Technology Offer

Dynamic Parallel Imaging: Accelerated MRI through Sensitivity Profile Modulation

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Abstract

This invention presents a novel method to accelerate Magnetic Resonance Imaging (MRI) by dynamically modulating the sensitivity profiles of RF receive coils. Traditional MRI methods rely on fixed sensitivity profiles, limiting the speed of acquisition. The new approach introduces time-dependent modifications, enabling access to additional spatial information for faster and higher-resolution imaging. By employing adjustable electronic components such as varactor diodes or metamaterials, the method enhances spatial encoding beyond conventional parallel imaging techniques. This innovation significantly reduces scan times, making MRI more efficient and applicable in dynamic imaging scenarios, such as real-time diagnostics and motion-sensitive environments.

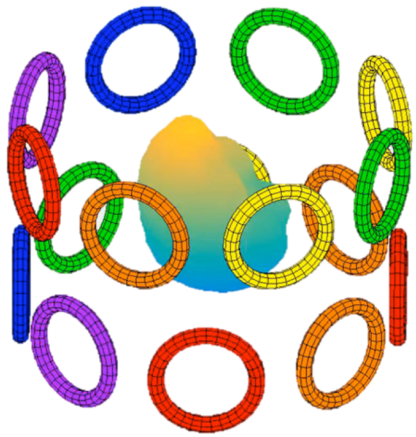

Figure 1: As in common parallel MR imaging, the sample is placed inside an arrangement of multiple RF receive coils to detect the MR signal with additional spatial information. Each coil can additionally be equipped with an individual modulation device to dynamically change the coils sensitivity profile. These profiles can be adjusted and monitored by a central modulation control unit.

Background

MRI is a critical imaging tool in modern medicine, known for its non-invasive nature and high-resolution imaging capabilities. However, conventional MRI techniques suffer from long acquisition times, especially in applications requiring high spatial resolution or dynamic imaging. Parallel imaging techniques, which utilize multiple RF receive coils, have improved acquisition speeds but remain limited by static sensitivity profiles. To further enhance MRI efficiency, a new method is required that dynamically modifies coil sensitivities during acquisition, allowing for additional spatial encoding without increasing measurement duration.

Technology

This invention improves parallel MRI by dynamically modulating the sensitivity profiles of RF receive coils. Unlike traditional methods with static profiles, this approach introduces time-dependent variations, providing additional spatial encoding without extending acquisition time.

The modulation can be achieved through varactor diodes, which adjust coil capacitance in real time, tunable metamaterials, which alter electromagnetic properties between the coil and sample, or auxiliary modulation coils, which create controlled electromagnetic interactions. These methods enhance spatial resolution and reduce scan times.

By integrating seamlessly with established parallel imaging techniques like SENSE and GRAPPA, this technology offers a cost-effective solution for faster, high-quality MRI. It is particularly beneficial for dynamic imaging applications where motion or high-resolution imaging is required.

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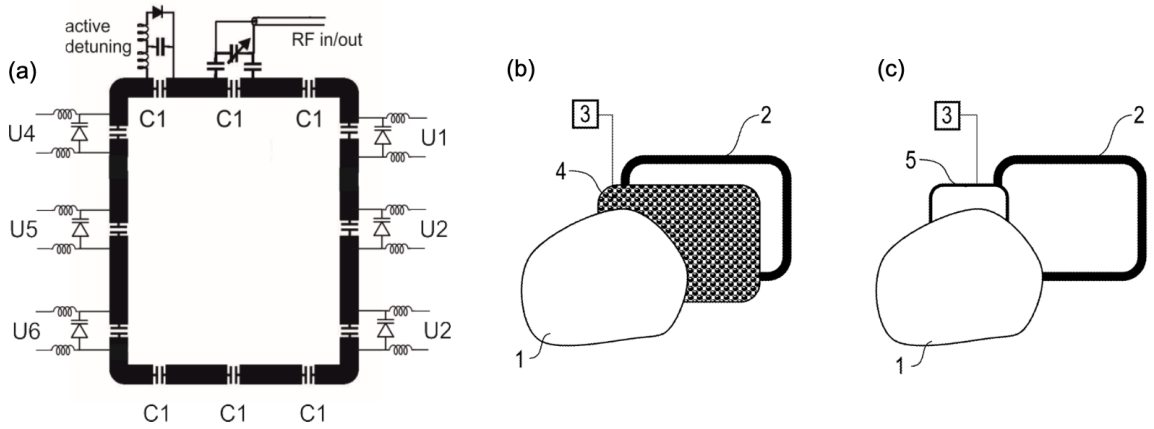

Figure 2: Design and application of localized B_0 modulation coils. (a) Circuit layout of a modulation coil with active detuning and multiple control units. (b–c) Illustrations of the coil positioned near a sample (1), showing integration with the system (2) and potential shielding or adjustment elements (4, 5) for precise field control.

Advantages

- **Significant reduction in MRI scan time** for static and dynamic imaging.
- **Enhanced spatial resolution** due to additional encoding information.
- **Compatible with existing parallel imaging techniques** (e.g., SENSE, GRAPPA).
- **Cost-effective integration** with commercial MRI systems.
- **Applicable to various MRI fields,** including clinical diagnostics, functional MRI, and material research.

Potential applications

- **Medical imaging:** Faster MRI scans for neurology, cardiology, and emergency diagnostics.
- **Dynamic imaging:** Improved motion capture in functional MRI and real-time imaging applications.
- **Industrial and materials testing:** High-resolution imaging of complex materials with reduced scan times.
- **Preclinical research:** Enhanced MRI efficiency in animal studies.
- **Portable MRI development:** Optimization of imaging in mobile or point-of-care MRI systems.

Patent Information

EP application (14.08.2019), active in EP and US

Publications

Scheffler, K., Loktyushin, A., Bause, J., Aghaeifar, A., Steffen, T., & Schölkopf, B. (2019). Spread-spectrum magnetic resonance imaging. *Magnetic resonance in medicine*, *82*(3), 877-885.

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