Update on Parallel Imaging & Body MRI

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Highlights

- Parallel imaging uses receiver coil arrays and advanced reconstruction algorithms to either increase the spatial resolution or reduce the scan times
- Parallel imaging algorithms use coil array sensitivity patterns to reconstruct the images without artifacts
- Knowledge of coil array spatial distribution, prescribed field of view, acceleration factors and directions is critical to minimize parallel imaging artifacts

Target Audience: Radiologists, scientists and technologists interested in parallel imaging

Objectives:

- Understand different parallel imaging techniques and their pros and cons
- Identify the key factors to achieve high quality images with parallel imaging
- Recognize the artifacts and the trade-offs involved with the use of parallel imaging in body MRI

A unique challenge in body MRI is to achieve higher spatial resolution in a limited amount of time to minimize artifacts due to cardiac and respiratory motion. In MRI, the spatial information of an image is generally measured using frequency and phase encoding steps with the help of magnetic field gradients. Higher spatial resolution typically requires the use of these encoding gradients for prolonged periods of time extending the total scan times. Additionally, the rate at which these encoding steps can be performed is determined by the physical, electrical and biosafety limits at which the magnetic field gradients can be switched.

Parallel imaging overcomes these limitations with the use of phased array coil sensitivity patterns to replace a fraction of phase encoding steps conventionally performed using gradients (1). In a normal MR image, when some of the conventional phase-encoding steps are skipped, it typically results in an aliased image. Parallel imaging uses the phased array coil sensitivity patterns measured using calibration data and subsequently uses advanced reconstruction algorithms to remove the image artifacts and reconstruction the un-aliased image.

Parallel imaging techniques are broadly divided into two categories: k-space based techniques (e.g. SMASH, GRAPPA, ARC etc.) and image based techniques (e.g. SENSE, ASSET etc.). k-space based parallel imaging techniques typically generate the phased array coil sensitivity patterns using self-calibration data. These sensitivity patterns are subsequently used to fill-in the missing k-space lines followed by the standard Fourier transformation to generate the final un-aliased image. On the other hand, image based parallel imaging techniques use a separate external calibration data to generate the phased array coil sensitivity patterns, which are used to reconstruct the final un-aliased image in the image space.

The use of parallel imaging has increased the acquisition speeds and a routine acceleration factor of two to three is common in current clinical practice. Additionally, with the use of increased number of phased array coils (e.g. 32 and 128 coils), acceleration factors of 10 and above can also be easily achieved in various research settings (2). However, parallel imaging introduces various challenges that need to be appropriately considered to generate high quality images (3). A few such examples include spatial distribution of the phased array coil, prescribed field of view, consideration of frequency and phase encoding directions and acceleration factors along each phase encoding direction. In addition, parallel imaging results in the loss of signal to noise ratio (SNR) throughout the image, which is also spatially varying (4).

The development of parallel imaging in the past fifteen years had a significant impact on the acquisition speeds of MR imaging. Particularly, in body MRI, this increase in the acquisition speed has led to high quality images with minimal cardiac and respiratory motion artifacts. Currently, different types of parallel imaging techniques are available on all major vendor MR scanners.

This talk will provide the basics and an update on parallel imaging with particular emphasis on various challenges that need to be considered to generate high quality images in body MRI protocols.

References:

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