Non-invasive Histology with Magnetic Resonance Imaging
The hMRI-toolbox

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Histology versus MRI

- invasive vs. non-invasive
- high resolution vs. low resolution
- restricted vs. multiple contrast

Source: Sandell & Peters, J. Comp. Neurol., 2002 / Courtesy of M. F. Callaghan
The hMRI approach

MRI

T₁ Weighted  PD Weighted  MT Weighted  Phase  T₂ Weighted

Physical Models

qMRI

R₁  PD⁺  MT  R₂⁺  cFA

Biophysical Models

hMRI

Myelin Mapping  Iron Mapping  Differentiate Tangential and radial fiber orientations  g-ratio (RI:RO) of myelinated fibers


quantitative maps of specific parameters

in-vivo biological mapping as ultimate target
Multi-Parameter Mapping (MPM)

- 3D RF spoiled gradient-echo sequences for T1, PD-, and MT-weighted multi-echo acquisitions
- RF field mapping, i.e. transmit and receive fields, to reduce instrumental bias

Helms et al., MRM, 2008/2011; Weiskopf et al., NeuroImage, 2011/Front Neurosci. 2013
The hMRI-toolbox

Quantitative map: \( R_1 = \frac{1}{T1} \)

Biological feature: myelin, water, iron

Proton Density (PD)

water content

Magnetization Transfer (MT)

macromolecules, myelin

\( R2^* = \frac{1}{T2^*} \)

iron

- SPM-toolbox (MATLAB based) for MPM data processing to get quantitative maps (depending on input)

For details: Tabelow et al., NeuroImage, 2019 / www.hmri.info
hMRI-toolbox functionalities

- including BIDS-like meta-data for traceability (from DICOM import to processed maps)
- process maps for longitudinal/cross-sectional analysis (DARTEL, tissue weighted smoothing, MNI normalisation)

For further information on Brain Imaging Data Structure (BIDS): bids.neuroimaging.io
Proposed hackathon project

Improve and extend data handling within the toolbox for ex-vivo data

- adapt GUI
- adapt processing scripts (e.g. not to use SPM segmentation, allow selection of echoes, use other physical models etc.)
- test processing

- branch to start off and work on: https://github.com/tleutritz-cbs/hMRI-toolbox/tree/mask_in_and_output
- sample data: https://owncloud.gwdg.de/index.php/s/hBLQeL97hb5Z5cW
Thank you!

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Martina Callaghan (UCL)  
Karsten Tabelow (WIAS)  
Gunther Helms (Lund)  
Enrico Reimer (CBS)  
Nikolaus Weiskopf (CBS)
Acknowledgements

This project has received funding from the European Union’s Horizon 2020 research and innovation programme / from the European Research Council under the Grant Agreement No 681094.