



MRI Pulse Sequence: Steering Resonance over the Object (20120049, Dr. Michael Garwood)

Technology No. 20120049

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Spatiotemporally-encoded MRI Technique

Steering Resonance over the Object (STEREO) is a magnetic resonance imaging (MRI) pulse sequence with a frequency and amplitude modulated RF pulse applied in the presence of modulated gradients to excite signals in an entirely spatiotemporal manner. STEREO represents a substantial departure from conventional MRI in which spins contained in the sample, slab, or slice are excited synchronously. By exciting spins sequentially along a curved spatial trajectory, STEREO affords a unique opportunity to adjust for spatial variations in static and radiofrequency fields.

Magnetic Resonance Imaging

To accomplish magnetic resonance imaging (MRI), the pulse sequence used to generate spatially-encoded signals must contain at least two basic elements: 1) a radiofrequency (RF) pulse with sufficient bandwidth to excite all the resonance frequencies in the region to be imaged, followed by 2) a finite time during which the excited magnetization vectors evolve in the presence of a field gradient (used to encode the spatial location of the signal). This well-established approach to MR imaging is optimal only under stringent experimental conditions. In particular, the strength of the static magnetic field (B_0) is allowed to vary by only a small fraction of the total field (i.e., $\Delta B_0 \ll B_0$) over the volume to be imaged.

Smaller MRI Magnet

Traditionally, MRI scanners need highly uniform magnetic fields which demand magnets that are physically large as compared to the object being imaged. In recent years, impressive advances have been made that significantly improve the ability of conventional (Fourier-based) MR imaging to tolerate B_0 inhomogeneity by multiple factors, but these improvements fall far short of meeting the technical demands for MRI using magnets that are just slightly

larger than the object to be imaged (e.g., a head-only magnet). STEREO significantly relaxes the homogeneity requirement and enables the use of smaller and potentially less costly magnets. STEREO represents a substantial departure from conventional MRI in which spins contained in the sample, slab or slice are excited simultaneously. By exciting spins sequentially along a curved spatial trajectory, STEREO affords a unique opportunity to adjust for spatial variations in B_0 and RF fields. The technology may dramatically reduce the cost of MRI scanners. Implemented entirely in software on an MRI scanner, STEREO enables tolerance to B_0 inhomogeneities on the order of hundreds of parts-per-million (ppm), which is substantially more than 1-2 ppm allowed by conventional MRI, and thus could significantly reduce manufacturing and operating costs.

BENEFITS AND FEATURES:

- Compatible with all standard MRI scanners (both low and high field strength)
- Implemented entirely in software
- Compensates for inhomogeneities in both the primary magnetic field (B_0) and the RF field (B_1)
- Compatible with techniques that enable imaging of bone and imaging near metal implants
- May enable a new class of MRI scanners in which hardware manufacturing and operating costs are substantially reduced
- May enable technology for high performance specialized scanners, e.g. brain, breast
- May significantly reduce scanner size, which would improve scanner siting
- More affordable (and possibly even portable) scanners (generating a homogeneous B_0 is one of the largest barriers to producing a relatively low-cost system)

APPLICATIONS:

- MRI scanners
- Under-served clinics and hospitals that cannot afford high-cost MRI scanners
- MR imaging
- Imaging using inhomogeneous B_1 and B_0 fields

Phase of Development

Proof of Concept. Need to improve reconstruction algorithms used to generate image from collected MR data. Images of human brain have been generated; ongoing work to: (1) refine procedure for existing scanners to enhance image quality and (2) determine the limits of inhomogeneity that STEREO can tolerate.

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Publications

[*MRI by steering resonance through space*](#)

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