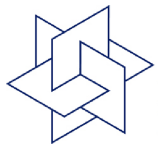
Weierstrass Institute for
Applied Analysis and Stochastics



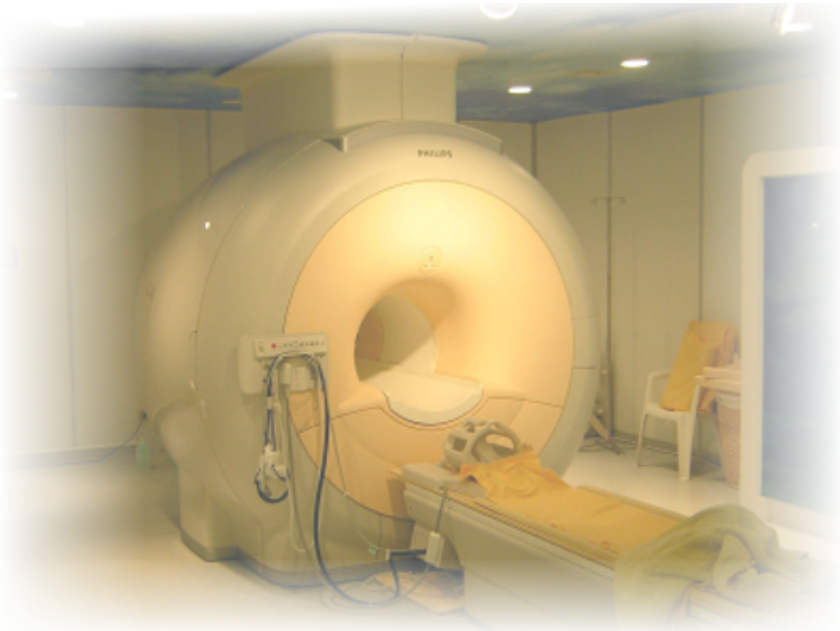
DFG-Forschungszentrum MATHEON
Mathematik für Schlüsseltechnologien

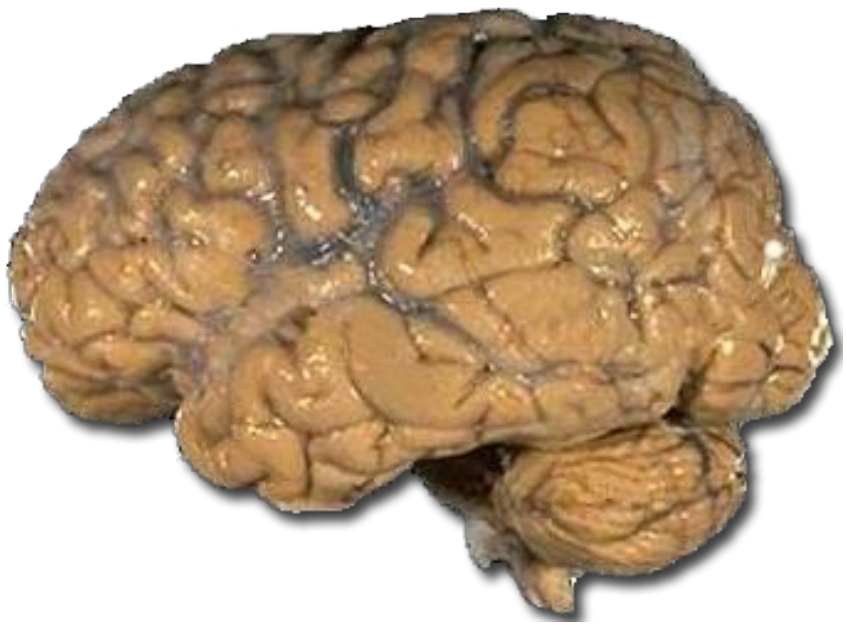
R in Statistical neuroscience research

Jörg Polzehl

Outline

- Neuro-imaging problems
- Neuroimaging Software
- Why R
- Short R overview
- R in neuroimaging

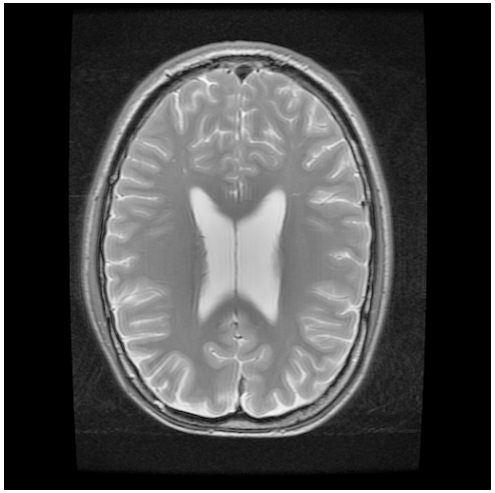




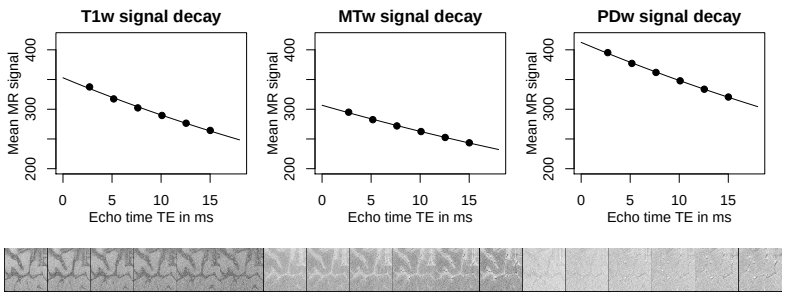
Neuro-imaging problems

NI experiments

- anatomic MRI
-
-
-
-
-
-



- image reconstruction, multiple receiver coils, K-space data



- multiparameter mapping
- voxelwise parametric statistical model

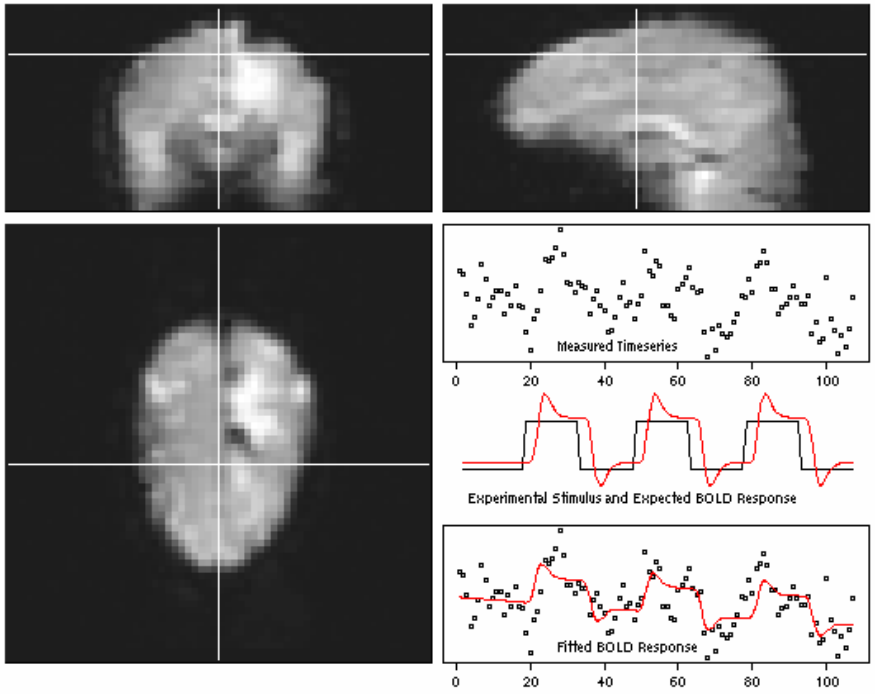
NI pipelines

- Preprocessing
- Statistical analysis

Neuro-imaging problems

NI experiments

- anatomic MRI
- functional MRI
-
-
-
-
-

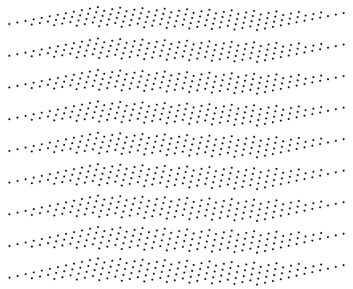


NI pipelines

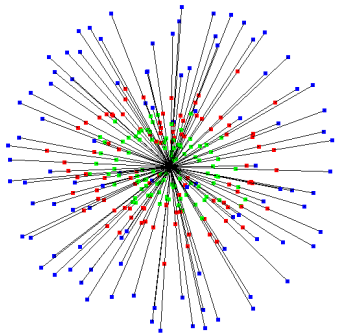
- Preprocessing
- Statistical analysis

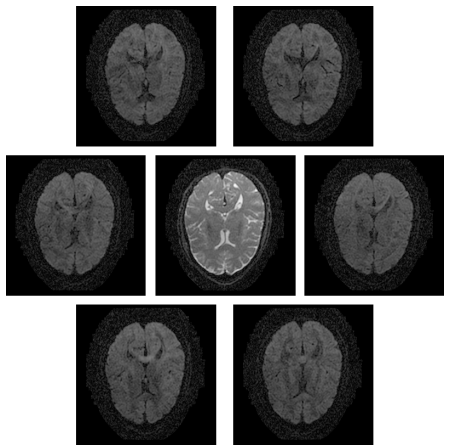
- image registration
- statistical model for BOLD response
- spatio-temporal decompositions (ICA)
- normalization (mapping to standard brain)

3D data cube



gradient directions + strength





NI experiments

- anatomic MRI
- functional MRI
- diffusion MRI
-
-
-
-

NI pipelines

- Preprocessing
- Statistical analysis

- susceptibility & eddy current correction, registration
- statistical modeling (DT, ODF, ...)
- fiber tracking

Neuro-imaging problems

NI experiments

- anatomic MRI
- functional MRI
- diffusion MRI

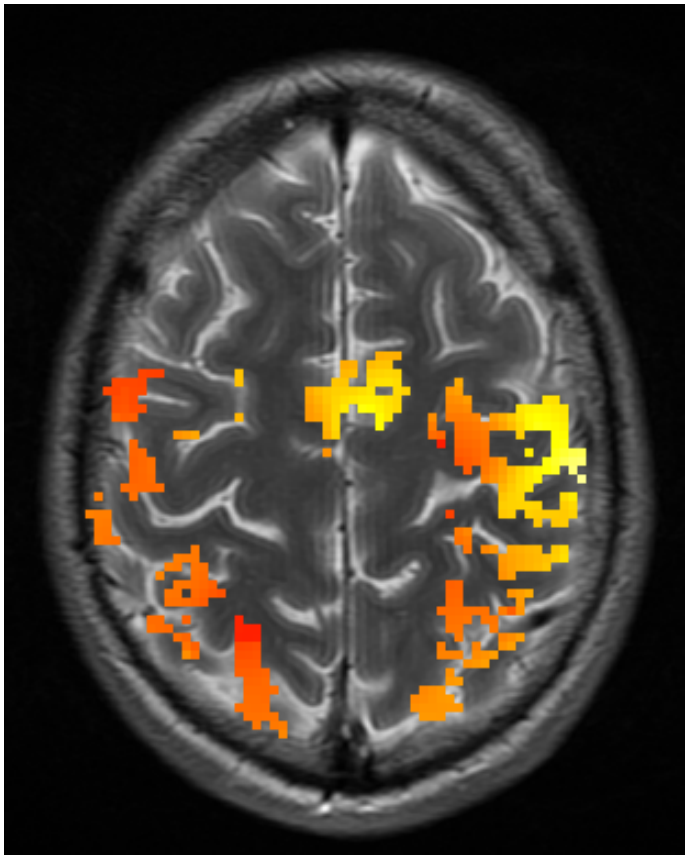
NI problems

- clinical operation planning (fMRI)
-
-
-

NI pipelines

- Preprocessing
- Statistical analysis

fMRI experiments to identify functional regions



Neuro-imaging problems

NI experiments

- anatomic MRI
- functional MRI
- diffusion MRI

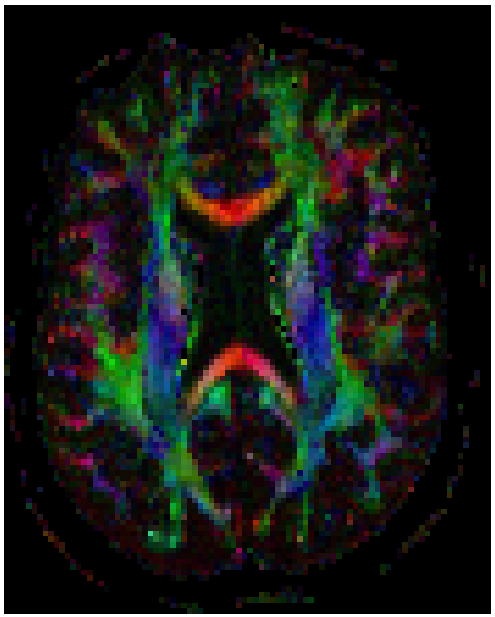
NI problems

- clinical operation planning (fMRI)
- clinical diagnostics (degenerative diseases, lesion detection)
-
-

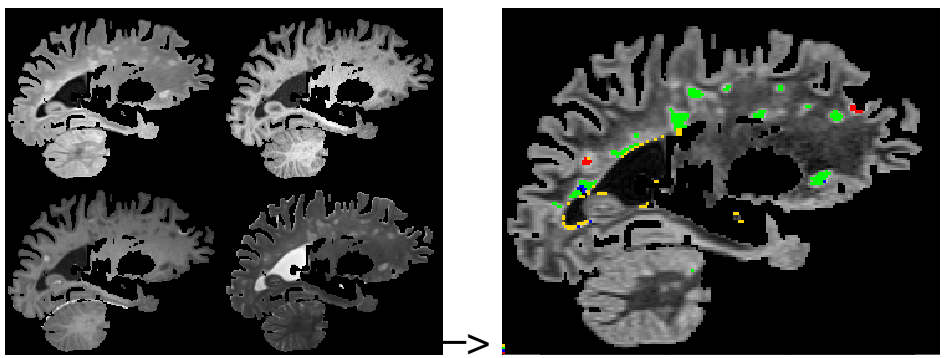
NI pipelines

- Preprocessing
- Statistical analysis

Diffusion MRI - Color coded FA



Multimodal imaging - leasion classification



Neuro-imaging problems

NI experiments

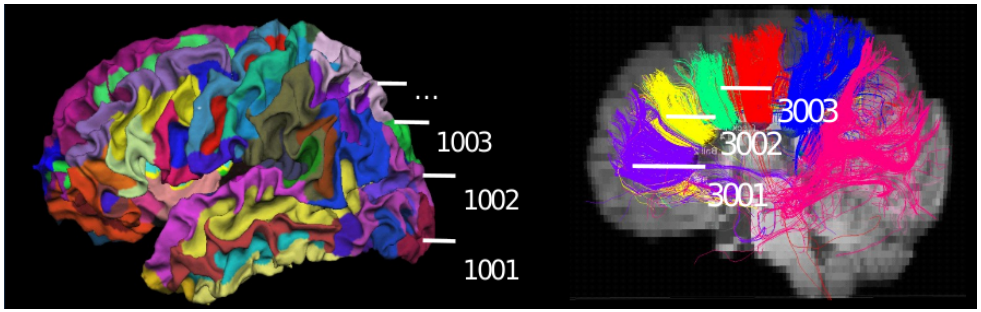
- anatomic MRI
- functional MRI
- diffusion MRI

NI problems

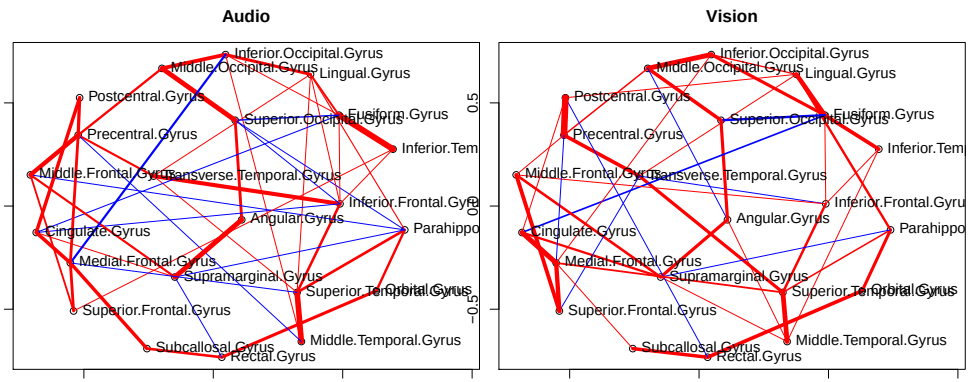
- clinical operation planning (fMRI)
- clinical diagnostics (degenerative diseases, lesion detection)
- brain functionality and anatomy (population studies)
- connectivity (functional, effective, anatomic)

NI pipelines

- Preprocessing
- Statistical analysis



- functional fMRI –> functional connectivity networks
-
-



Neuro-imaging problems

NI experiments

- anatomic MRI
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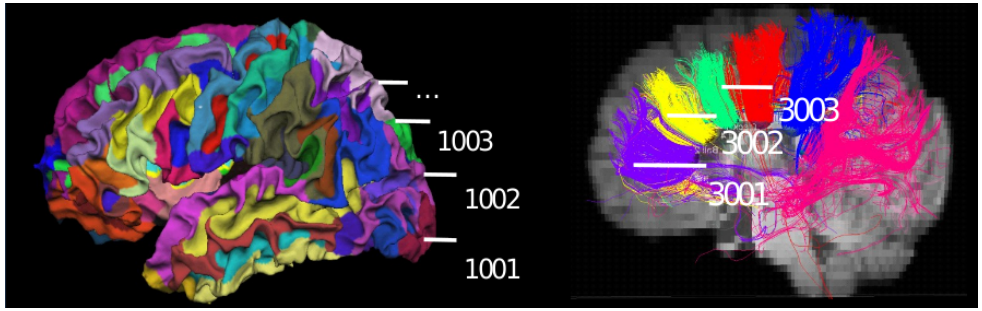

NI problems

- clinical operation planning (fMRI)
- clinical diagnostics (degenerative diseases, lesion detection)
- brain functionality and anatomy (population studies)
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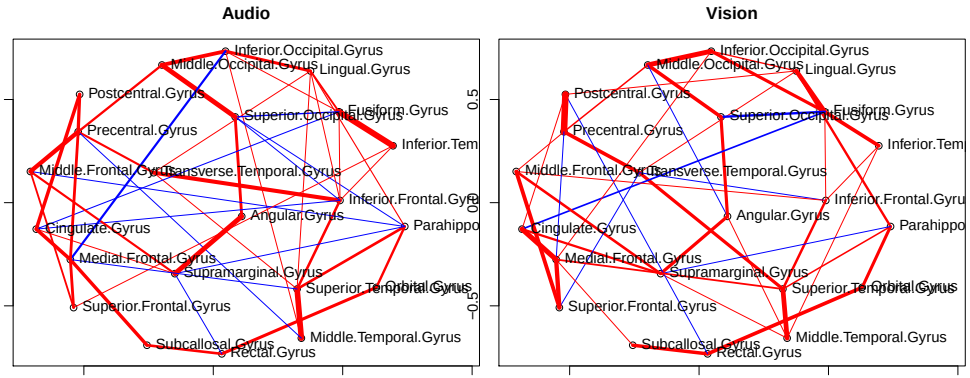
NI pipelines

- Preprocessing
- Statistical analysis

- functional fMRI –> functional connectivity networks
- EEG/MEG –> effective (and functional) connectivity networks
-



Neuro-imaging problems

NI experiments

- anatomic MRI
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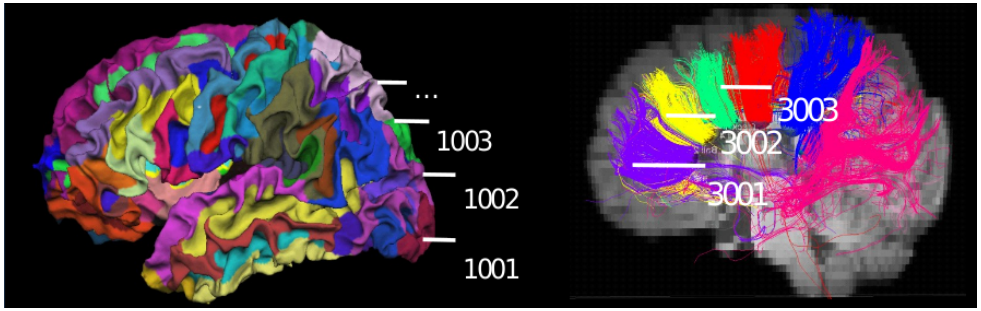
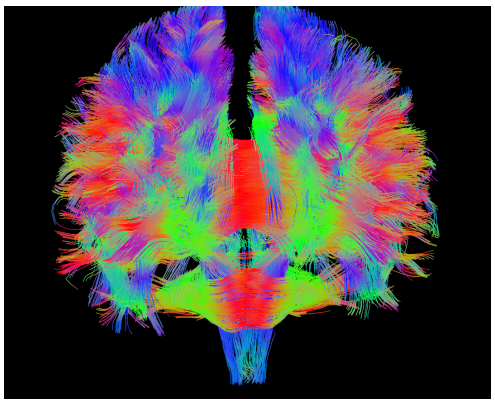


NI problems

- clinical operation planning (fMRI)
- clinical diagnostics (degenerative diseases, lesion detection)
- brain functionality and anatomy (population studies)
- connectivity (functional, effective, anatomic)

- functional fMRI –> functional connectivity networks
- EEG/MEG –> effective (and functional) connectivity networks
- diffusion MRI –> anatomic connectivity networks



NI pipelines

- Preprocessing
- Statistical analysis

Neuroimaging Software

- Neuroscience Community: AFNI, FSL, Freesurfer, SPM (matlab), . . .
- Commertial: Brainvoyager
- NeuroDebian, NIPY, NIPipe (python + interfaces)
- Neuroimaging Informatics Tools and Resources Clearinghouse (NITRC) NITRC.org
- R

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- R

Why R

- high quality open source (GPL)
- extensive statistics capabilities
- Extended Matrix-Algebra, optimization tools
- good interfaces to low level languages (C, Fortran, C++, ...)
- good visualization capabilities
- easily extendable by packages
- the statistical environment used in statistical education worldwide

from R's webside:

R is an integrated suite of software facilities for data manipulation, calculation and graphical display. It includes

- an effective data handling and storage facility,
- a suite of operators for calculations on arrays, in particular matrices,
- a large, coherent, integrated collection of intermediate tools for data analysis,
- graphical facilities for data analysis and display either on-screen or on hardcopy, and
- a well-developed, simple and effective programming language which includes conditionals, loops, user-defined recursive functions and input and output facilities.

Additionally:

- certified for clinical use by FDA, ICH, IMEA, PMDA ...
- high quality documentation and quality management
- report generating capabilities (knitr, sweave) –> latex, web, even word
- >7800 contributed packages, large user community

- Statistics community is involved in neuroscience research for at least 2 decades
- Software development for neuroimaging partly coordinated
- R Taskview on Medical imaging has about 20 contributed packages for neuroimaging (on CRAN)
- Interface packages to FSL, ITK, NIfTI-libraries
- more contributions on GitHub
- 2015/16 program on Challenges in Computational Neuroscience at SAMSI, NC
- Initiative from John Hopkins Univ. for a neuroconductor project/network (comparable to the successfull bioconductor in statistical genetics)