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An Algorithm for Maximum-SAR Targeted Hyperthermia

Magnetic resonance (MR) thermometry is a fast and noninvasive method for performing the necessary temperature mapping. Typically, the heating apparatus (RF or microwave applicator) and imaging apparatus (MR RF tranceiver coil) are separate pieces of hardware, which can be cumbersome and pose practical complications. At high static field strengths, the wavelength of the electromagnetic radiation in MRI is small enough that localized hotspots result from constructive interference of electric fields. For the purpose of imaging, this phenomenon is problematic since the hotspots (quantified by the specific absorption rate, SAR) can violate regulatory limits. For this reason parallel transmission with a multichannel RF coil is used in high field MRI as a way to homogenize electric and magnetic field distributions. The additional degrees of freedom introduced through parallel transmission, while initially intended for hotspot mitigation in imaging, can be repurposed for localized hotspot generation in hyperthermia.

Stanford researchers have developed an efficient algorithm for determining the optimal channel weightings to maximize the SAR over an arbitrary target region of a particular patient while constraining SAR elsewhere to be below regulatory local SAR limits. The algorithm is efficient enough that it can be performed in real-time in an iterative manner to ensure accuracy.

This invention can be used with MRI RF coils operating at sufficiently high frequencies (300 MHz) to perform interleaved imaging and hyperthermia with a single apparatus. This will allow a convenient method for monitored thermal therapy in an efficient and noninvasive manner.

Applications

- Localized chemotherapy;

- Ablation of tumors;
- Cardiac stimulation

Advantages

- Hyperthermia and imaging can be accomplished with a single RF apparatus, making such a system much less cumbersome than current methods with separate pieces of hardware.
- The speed of the algorithm is orders of magnitude faster than what would be possible using other SAR formalisms, allowing for the real-time iterative optimization described.
- The optimization can be performed for arbitrary target locations without a separate time-consuming EM simulation.

Publications

- U.S. Patent Application Serial No. 14/711,484

Patents

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