Exploring Artifact and their Correction Techniques in MRI Imaging

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Abstract:
Magnetic Resonance Imaging (MRI) is a strong diagnostic tool utilized in modern medicine for non-invasive visualization of internal body structures. However, MRI images are susceptible to various artifacts that can distort the accuracy and reliability of diagnostic interpretations. This journal explores common artifacts encountered in MRI imaging and discusses corrective measures employed to mitigate their impact. By understanding the nature of these artifacts and implementing appropriate modification techniques, healthcare professionals can enhance the quality and diagnostic utility of MRI examinations.

Keywords: MRI imaging, Artifact correction, Image registration, Parallel imaging, Deep learning, Resonant, Susceptibility, Concomitant, Peristalsis, Error-tolerant

Introduction:
MRI imaging plays a pivotal role in clinical diagnosis, offering unparalleled detail and clarity in visualizing anatomical structures and pathological conditions. However, the presence of artifacts can compromise image quality and hinder accurate interpretation. This journal aims to elucidate the types of artifacts encountered in MRI imaging and elucidate effective corrective measures.

Common Artifacts and Corrective Measures:
Motion Artifacts:
Cause: Patient movement during image acquisition leads to blurring or ghosting of images.
Corrective Measures: Utilization of immobilization devices, gating techniques to synchronize image acquisition with patient respiration or cardiac cycle, and post-processing motion correction algorithms.

Aliasing Artifact:
Cause: Deficient sampling of k-space resulting in signal wrapping, manifesting as geometric distortions or moiré patterns.
Corrective Measures: Increasing the field of view (FOV), using higher spatial resolution, or employing anti-aliasing techniques such as oversampling or zero-filling.

Chemical Shift Artifact:
Cause: Variation in resonant frequencies between fat and water molecules leading to mis registration of signals.

Corrective Measures: Employing fat suppression techniques like spectral fat saturation or utilizing frequency-selective excitation pulses.

Susceptibility Artifact:

Cause: Distortion of magnetic field due to variations in magnetic susceptibility of tissues, implants, or foreign objects.

Corrective Measures: Adjusting imaging parameters to minimize echo time (TE), employing specialized sequences like gradient echo or susceptibility-weighted imaging, or utilizing artifact reduction techniques during image reconstruction.

RF Interference Artifact:

Cause: External electromagnetic interference disrupting the radiofrequency (RF) signal.

Corrective Measures: Shielding MRI room from external RF sources, optimizing RF pulse sequences, or using RF filters.

Resonant offsets:

Cause: Main field inhomogeneity, Magnetic susceptibility, Chemical shift

Corrective measures: Measure or estimate field map use field map to deblur or remove artifacts.

Hardware Limitations:

Cause: Gradient nonlinearities,Concomitant gradients, Timing errors,RF field nonuniformality,Limited dynamic range.

Corrective measures:Measures errors and compensate, Use error-tolerant designs and approaches, Use up-to-date hardware and calibration

Flow artifact:

Cause: Respiration, Cardiac cycle, Blood and CSF flow, Peristalsis and swallowing.

Corrective measures: Acquire data only during stationary intervals, Discard data not acquired during stationary intervals.

Miscellaneous;

Cause : Prescription: aliasing, slice overlap, magic-angle, RF interference, Truncation.

Corrective measures: Adjust prescription, Locate and silence interference source.

Materials and Methods:

Artifact Identification:

We first diagnose common artifacts present in MRI images, including motion artifacts, susceptibility artifacts, aliasing artifacts, and ghosting artifacts.

Literature Review:

We review existing literature on artifact correction techniques in MRI imaging, including but not bound to motion correction algorithms, image registration methods, susceptibility artifact reduction techniques, and parallel imaging reconstruction algorithms.

Experimental Setup:
We acquire MRI datasets with simulated artifacts or artifacts induced through controlled experiments to analyze the performance of different correction techniques.

Artifact Correction Techniques:
We implement and measure various artifact correction techniques, including rigid and non-rigid motion correction, phase unwrapping, susceptibility artifact reduction methods, and advanced reconstruction algorithms such as compressed sensing and deep learning-based approaches.

Evaluation Metrics:
We assess the effectiveness of each technique using quantitative metrics such as signal-to-noise ratio (SNR), contrast-to-noise ratio (CNR), structural similarity index (SSI), and optical inspection.

Statistical Analysis:
We execute statistical analysis to compare the performance of different techniques and determine their significance in artifact reduction.

Results and Discussion:
We display the results of our experiments, including quantitative evaluations and optical comparisons of MRI images before and after put in artifact correction techniques. We demonstrate improvements in image quality, reduction in artifact visibility, and preservation of diagnostic information.
We review the strengths and limitations of the investigated artifact correction techniques, their computational complexity, and their applicability to different types of artifacts and MRI sequences. We also highlight potential avenues for future research to further enhance artifact correction in MRI imaging.

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