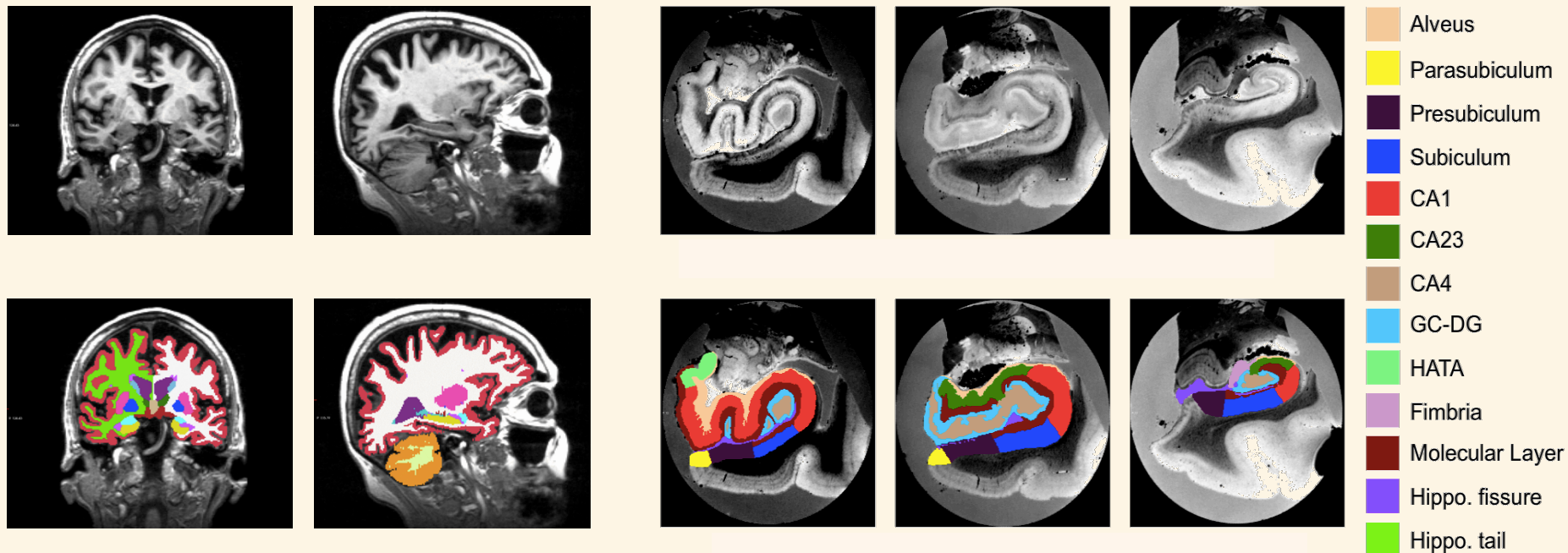
- *Ex vivo*:

- Higher resolution and / or contrast (no motion, dedicated coils).
- Enables more detailed delineations



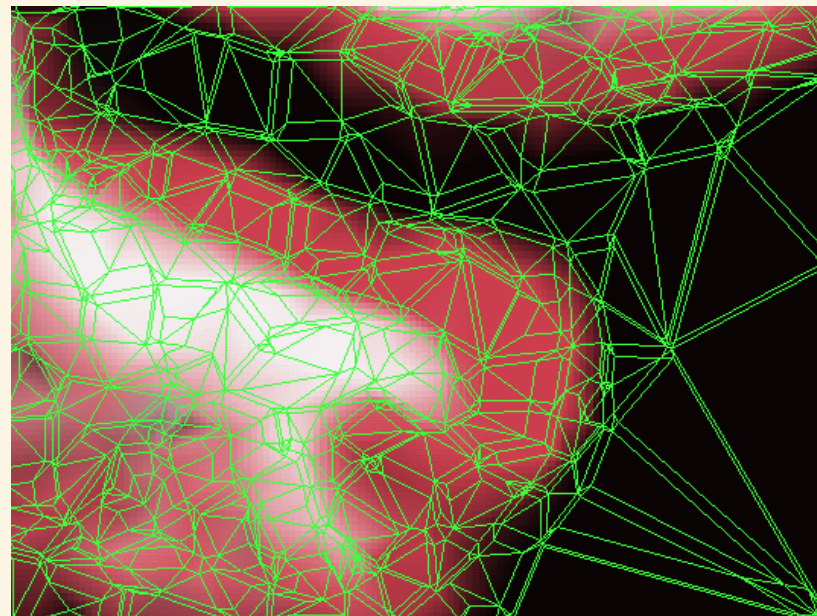
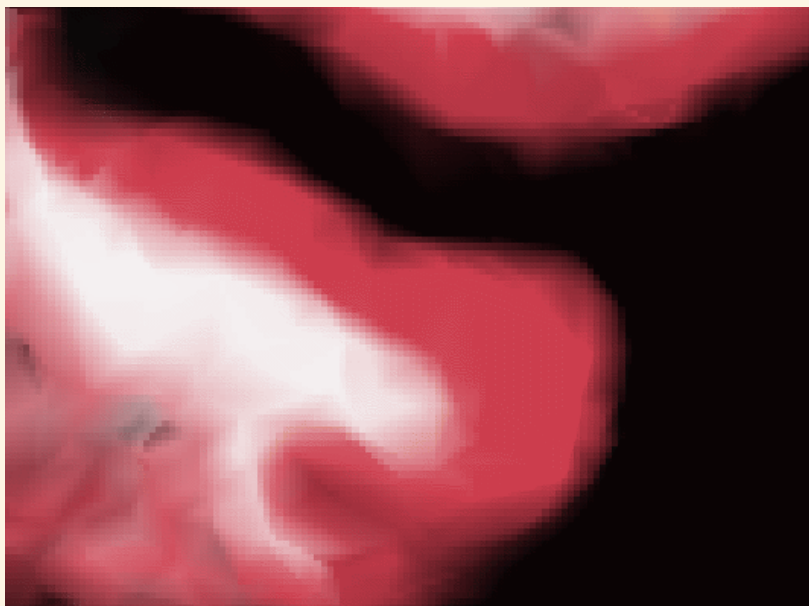
- We have a framework to combine both!

Example: atlas of hippocampal subfields



Example: atlas of hippocampal subfields

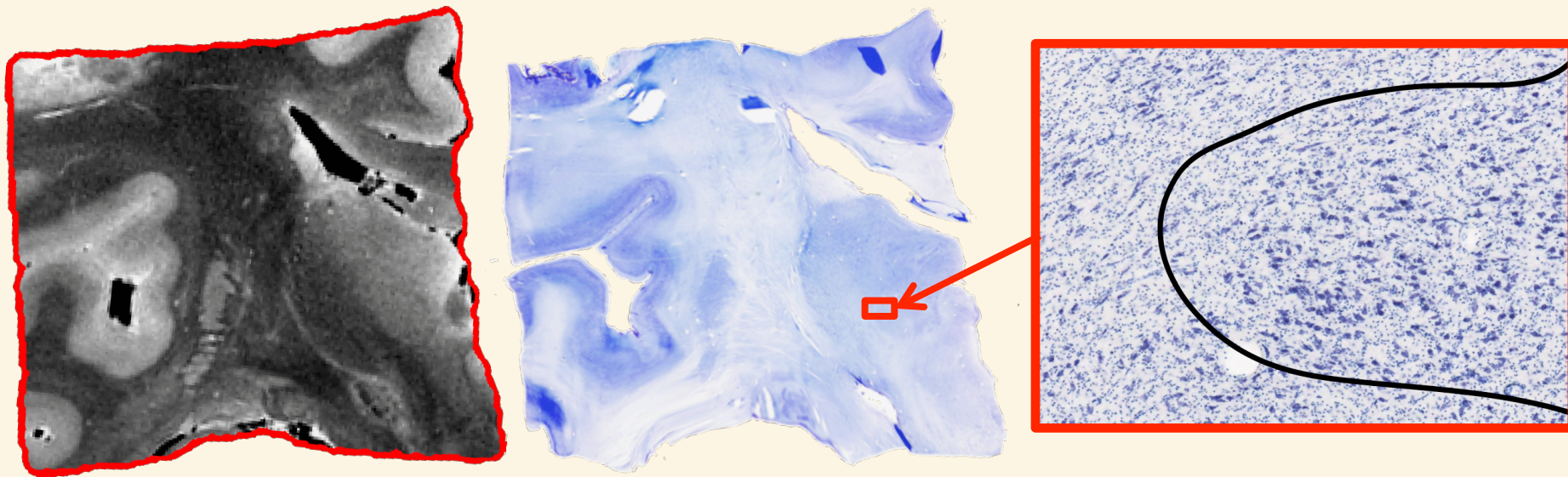
Represented as sparse, adaptive, tetrahedral mesh



(Iglesias et al., Neuroimage, 2015)

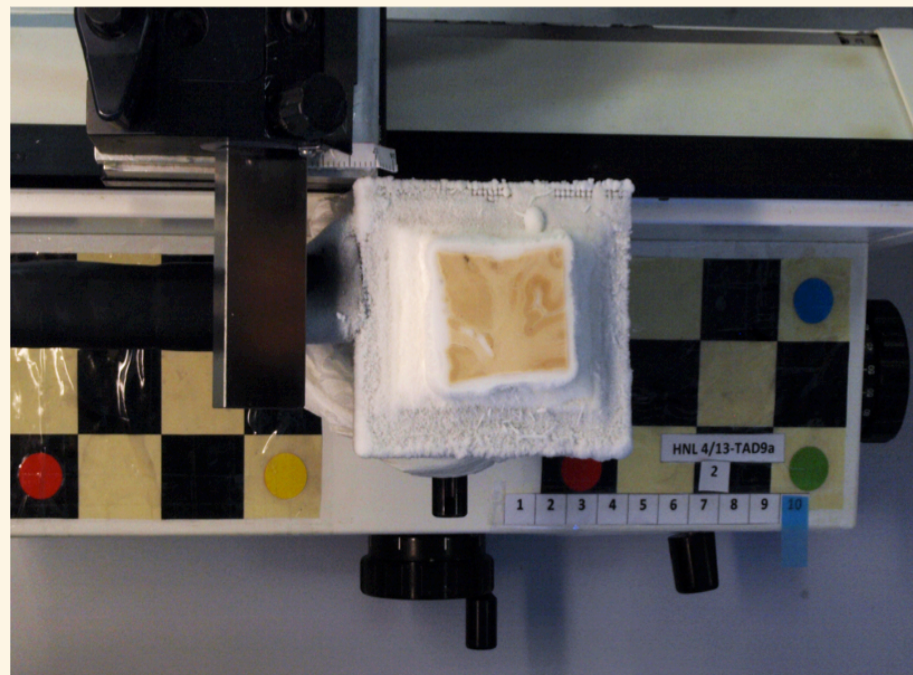
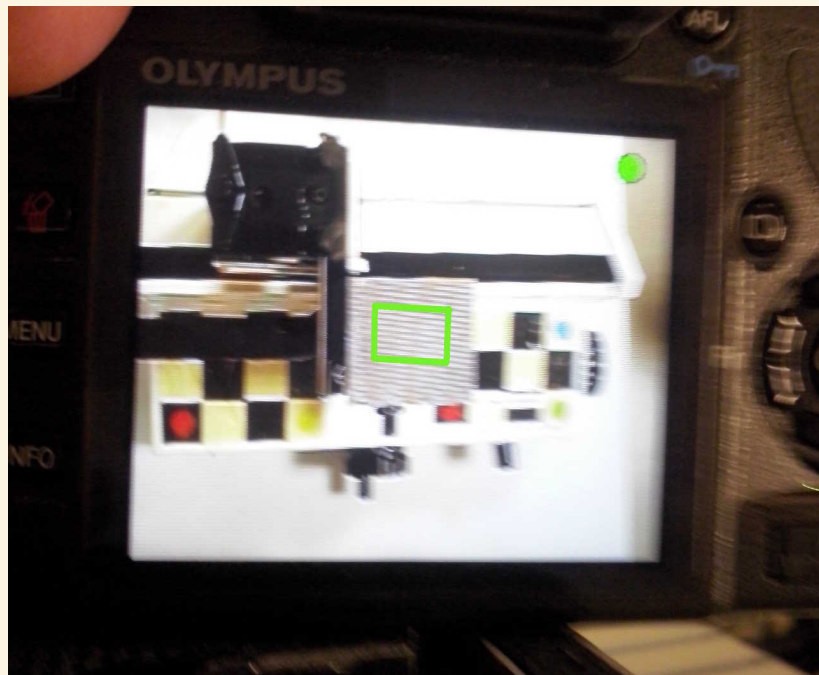
However, *ex vivo* is MRI not always enough

Some boundaries are only visible in histology



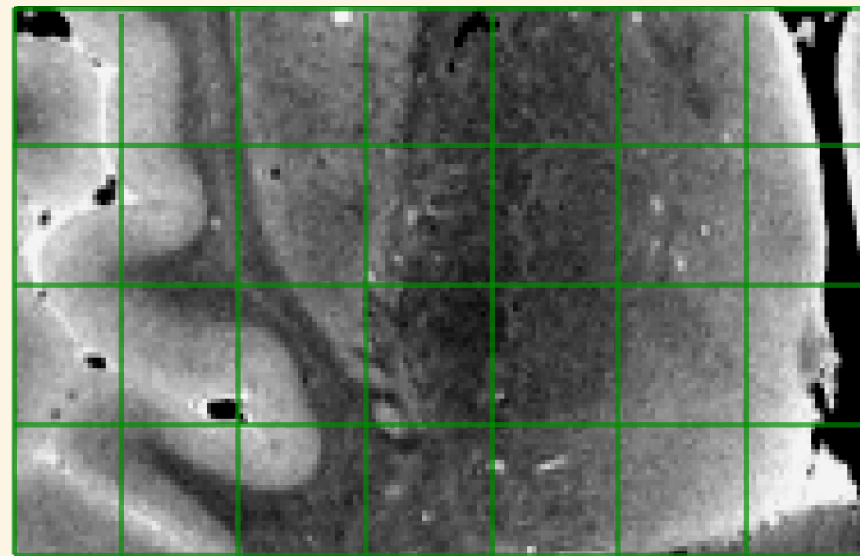
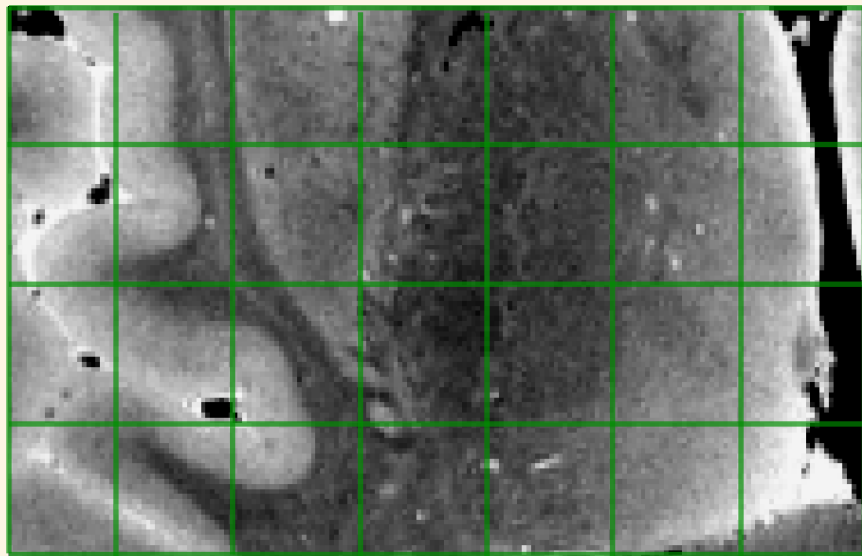
Histology reconstruction: Blockface photos

Block-face photographs to assist reconstruction



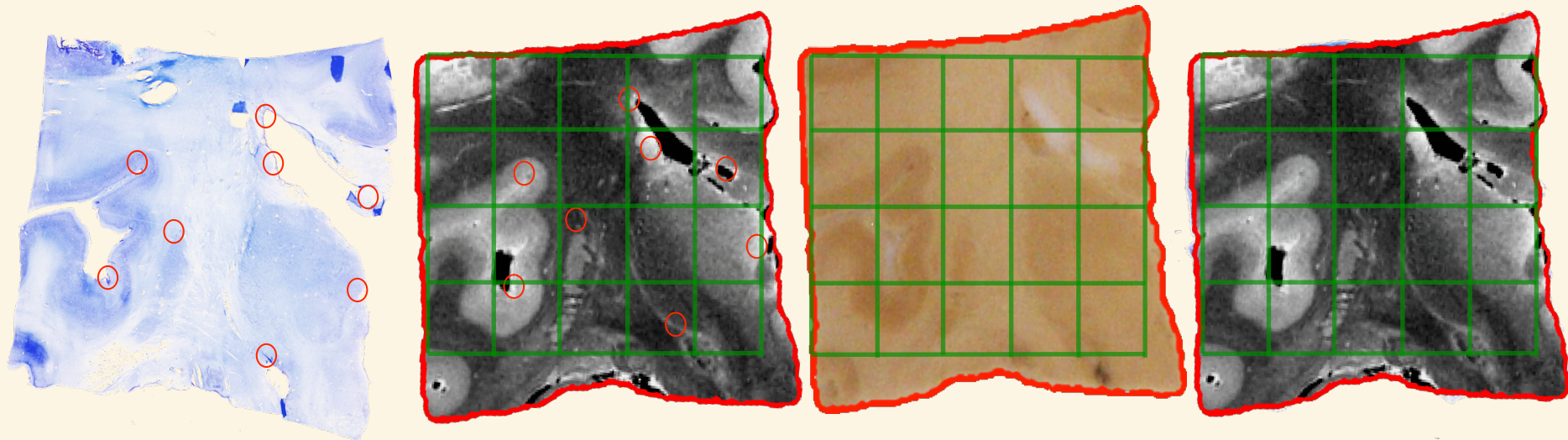
Example: Thalamic atlas

Block-face to MRI registration (rigid = easy!)



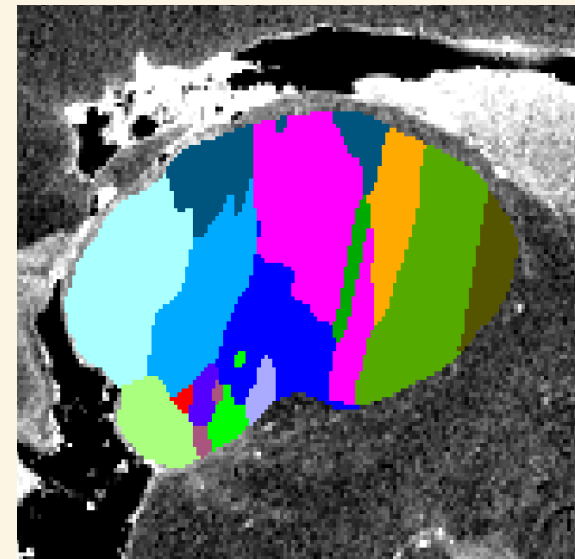
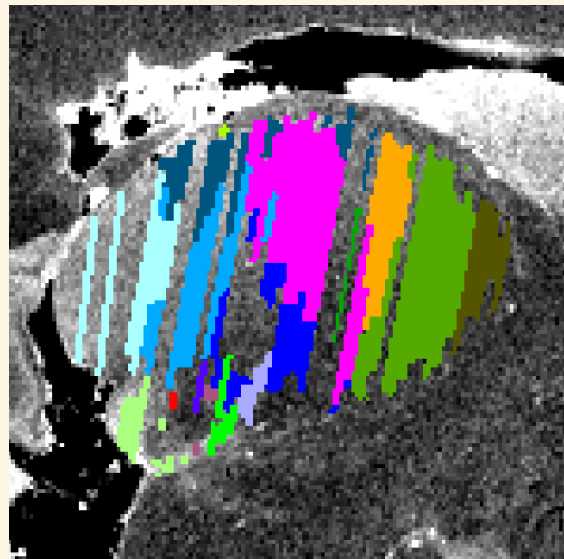
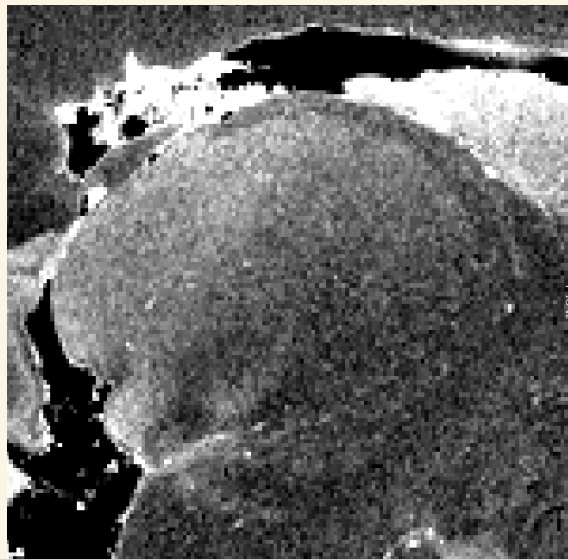
Thalamic atlas

Resampled MRI to histology



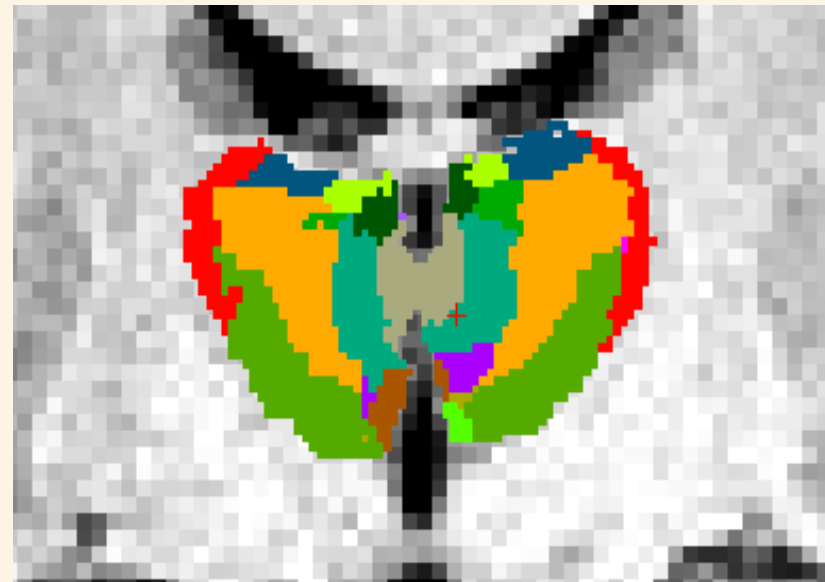
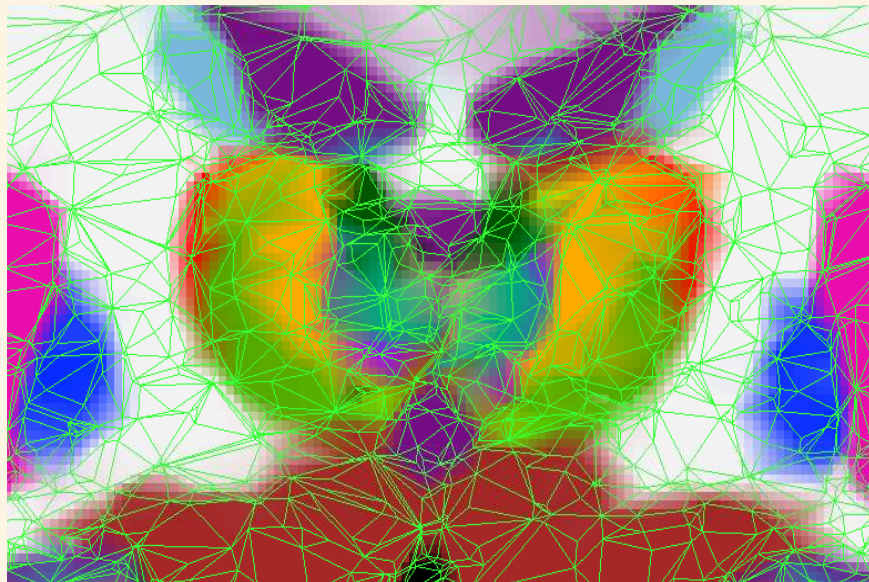
Thalamic atlas

Reconstructing segmentations with “smart” interpolation
(Gaussian mixture model + Markov random field)



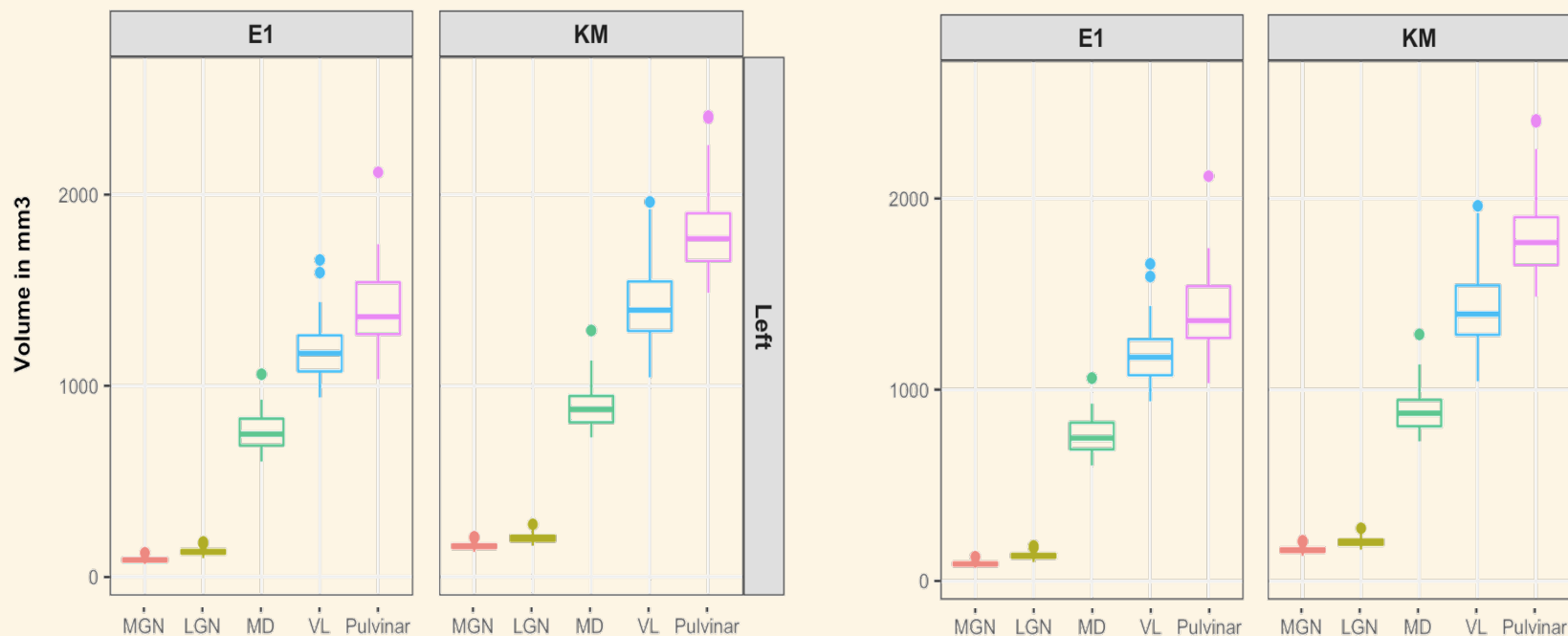
Atlas construction and image segmentation

In vivo segmentations to learn surrounding structures



Thalamic atlas

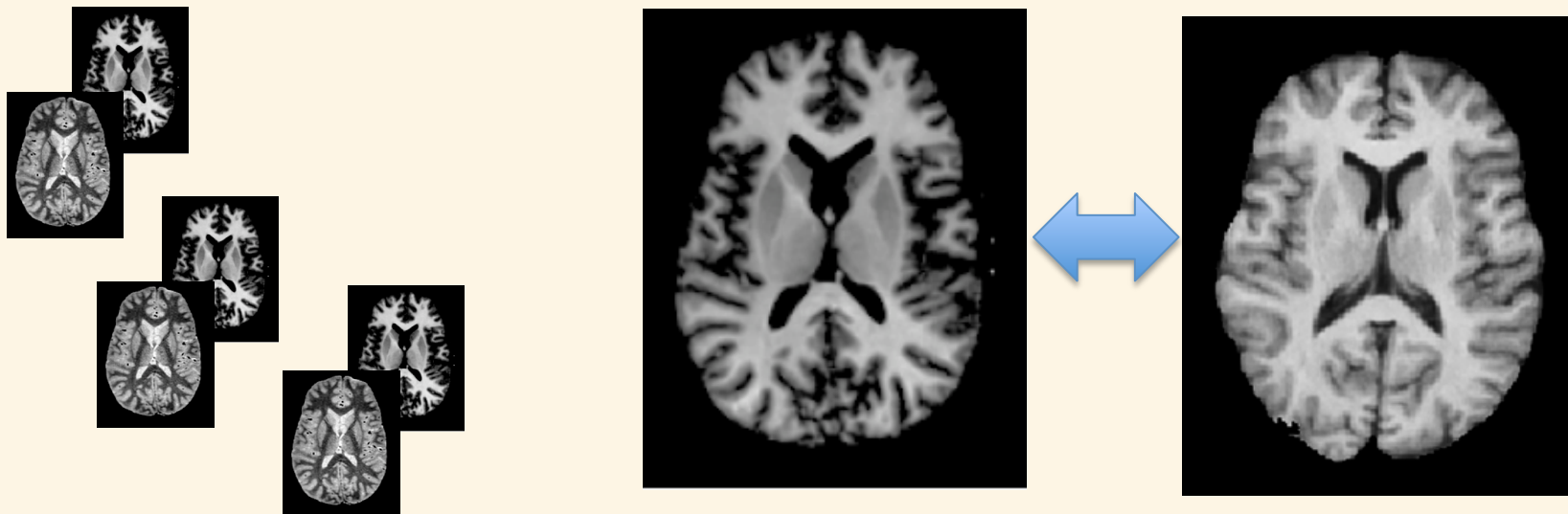
Comparison with *Krauth, Morel, et al.* (also based on histology)



(Iglesias et al., SfN 2017, OHBM 2017)

How about the 2D inter-modality registration?

Synthesis and multimodal registration

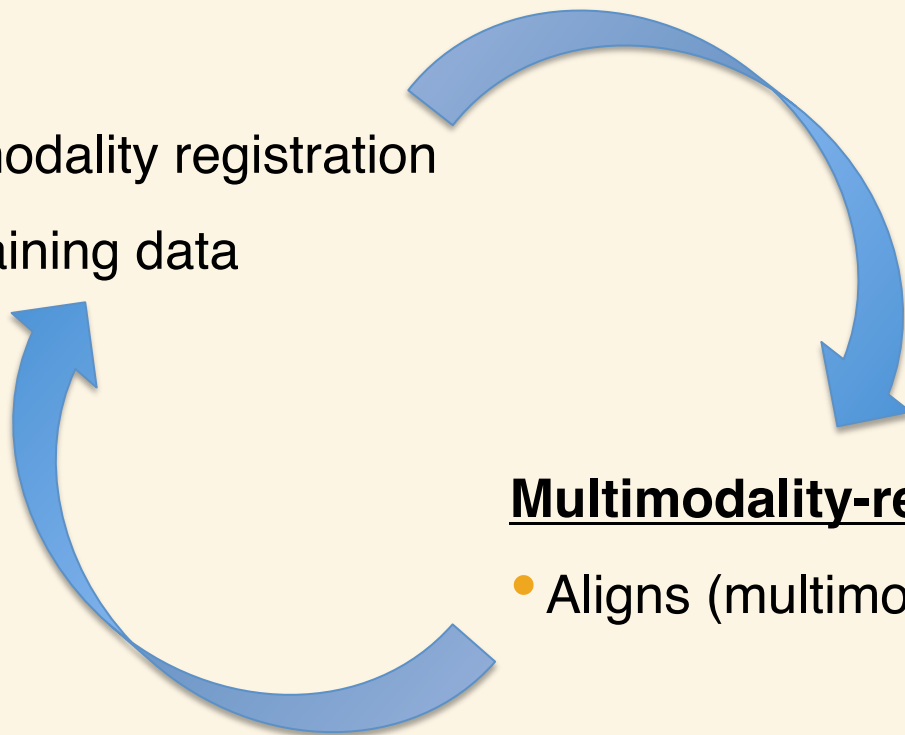


How about the 2D inter-modality registration?

Synthesis and multimodality registration

Synthesis:

- Can improve multimodality registration
- Requires aligned training data

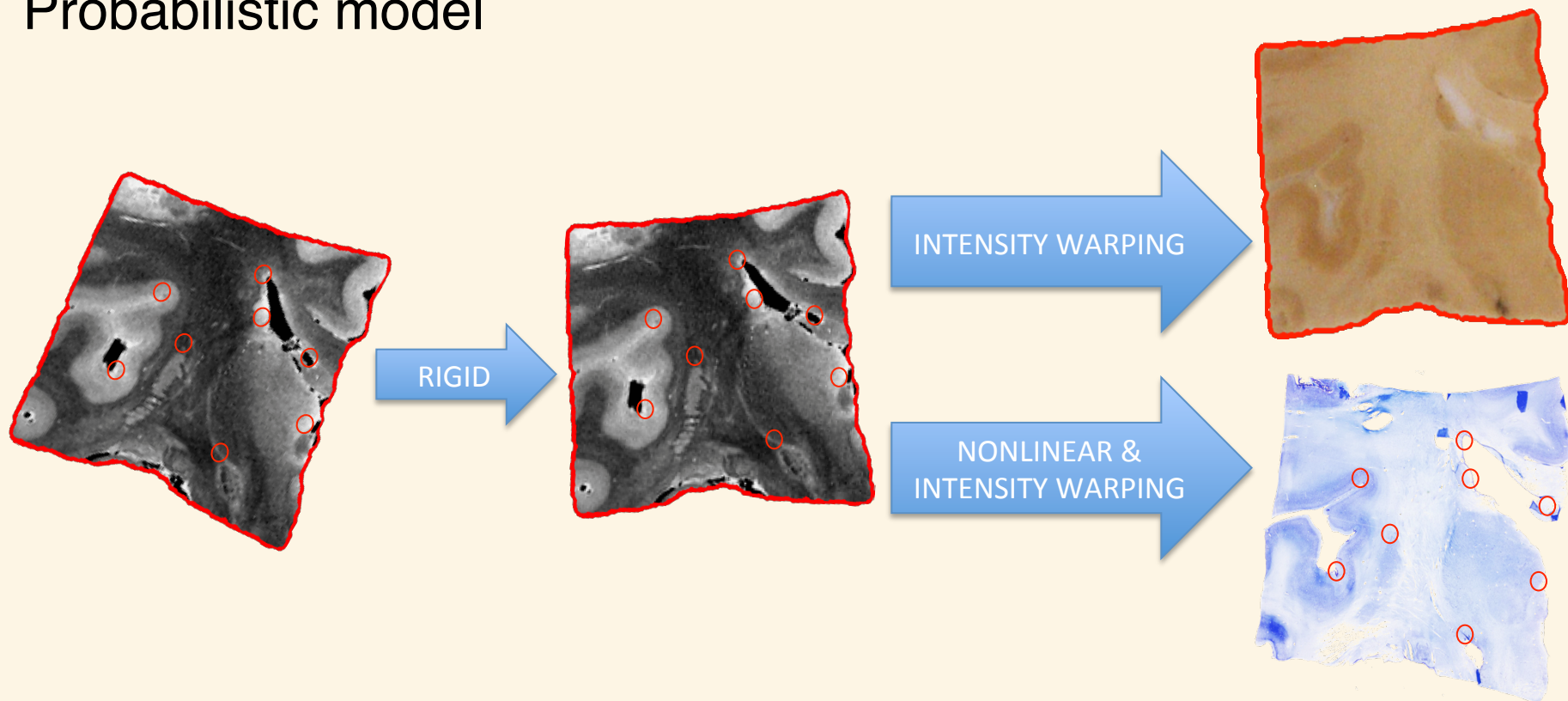


Multimodality-registration:

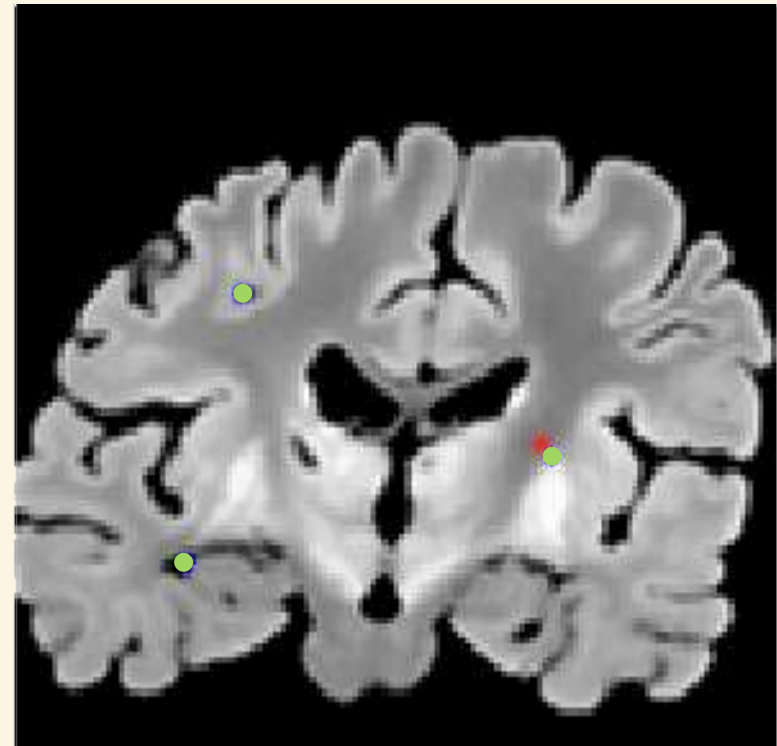
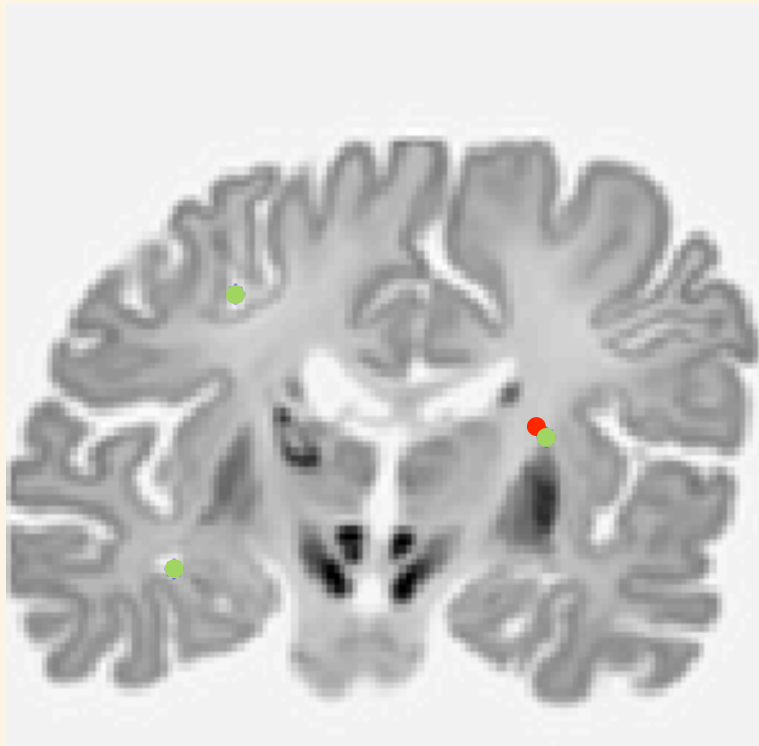
- Aligns (multimodality) data

Histology reconstruction

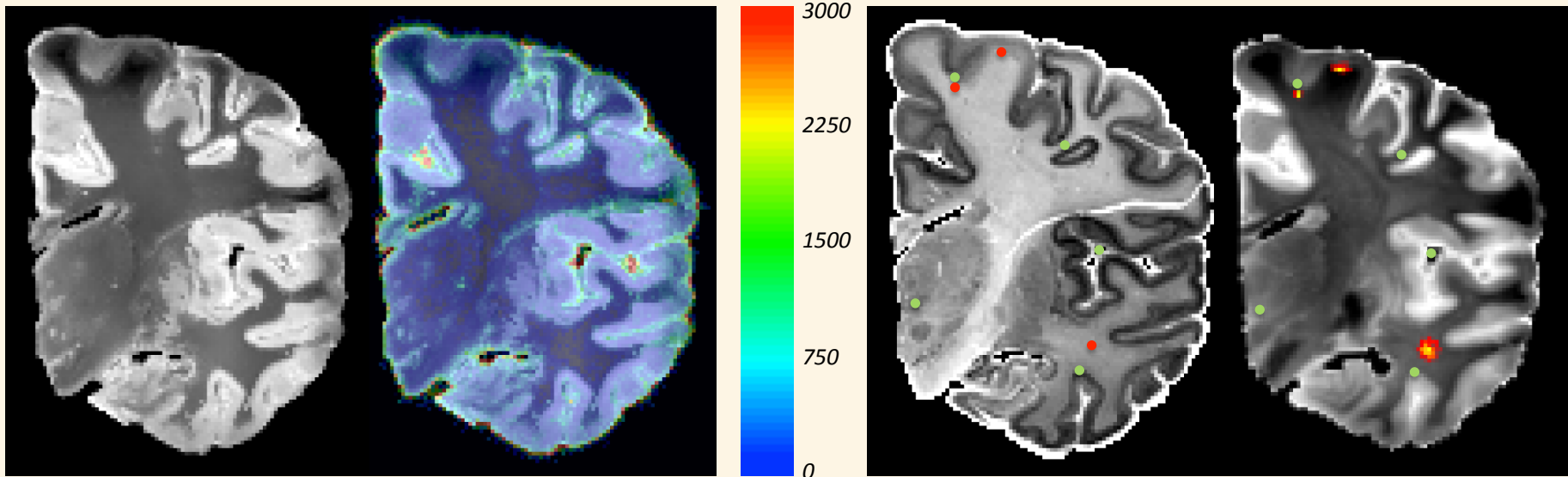
Probabilistic model



Uncertainty in registration (BigBrain)



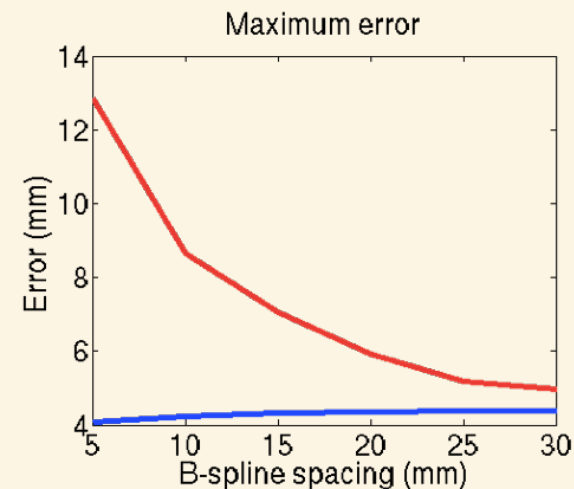
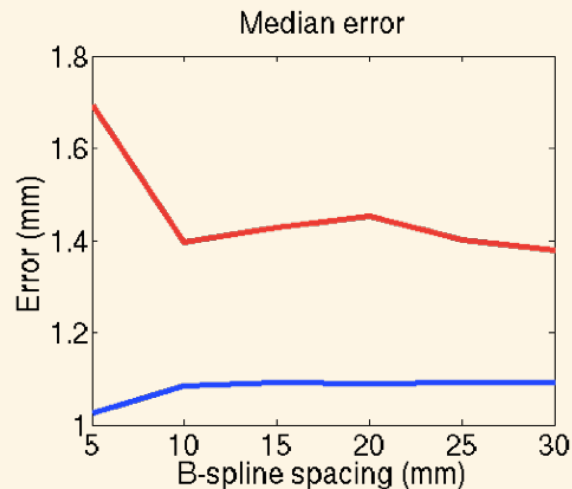
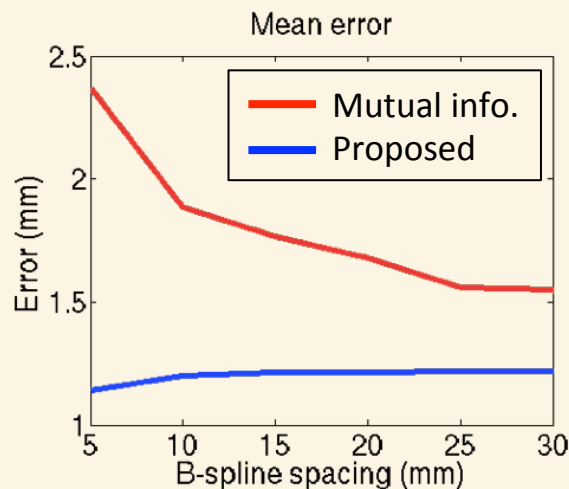
Uncertainty in registration (Allen)



Quantitative evaluation of registration

Simulated deformations on ADNI T1-T2 data (2D)

- 1 mm isotropic T1, 0.4x0.4x2.0mm T2 (coronal, resampled to 1mm)
- 1000 randomly selected coronal planes.
- Diffeomorphic random deformations, recovered with control points + Bsplines



Example on synthetic data

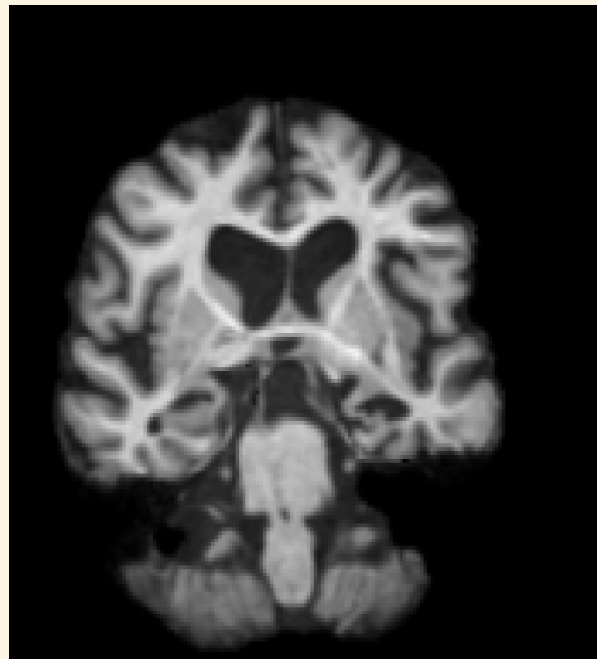
T1-T2 MRI with known correspondence



T2 (floating)

Example on synthetic data

T1-T2 MRI with known correspondence



T1 (reference)

Example on synthetic data

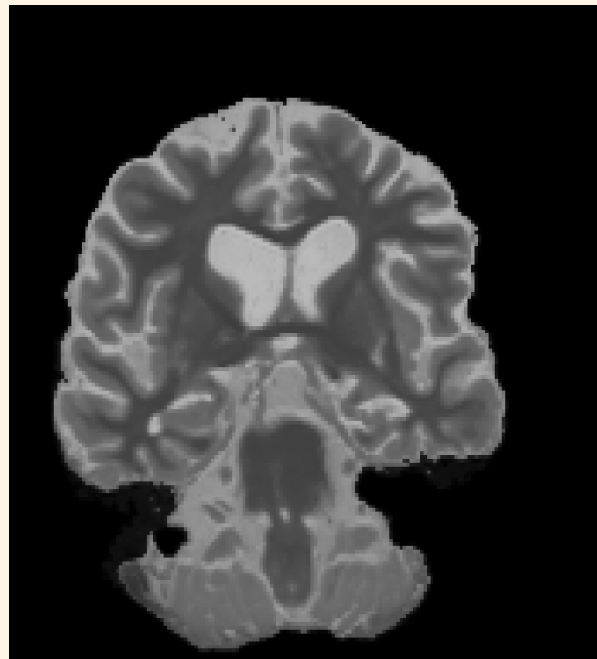
T1-T2 MRI with known correspondence



Real T2

Example on synthetic data

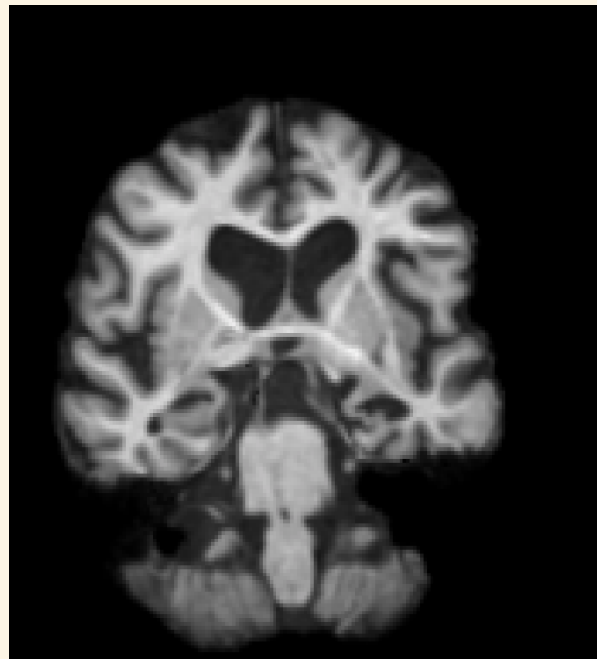
T1-T2 MRI with known correspondence



Synthetic T2

Example on synthetic data

T1-T2 MRI with known correspondence



T1 (reference)

Example on synthetic data

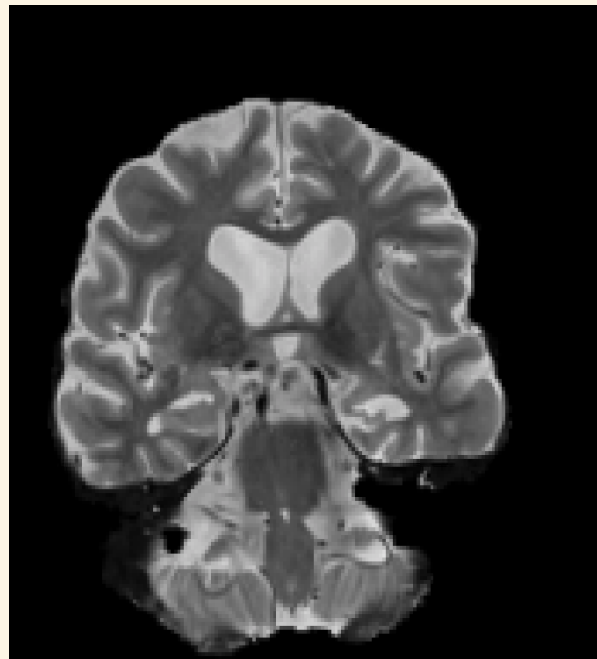
T1-T2 MRI with known correspondence



Registered with MI
(spacing: 6 mm)

Joint registration / synthesis

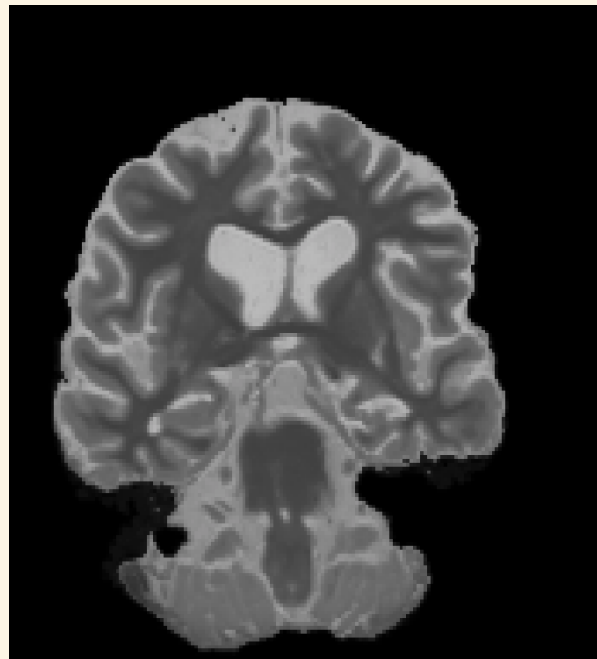
T1-T2 MRI with known correspondence



Registered with synthesis
(spacing: 6 mm)

Joint registration / synthesis

T1-T2 MRI with known correspondence



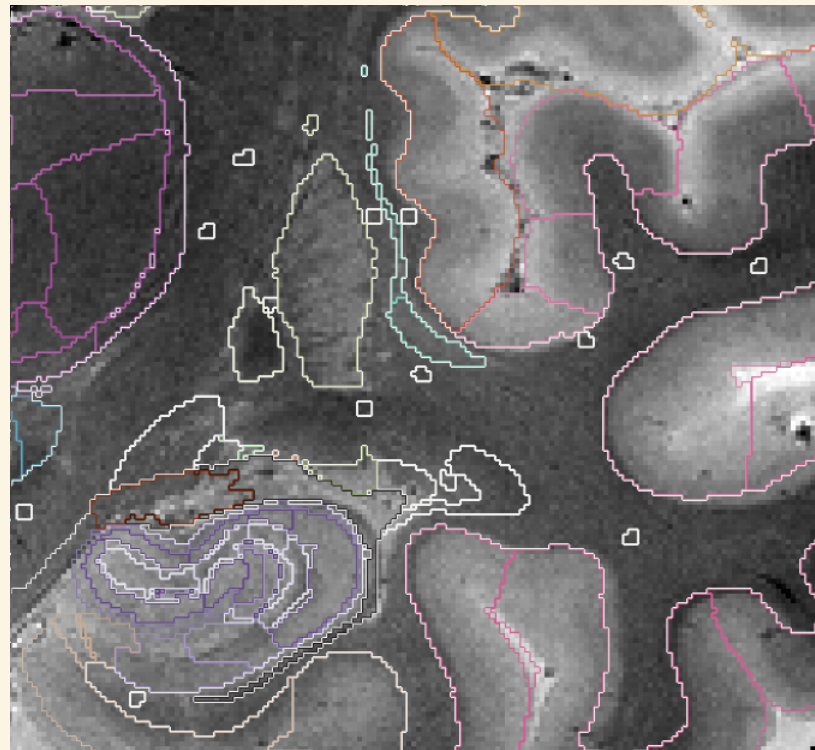
Synthetic T2

Allen atlas

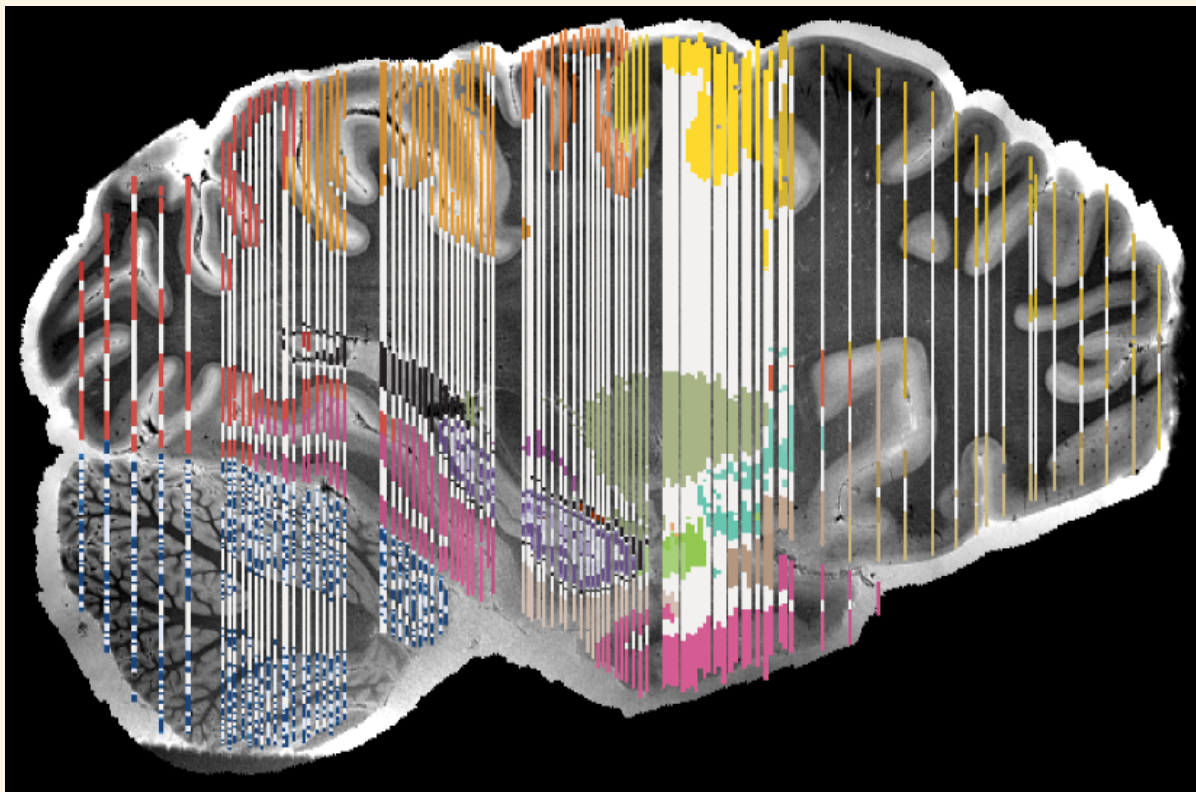
Publicly available at brain-map.org

- 106 coronal slices (histology) with manual segmentation of 806 structures
- Whole hemisphere microtome, but major cracks present on many sections.
- Manually placed ~200 landmarks.
- Problems:
 - **No blockface images available.**
 - Pixel dimensions are wrong for many sections.
 - Section thickness not consistent.
 - Spacing between coronal slices very uneven.

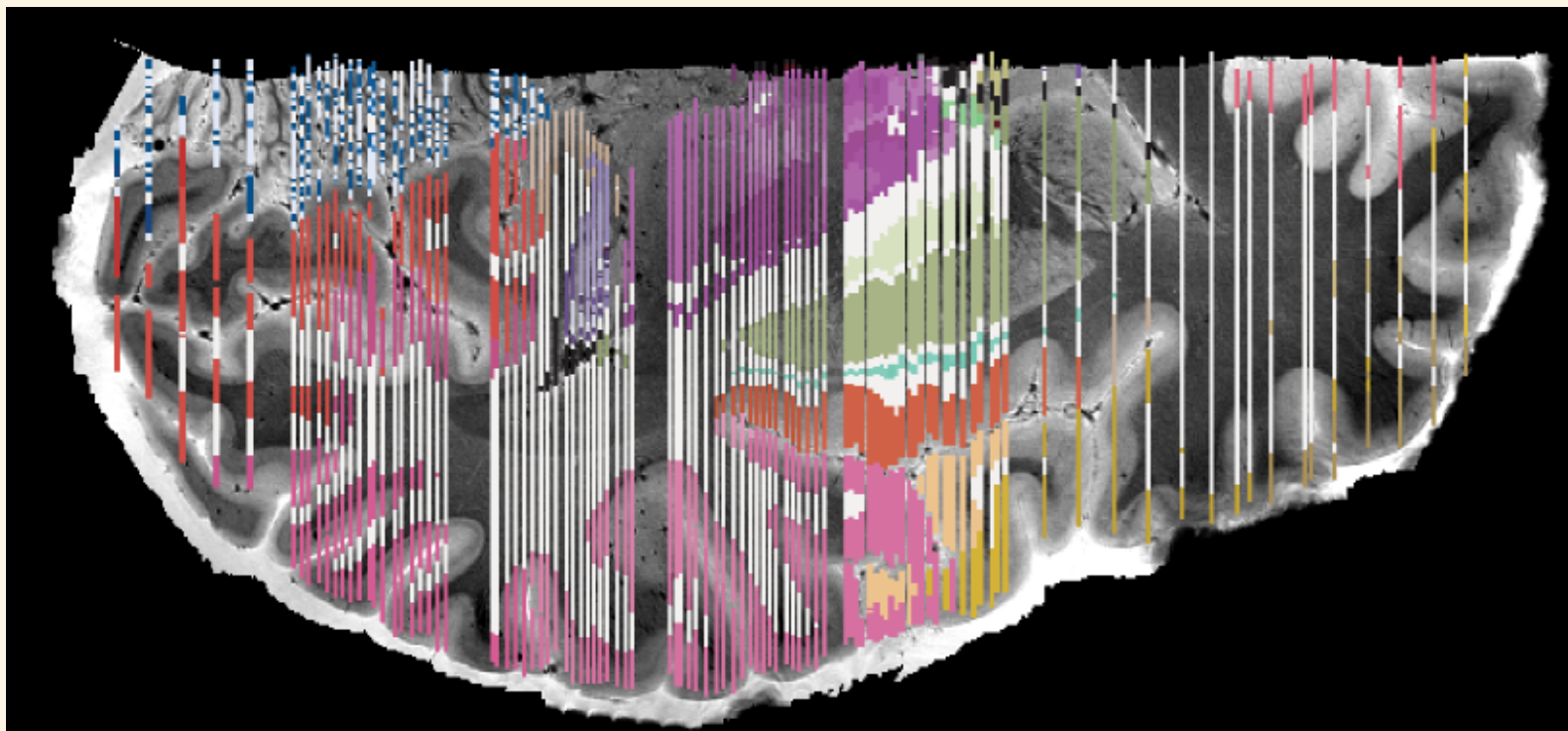
Qualitative evaluation of registration (Allen)



Qualitative evaluation of registration (Allen)



Qualitative evaluation of registration (Allen)



Extensions

And open questions

- Integration of multiple blocks (jigsaw puzzle) into probabilistic model.
- Make model robust when no blockface images and/or landmarks are given.
- Exploring smarter ways of interpolating segmentations*
- Smoothness priors in probabilistic model to make reconstructions visually more pleasant in orthogonal view.
- How do bridge (large) resolution gaps in Bayesian segmentation?
Forward model is simple, but inference is complex (especially in multimodal).

* Iglesias, IPMI, 2017

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Thank you for your attention!

Questions?