Real-Time Phase Error Correction for Off-Axis MRI Systems to Improve Efficiency and Image Quality

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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing an improved real-time method for calibrating off-axis MRI systems by correcting phase errors in non-Cartesian k-space sampling to reduce scan times, improve patient comfort and enhance image quality.

Overview

Magnetic resonance imaging (MRI) is a diagnostic imaging technique that is especially effective for soft tissues such as the brain or other organs. To produce an MR image the patient is subjected to a polarizing magnetic field, B_0, causing the protons of water molecules in tissues to align with the field. An excitation field, B_1, then is applied perpendicular to B_0 via radio frequency (RF) antenna or coils, which induce a slight excitation in the protons magnetic moment, or spin, as energy is absorbed. When the excitation signal B_1 is terminated, the excited spins fall down to their equilibrium energy state at a rate characteristic of the specific tissue, emitting very weak nuclear magnetic resonance (NMR) signals. The NMR signals are received by the RF coils, digitized and processed to reconstruct a diagnostic image.

NMR data can be processed in several ways; commonly the image is reconstructed line by line from raw, digitized data. The spin-warp method uses Cartesian sampling of k-space, a spatial coordinate system of phase-encoding lines which holds the digitized MR signals during data acquisition, to transform NMR data into a diagnostic image. Non-Cartesian sampling of k-space is a faster method of processing of NMR data, but is more sensitive to instabilities in the system such as hardware delay and eddy currents.

Another challenge in MRI is imaging a region of interest that is off-axis with respect to the magnetic field such as the heart, knee or shoulder. In Cartesian imaging, shifting the center of the reconstructed image is accomplished easily by introducing a constant frequency shift in the NMR signal. Shifting the data is more difficult for non-Cartesian sampling because the imaging gradient field strength varies with time.

The Invention

UW-Madison researchers have developed an improved method for off-axis MRI system calibration of non-Cartesian k-space data. In this method a pulse sequence is performed to acquire k-space samples from which calibration phase data can be calculated. A subsequent pulse sequence is performed while applying a frequency modulation that shifts the system axis to attain modified k-space samples centered on the region of interest, the heart for example. Then a second calibration phase is calculated from the modified k-space and ideal phase data is calculated from the gradient waveform. The phase error then is calculated from the first and second calibration and ideal phase data. Finally, the timing error of acquired signals is calculated using the phase error and applied to the NMR data to correct image degradation.

This method minimizes artifacts from phase errors introduced by real-time demodulation hardware in the MRI system by measuring the timing delays that cause phase errors. The correction can be made prospectively by offsetting the timing error during data acquisition or

retrospectively by phase correction of the data after acquisition. The improved method allows for more accurate processing of non-Cartesian imaging techniques, making MRI faster and more accurate in medical diagnostic imaging and other applications.

Applications

- Off-axis non-Cartesian MRI for areas such as the heart, knee or shoulder
- MRI to evaluate structural integrity in material science and research

Key Benefits

- Allows real-time processing of off-axis non-Cartesian MR images
- Works in all MR scanners regardless of specific timing variations
- Reduces scan times
- Increases patient throughput
- Improves patient comfort
- Improves image quality by reducing artifacts
- Improves efficiency in structural integrity evaluation

Additional Information

For More Information About the Inventors

- Walter Block

Related Technologies

- UW-Madison researchers have subsequently developed a method for an MRI pre-scan calibration procedure to allow demodulation correction for off-axis imaging using NMR free induction decay (FID) signals (see WARF reference number P06440US).

Related Intellectual Property

- View Continuation-in-Part Patent in PDF format.

Publications

- Jung Y., Jashnani Y., Kijowski R. and Block W. F. 2007. Consistent Non-Cartesian Off-Axis MRI Quality: Calibrating and Removing Multiple Sources of Demodulation Phase Errors. Mag. Res. in Med. 57, 206-212.

Tech Fields

- Medical Imaging : MRI

For current licensing status, please contact Jeanine Burmania at jeanine@warf.org or 608-960-9846