New developments in MRI

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Techno-trends in neuro-MRI

↑ Field strength
↑ RF-technology
↑ Gradient-system
↑ Sequences
↑ Post-processing
↑ sensitivity
↑ time resolution

SNR
CNR

Some MRI trends...

- Digital RF chains
- Parallel RF receive and transmit
- Increasing # of independent RF channels
- Higher fields
- Dedicated systems (human connectome...)
- Hybrid imaging (MR/PET)

Multi-channel RF coils

Multi-channel RF coils

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Adapted from F. Courivaud, PhD
State-of-the-art 32-channel head coil

SENSE: Sensitivity Encoding for Fast MRI

Klaas F. Prosenmann, Markus Hetzer, Markus R. Schellinger, and Peter Boesiger*
**SENSE**

- Reduced acquisition time (fewer K-space lines)
- Reduced Bo-artifacts in EPI acquisitions (shorter echo-trains)
- No loss of spatial resolution
- Loss of SNR
- Requires multi-channel coils

**SENSE in EPI**

Jaermann et al; MRM 2006

**Multi-transmit RF technology**

- At higher fields, RF excitation fields become inherently non-uniform:
  - Electrical (dielectric) properties of human body
  - Reduced wavelength of Larmor frequency
- Multi-transmit RF technology: major breakthrough in generating homogeneous RF fields at high fields

**Conventional RF technology at 3 T**

Courtesy of Philips Medical Systems

**Multi-transmit**

Courtesy of Philips Medical Systems

**Multi-transmit RF**

Courtesy of Philips Medical Systems
Multi-transmit RF

New developments

The human connectome project

Human connectome project

- The brain consists of $10^{11}$ neurons and $10^{15}$ synaptic links
- Total wiring of the brain is estimated to span thousands of miles
- Aim: to map out functional and structural connections of the healthy living human brain

The Human Connectome

Meet the World’s Most Advanced Brain Scanner

The super MRI used in the Human Connectome Project is the ultimate brain hacking machine.
Hybrid PET-MRI

- Combination of superb soft-tissue contrast (MRI) and high disease specificity (PET)
- Enables simultaneous PET-MRI acquisition of:
  - moving organs
  - temporal processes (functional response, perfusion etc)

Why combined PET-MRI??

- Reduced ionizing radiation (no CT)
- Improved logistics (time-saving)

PET-MRI – currently two approaches

- PET-detectors integrated in MRI gantry (Siemens)
- PET and MRI acquired separably on moving table (Philips)
65 yr old woman with GBM. PET C-11 methionine.

Images courtesy of the Journal of Nuclear Medicine.
### MR-based PET attenuation correction

| MR | Pseudo-CT | PET |

### PET-MRI : where?

- Brain (fMRI, MRS, ASL,...)
- Spine
- Prostate
- Bone marrow
- Breast
- (Heart)
- (Musculoskeletal)
- (Liver)

### PET-MRI challenges

- Complicated PET attenuation correction
- 'Non-optimal' MRI and PET performance due to mutual interference
- Currently lack of ‘killer-app’
- Cost!

### Summary

- Rapid advances in MRI technology
  - Advanced RF-technology
  - Multi-channel parallelization
  - Higher fields
- Dedicated systems for dedicated applications (e.g. human connectome)
- Hybrid imaging PET-MRI, EEG-MRI,...