Simulation of RF Fields for MRI: Methods and Applications

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RF fields in MRI are applied to manipulate nuclear magnetic moments, but in doing so cause heating of tissues. RF coils are used to detect signal from nuclear magnetic moments, but are also sensitive to noise induced by random motion of ions and molecules throughout the body. While we often desire a homogeneous field in transmission, this is increasingly difficult to achieve as we move to higher frequencies in search of better SNR. And while we desire a configuration of receive coils with high sensitivity to local signal, low noise correlation, and field distributions optimal for SNR and accelerated imaging, design of such arrays is confounded by the variation of field distributions with subject geometry.

Simulation of RF fields in MRI is increasingly used to understand observed effects, ensure safety (including in the presence of active and passive metallic implants), design transmit and receive coils and arrays, and design pulses and sequences that maximize desired image characteristics, minimize undesired effects and artifacts, and ensure RF safety. There are a wide variety of approaches to simulation and interpretation of results, and the best methods are often dependent on the particular application.

Here we review a wide variety of methods for field calculation, representation of coils and the human body, interpretation of results, and compromises between these approaches for a wide array of engineering problems in MRI. Special attention will be paid to current challenges in design of pulses for transmit arrays to ensure safety and minimize inhomogeneity-related artifacts, the characterization of receive array performance, and representation of implants.

Recommended reading:


