Department of Computer Science

Biomedical Imaging, Neuroimaging and BCI

NeuroImaging Group

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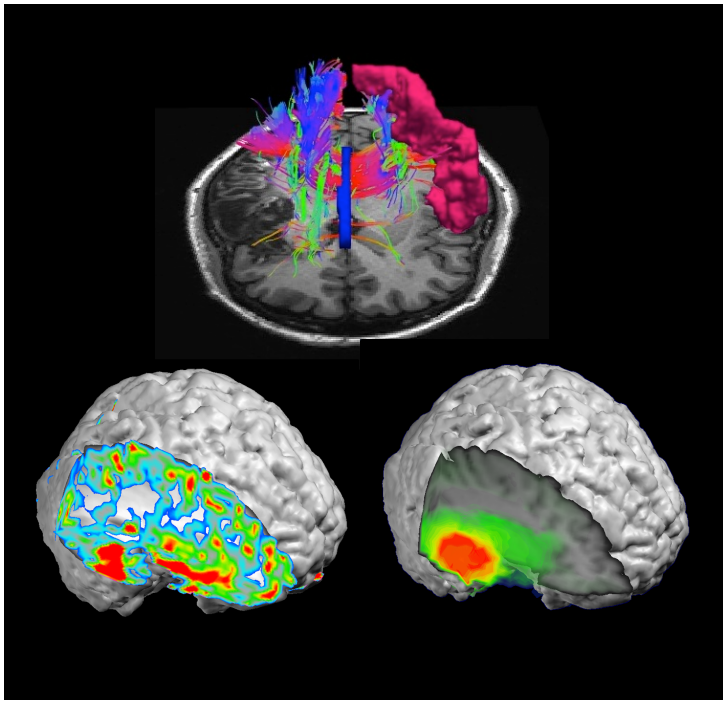
Research topics

Neuroimaging: Connectivity and Microstructure

- Signal reconstruction in dMRI and white matter tissue microstructure
- Structural, Functional and effective connectivity based on dMRI, fMRI, ASL and EEG and their interplay
  - Diagnostics, neural plasticity, surgical planning



Medical Image Processing

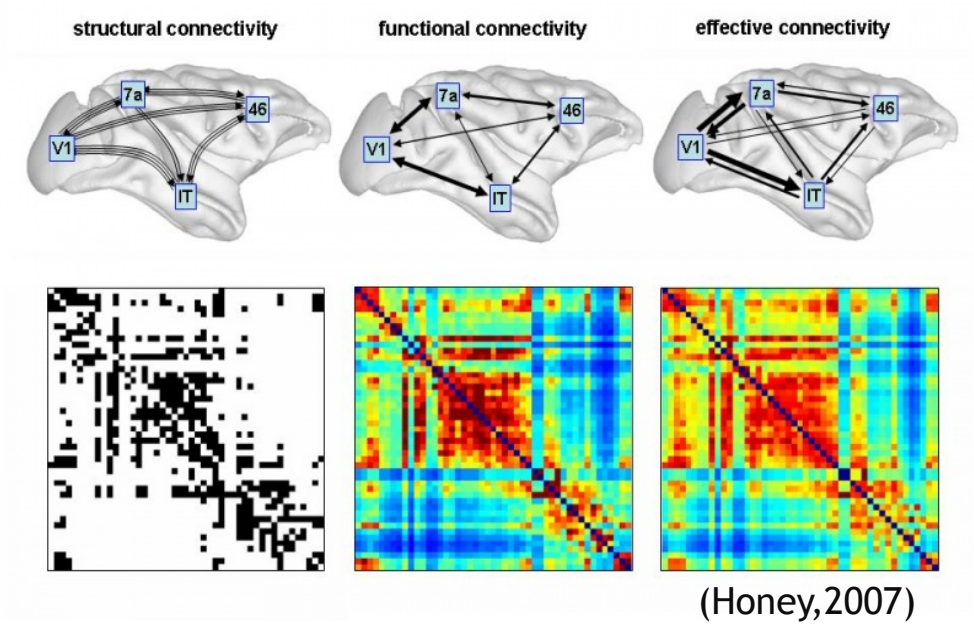
- Pattern recognition in biomedicine
  - Tissue classification in pathology

Brain Computer Interfaces

Connectivity

A pattern between distinct units within a nervous system of

- Anatomical links (structural connectivity)
- Statistical dependencies (functional connectivity)
- Causal interactions (effective connectivity)



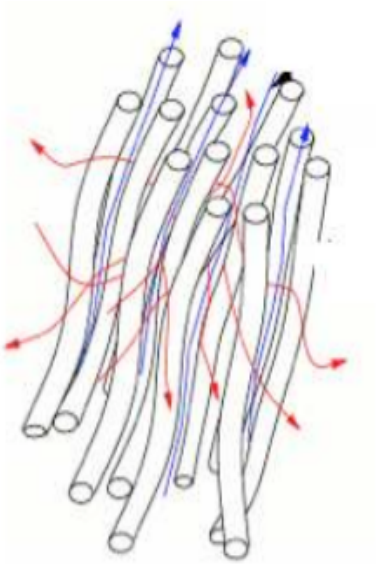
(Honey,2007)

Diffusion MRI

- Signal reconstruction in dMRI and white matter tissue microstructure

Magnetic resonance imaging (MRI) is a **non-invasive** technique that provides information about the soft tissues of the body

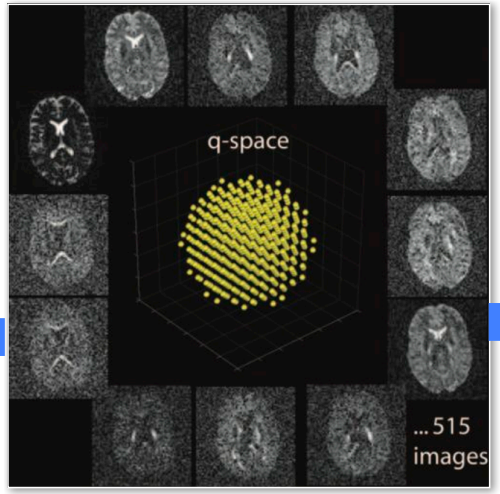
Diffusion Weighted Imaging (**dMRI**) is an evolution of standard MRI which permits to measure the **diffusion** of water molecules in a particular direction



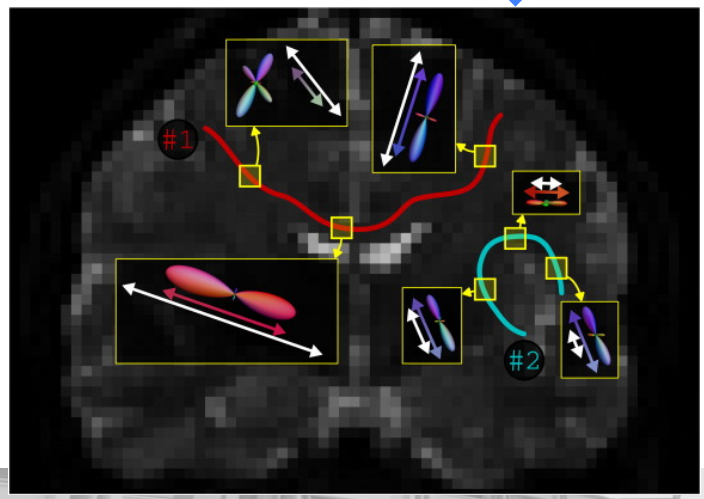
H_2O brownian motion in white matter fibers from [Poupon, C. 1999]

Diffusion MRI

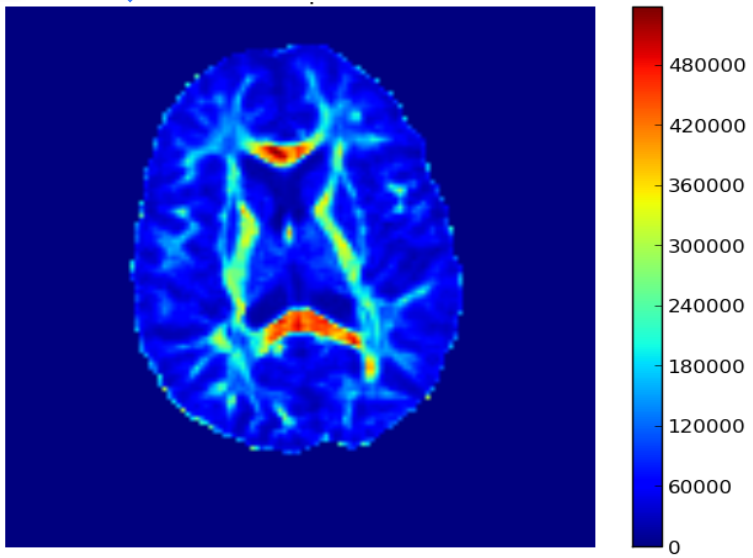
Acquisition and signal reconstruction



Tractography

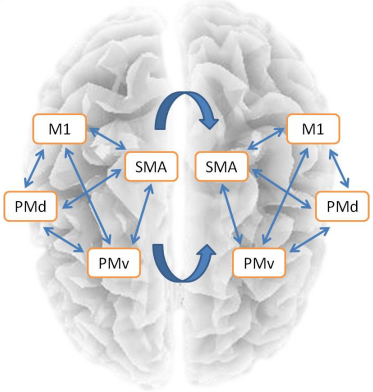


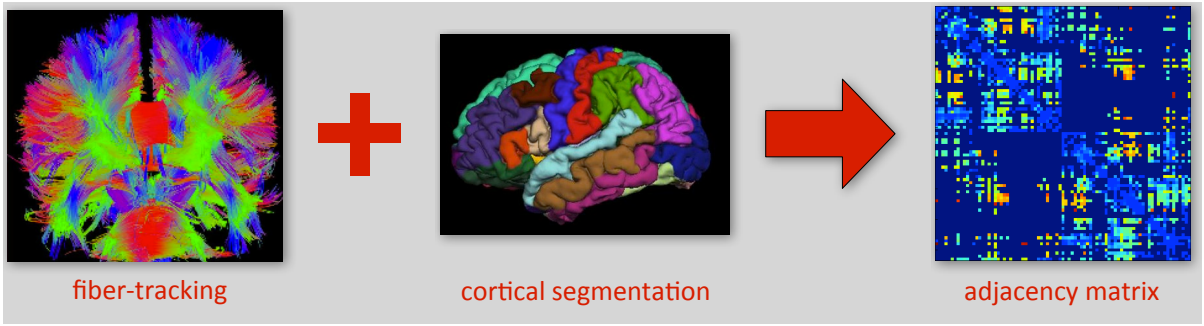
Microstructure



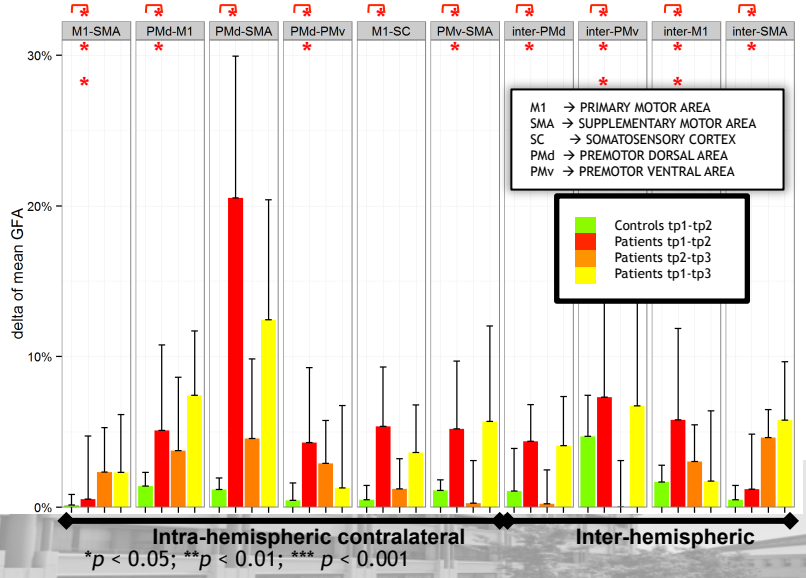
Tractography and beyond

Structural connectivity

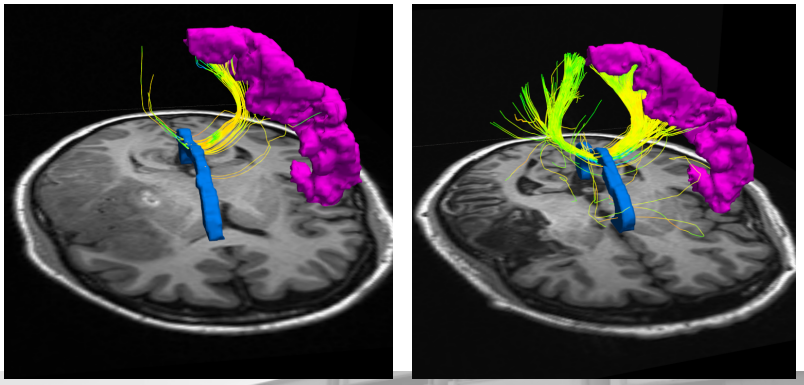




Numerical biomarkers (*quantitative tractography*)

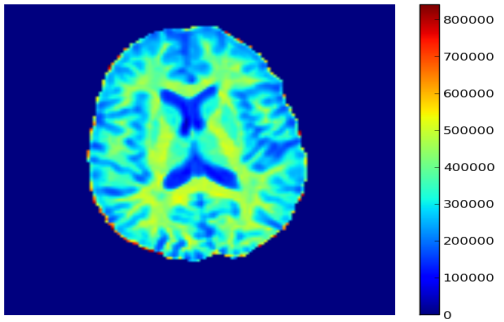


In-vivo assessment of neural plasticity (stroke)

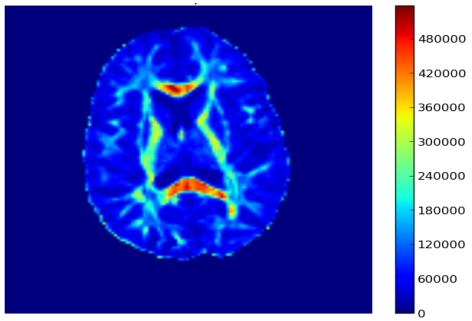


Microstructure

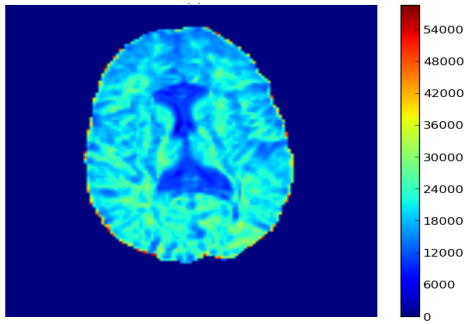
	General	DSI	SHORE
ODF	$\int_0^\infty P(r\mathbf{u})r^2dr$	$\sum_r P[\mathbf{u},r]\cdot r^2$	$\sum_N c_{nlm}k_{nml}{}_2F_1(-n+l,l/2+3/2,l+3/2,2)Y_l^m(\mathbf{u})$
RTOP	$\int_\mathbf{q} E(\mathbf{q})d\mathbf{q}$	$\sum_\mathbf{q} E[q_x,q_y,q_z]$	$\sum_N c_{n00}(-1)^n\left[\frac{16\pi\zeta^{3/2}\Gamma(n+3/2)}{n!}\right]^{1/2}$
MSD	$\int_\mathbf{r} P(\mathbf{r})r^2d\mathbf{r}$	$\sum_\mathbf{r} P[r_x,r_y,r_z]\cdot r^2$	$\sum_N c_{n00}(-1)^n\left[\frac{9\Gamma(n+3/2)}{4\pi^6\zeta^{7/2}n!}\right]^{1/2}{}_2F_1(-n,5/2,3/2,2)$



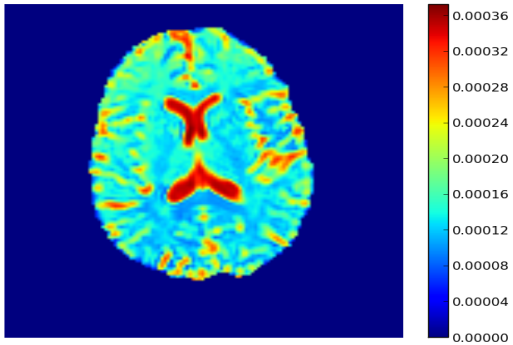
1/Volume



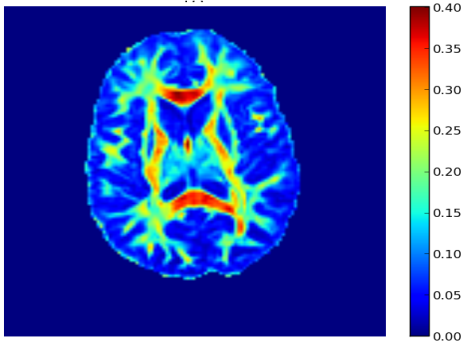
1/Cross-section



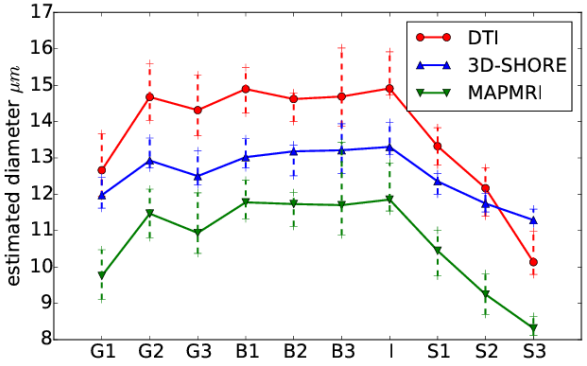
1/Length



Meas Squared Displacement



Diffusion anysotropy

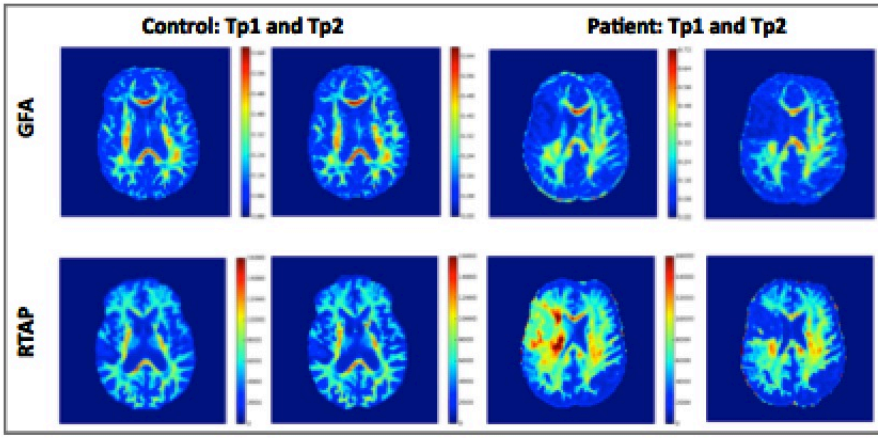


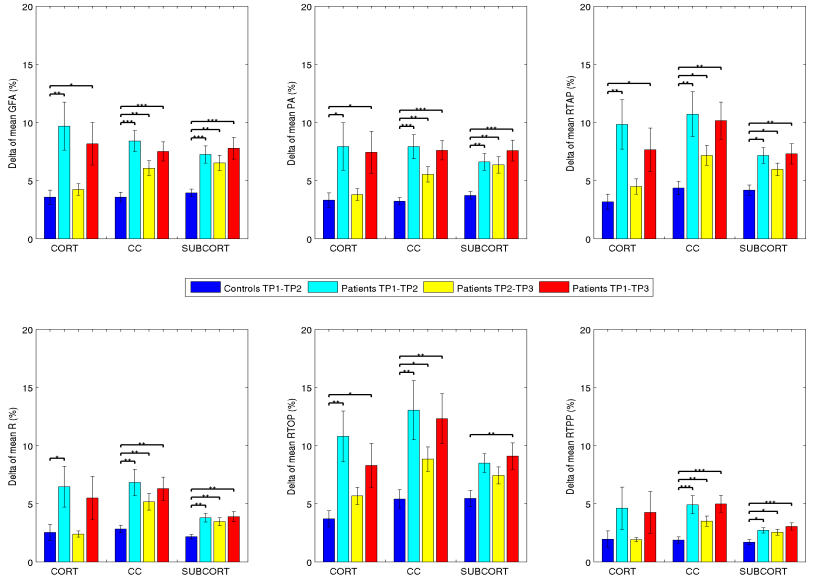
Biomarkers for neuronal plasticity

Neuronal plasticity in stroke

We investigated whether MAP-based indices could:

- Characterise contralesional structural changes after stroke
- Represent a new class of biomarkers for differentiating patients from controls
- Have a strong prediction power togethe



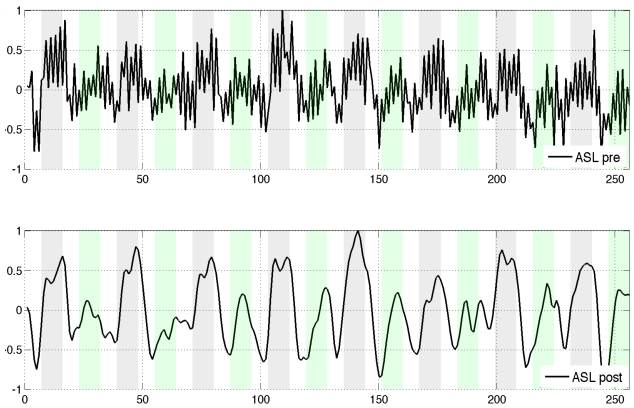


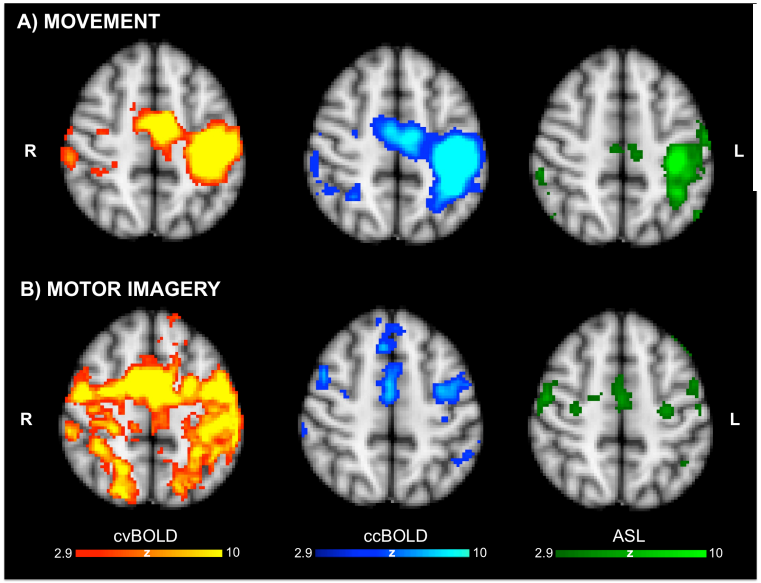
Functional connectivity

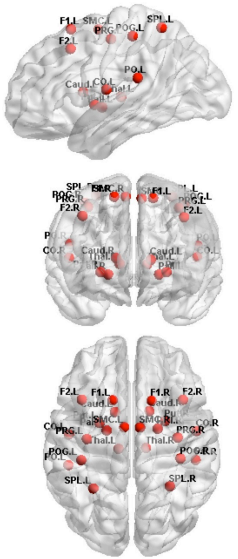
Functional connectivity based on fMRI and ASL

The aims are:

- to assess the sensitivity of the ASL in comparison to the BOLD-fMRI in detecting brain activations in active and motor imagery hand movements
- to quantify topological structures of brain functional networks derived from ASL and fMRI







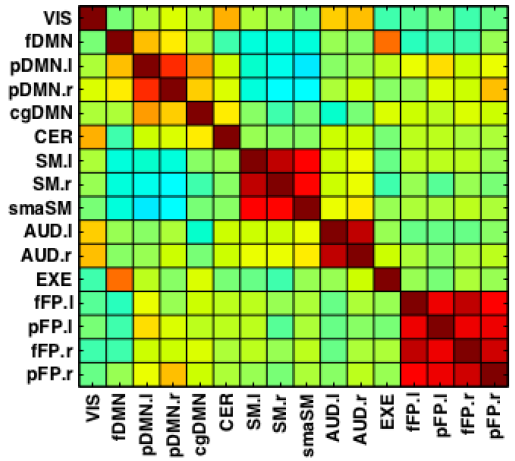
Clinical applications

Clinical: functional connectivity in Epilepsy

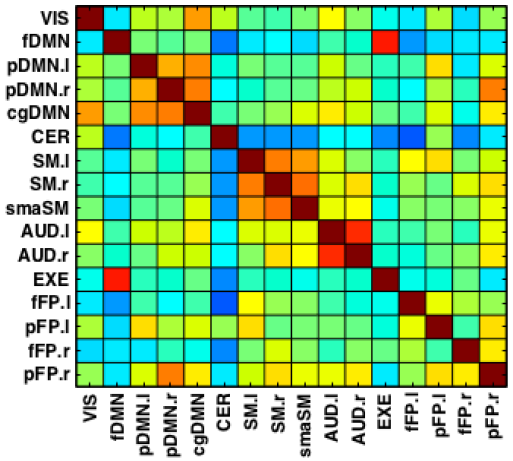
The aims are:

- to quantify spatial Resting State Networks in controls and epilepsy patients
- to evaluate the temporal properties of spatial independent components for measuring brain connectivity

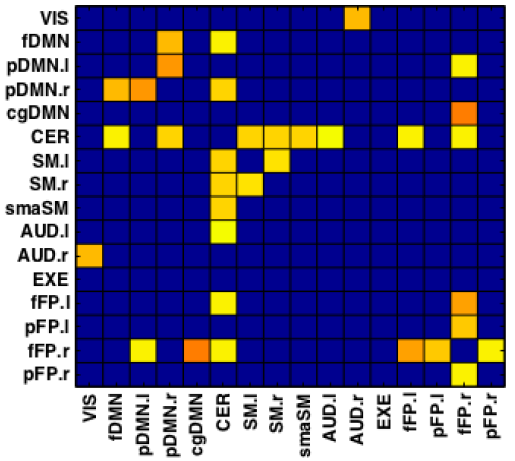
Controls



Patients



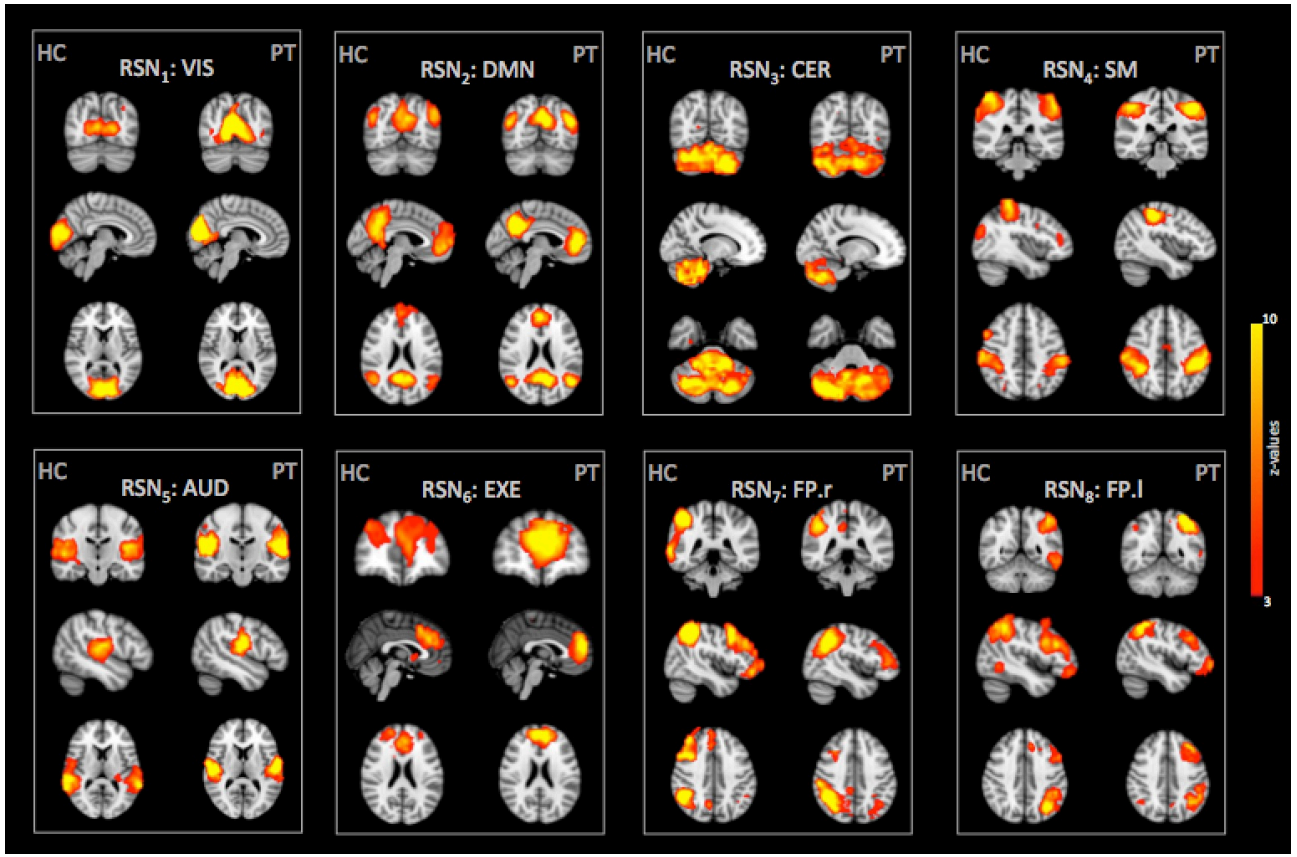
Statistics



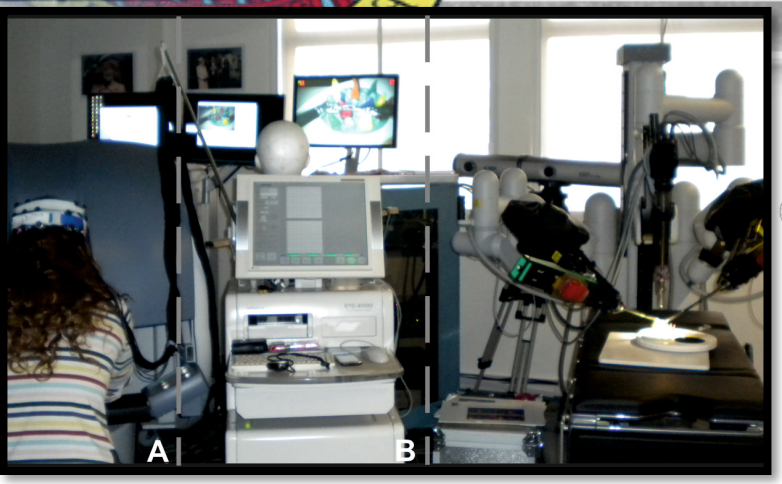
Neuroimaging

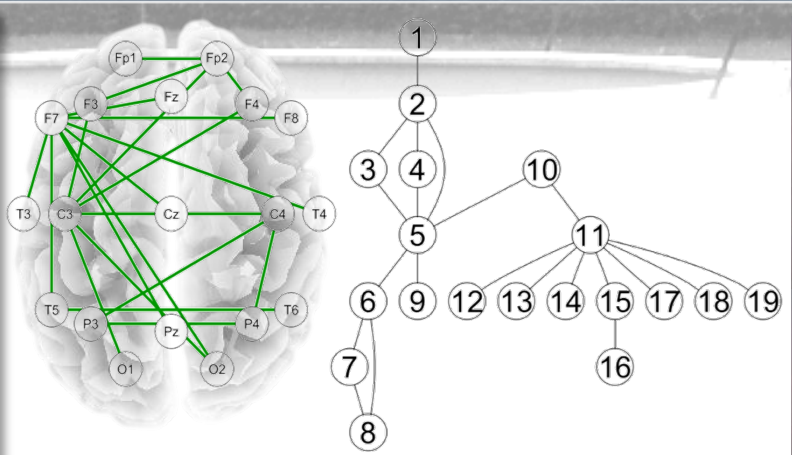
Clinical and preclinical: Epilepsy

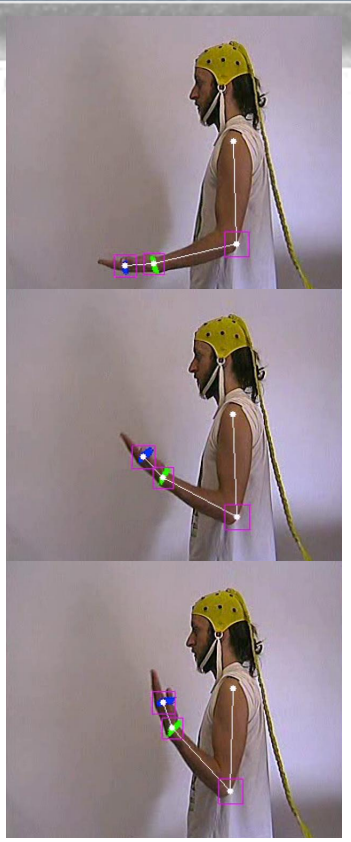
Resting State Networks in controls and epileptic patients

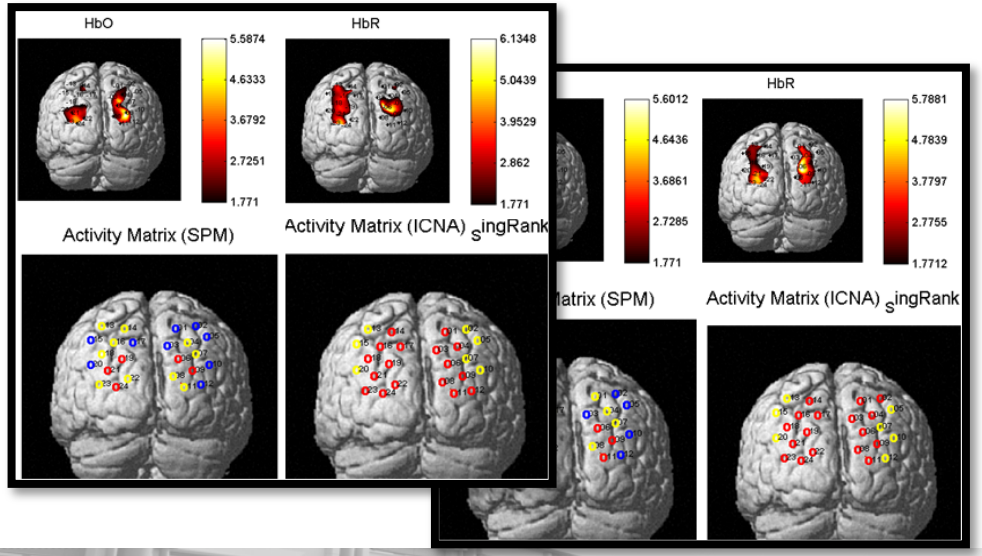


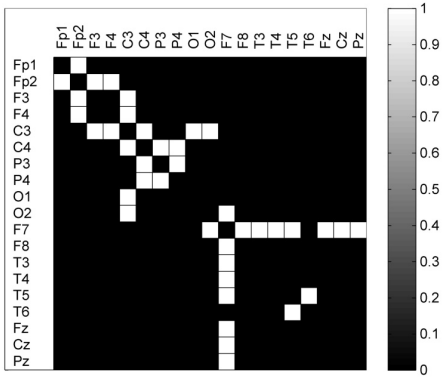
Brain Computer Interfaces



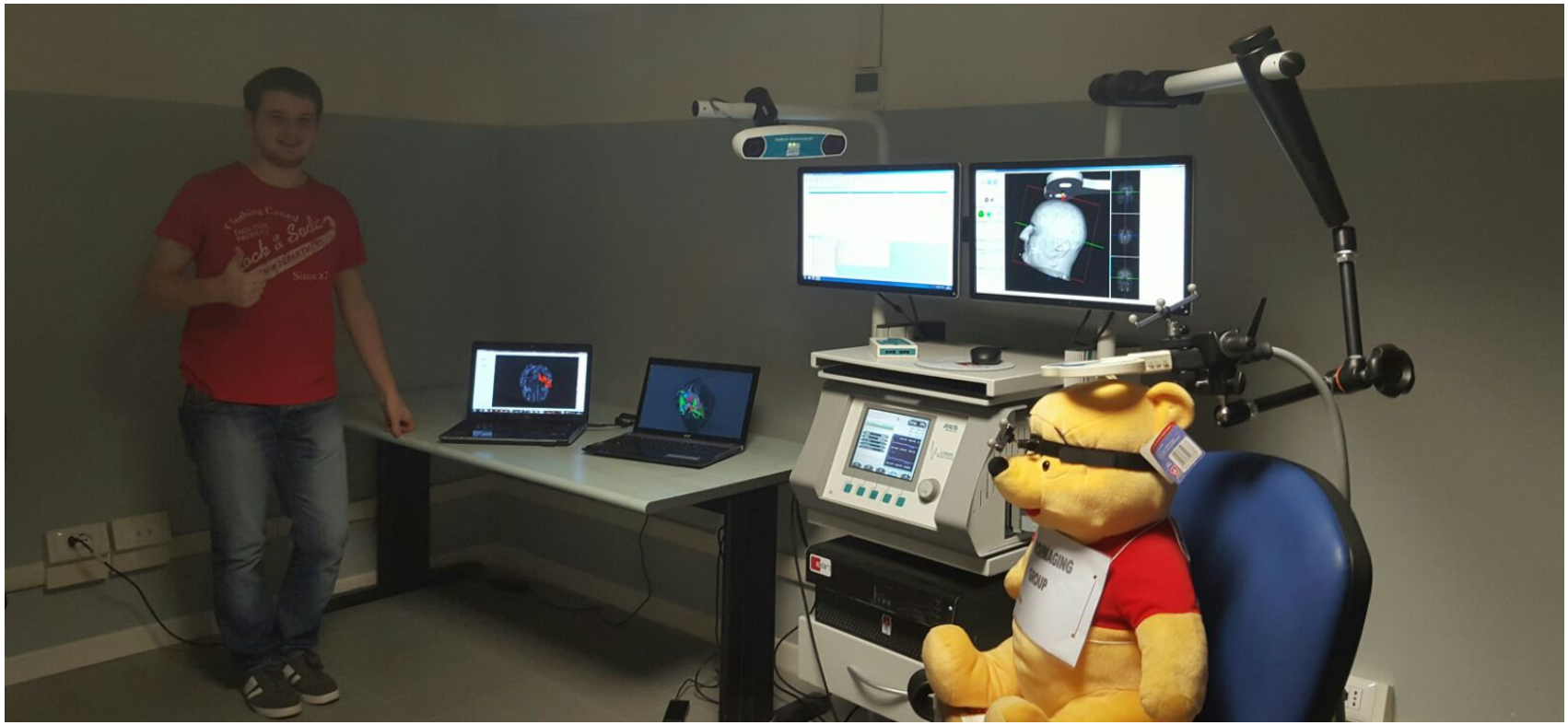






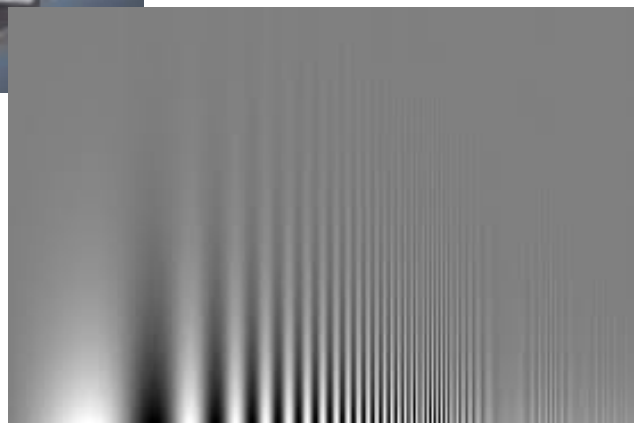


NAVLab



Visage System

Visage system
(Cambridge research)



Funded projects

- **2015**: Joint Project, *Brain microstructural modeling for improved TMS anchoring*, with the **Dept. of Medicine, Surgery and Health Sciences**, Clinical Neurology Unit, Cattinara University Hospital, Trieste, Italy (Prof. P. Manganotti) end EBNeuro
- **2014**: Joint Project, *Investigation of structural and functional brain connectivity from multimodal data* with the **Dept. of Neur. and Mov. Sciences** (Prof. P. Manganotti) end EBNeuro
- **2013**: Regione Veneto, in collaborazione con QR Srl, Verona, *Fusione e quality assessment di immagini da TC volumetrica Cone Beam*
- **2012**: Joint Project, AHeAD, *Automatic Human behavior Analysis in neurological Diseases: the case of epilepsy in collaboration* with the **Dept. of Neur. and Mov. Sciences** (Prof. P. Manganotti) end EBNeuro
- **2011** : Joint Project, *Highly reliable image-guided multimodal neuro-navigation for motor cortex stimulation*, in collaboration with the **Dept. Neur. and Mov. Sciences** (Prof. P. Manganotti) end EBNeuro
- **2010** : Joint Project, *Assessment of tumor infiltrative region in glioma mouse models: development of ad hoc data processing for advanced MRI techniques*, in collaboration with the NRM Lab, of the University of Verona and Nerviano Medical Systems
- **2010** : PRIN-2009, BrainFit : *Brain tractography from diffusion imaging for radiotherapical and surgical planning*, with the **Dept. of Neurosurgery** of the University of Verona and the Signal Processing Lab. (LTS5) of EPFL (Prof. J.-Ph. Thi¡ran)

Jointly submitted projects

- PRIN-2015: Connecting microstructural features with regional specificity for brain tumours: a multi-modal approach (CONNECT), in collaboration with Dr. Francesca Pizzini, Neuroradiology, Dpt. of Diagn. and Path., Verona University Hospital; *Honorary Lecturer*, Dpt. of Neuroradiology, Queen Square, London

- ERC Consolidator grant: neuroRadiogenomics and InfoGenetic Approach for a new signature of Gliomas (RIGA), PI Dr. Francesca Pizzini, Neuroradiology, Dpt. of Diagn. and Path., Verona University Hospital; *Honorary Lecturer*, Dpt. of Neuroradiology, Queen Square, London