Image Acquisition and Reconstruction: Contrast Manipulation

Pulse Sequence Modules I (IR, DE, Spatial Sat., Chem. Sat.)

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Highlights:

- Pulse sequences and contrast manipulations in terms of modular building blocks.
- Longitudinal spin magnetization preparation.
- Usage and pitfalls of four contrast manipulation strategies.

Target Audience: Clinicians and scientists relatively new to MR imaging physics.

Introduction: Contrast manipulation is an integral part of MR imaging. The primary contrast mechanism is provided by the choice of imaging sequence and associated timing and flip angles, which alter the tissue appearance dependent on the inherent tissue T1 and T2 relaxation values. However one can also modify image contrast through the use of additional pulse sequence modules, applied either before during or after the imaging sequence. These modules are used to selectively modify spins based on such attributes as spatial location, chemical shift, relaxation values, velocity, or diffusion.

This talk explains some of the more basic contrast manipulating modules. The first three are applied prior to the imaging sequence, and involve modifications to the longitudinal spin magnetization. These are largely non-interacting modules, and so several can be applied sequentially to achieve multiple contrast manipulations. The fourth is applied after the imaging sequence and involves the accelerated recovery of transverse spin magnetization. This kind of module, interacting with transverse spin magnetization, needs to be carefully synchronized with the internals of the image generating sequence.

Inversion Recovery (IR): This involves a 180° RF inversion pulse applied an inversion time (TI) prior to the imaging sequence. The longitudinal spin magnetization recovery is governed by the spin's T1 value, so the IR module impacts the T1 contrast. TI is often chosen to null a particular spin species, such as fat or CSF.

Spatial Saturation (Spatial Sat.): This is similar to slice or slab selection, comprising a 90° RF excitation pulse in the presence of a gradient. However here the goal is to eliminate signal rather than image it, so the resulting transverse spin magnetization is dispersed by appending an additional gradient pulse. The Spatial Sat. module is applied immediately before the imaging sequence such that the spin signal has little time to recover. Generally this is used to eliminate signal from motion regions which could produce artifacts over the image.

Chemical Saturation (Chem. Sat.): The resonant frequencies of fat and water spins are different by a few 100Hz, so that a narrow-band 90° RF pulse can selectively excite one or the other set of spins. Like Spatial Sat., this is followed by a dispersing gradient pulse to null the transverse spin magnetization. The Chem. Sat. module is also applied immediately prior to the image generating sequence. Typically this is used to null the fat signal.

Driven Equilibrium (DI): This is used to accelerate the recovery of long T1 spin species, and hence to allow a reduced repetition time (TR) time. Recovery is accelerated by first adding an echo to the imaging sequence, and then taking this (transverse magnetization) echo and flipping it with a 90° RF reversed-excitation pulse into longitudinal spin magnetization. This is often called fast recovery (FR).

Reference:

[1] Bernstein MA, King KF, Zhou XJ, "Handbook of MRI Pulse Sequences", Elsevier (2004).