MR Systems Engineering

Field Monitoring & System Calibration

Christoph Barmet, PhD (barmet@biomed.ee.ethz.ch)

Target audience: engineers & physicists with a basic knowledge of MR physics and system design

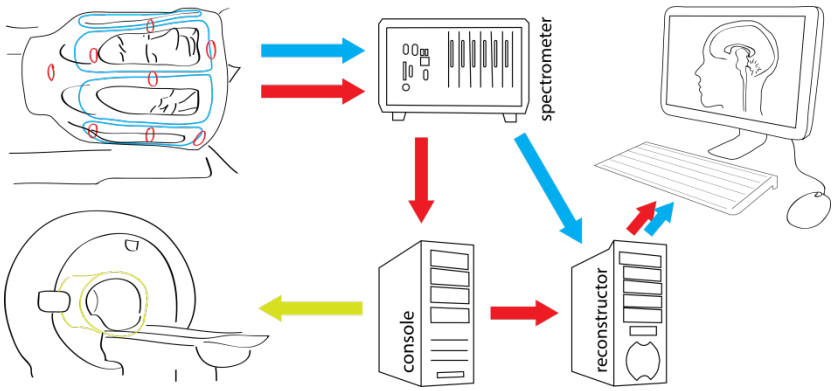
Highlights:

- Effects of dynamic magnetic field perturbations on image /spectra quality
- Introduction to magnetic field monitoring
- Expanded scope of current and next-generation MR systems by improved dynamic field control

Objectives: Get to know the sources, nature, and consequences of dynamic magnetic field perturbations in MR scanners. Conventional and novel approaches to cope with such magnetic field perturbations are presented.

Purpose: How can improved dynamic field control expand the scope of current and next-generation MR diagnostics?

Methods: Three approaches to address dynamic field perturbations in MR systems are presented: system calibration, real-time field feedback, and image reconstruction. Their assets and drawbacks are analyzed with respect to various types of field perturbations. Special focus is placed on magnetic field monitoring with NMR field probes.



Results: Dynamic field perturbations are not just created by MR system imperfections, but also by patient physiology. The field perturbations differ greatly in their frequency range, reproducibility, predictability, effect on image quality, ease of detection and correction. High-field imaging, quantitative flow measurements, spectroscopy, diffusion, and real-time shimming are particularly sensitive to dynamic field perturbations. Image reconstruction based on predicted or actually measured field dynamics is often a viable alternative to system calibration and real-time field control, as long as the encoding process does not get ill-conditioned (e.g., by losing the steady-state). While some perturbations can be tackled by one single approach, others require the combination of the methods.

Discussion/Conclusion: Dynamic field perturbations span many orders of magnitude in time. Their consequences on image / spectra quality can be mitigated by either adjusting the hardware settings in an initial calibration step, by real-time feedback or a posteriori by image reconstruction.

Magnetic field monitoring empowers all three approaches by adding field sensor information that allows for fast system calibration, real-time feedback and image reconstruction based on the actual field evolution.