New Parallel Imaging Method Enhances Imaging Speed and Accuracy

Enables Fast, Robust Scanning Even with Motion or Tight FOV Prescription

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Over the last decade, parallel imaging technology in MRI has progressed from early research prototype to established clinical tool. By exploiting the spatial arrangement of phased-array receiver coils, parallel imaging can accelerate MR data acquisition, which in turn can reduce scan time and improve diagnostic utility.

There are two basic classes of parallel imaging methods. "Physically-based" methods, such as SENSE,[1] require an explicit coil sensitivity map to model the underlying physical process that occurs during image acquisition. The success of physically-based methods relies on calculating accurate coil sensitivity maps, which can be difficult to achieve in practice.

Coil sensitivity calibration can be performed in one of two ways:

External calibration requires a separate calibration scan (Figure 1). However, a primary source of error in this case is motion that can occur between the calibration scan and the accelerated scan – for example, due to different breath-hold positions – causing residual aliasing artifacts in the final image due to a mismapping of coil sensitivities.

Internal calibration embeds a small amount of calibration data within the accelerated scan itself (Figure 2). While this approach is more robust to motion, a primary source of error is insufficient resolution, especially when a tight field of view (FOV) is prescribed.

Figure 1
External calibration.

Figure 2
Internal calibration.

What makes ARC unique?

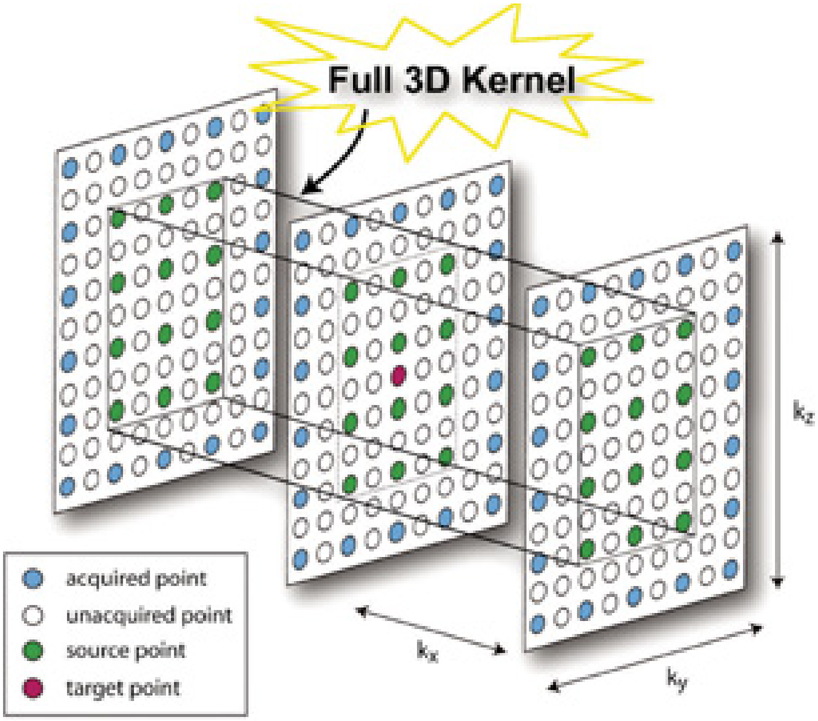

Figure 3

ARC's unique 3D kernel fully utilizes available data along ALL three directions, unlike other methods that only use 1D kernels. A 3D kernel means more accurate reconstructions and improved image quality. Only GE's efficient, streamlined ARC reconstruction can leverage the power of a 3D kernel.

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"Data-driven" methods, such as GRAPPA2, comprise the second class of parallel imaging techniques. These methods do not require an explicit coil sensitivity map but rather rely on "training" data to calibrate the reconstruction directly, thus avoiding errors from coil sensitivity mismapping. Furthermore, the training data is typically embedded in the acquisition in an autocalibrated manner, minimizing the susceptibility to motion errors.

ARC: A Step Forward for Parallel Imaging

GE has developed a new data-driven parallel imaging reconstruction known as ARC, or Autocalibrating Reconstruction for Cartesian imaging, that represents a major step forward in the speed and accuracy of highly accelerated parallel imaging. Unlike other methods,[2,3] ARC uses a full 3D kernel to synthesize missing target data (Figure 3, shown in pink) from neighboring source data (Figure 3, shown in green) from all three imaging directions. In this way, ARC's 3D kernel takes full advantage of available information along all three dimensions for improved reconstruction accuracy with fewer required calibration lines. The end result is highly accelerated MR data acquisition with improved image quality and fewer artifacts.

The calculation of a full 3D kernel reconstruction, previously considered a computationally prohibitive task, is now feasible with ARC's streamlined reconstruction. Several innovations in the calculation of the training and synthesis phases allow ARC to reduce computation time.[4,5] For example, while ARC's training phase is performed in k-space (kx, ky, kz), the synthesis phase is performed in hybrid (x, ky, kz) space (Figure 4) following 1D Fourier Transformation along kx, reducing the 3D kernel neighborhood to a smaller, more manageable 2D kernel neighborhood. These strategies drive the computational efficiencies that streamline ARC reconstruction, creating new possibilities such as the ability to compute a 3D kernel in clinically practical reconstruction times.

ARC enables highly accelerated parallel imaging with an accurate, streamlined reconstruction. Because it is autocalibrating and requires no coil sensitivity map, ARC enables smaller FOV prescriptions and is less sensitive to motion artifacts compared to conventional parallel imaging techniques. ARC can potentially replace physically based methods that can suffer from image artifacts caused by inaccuracies in coil sensitivity calibration. In clinical testing, the technique used by ARC has been shown to achieve high quality reconstructions even in challenging imaging applications, such as tight FOV prescription.

ARC reconstruction phases

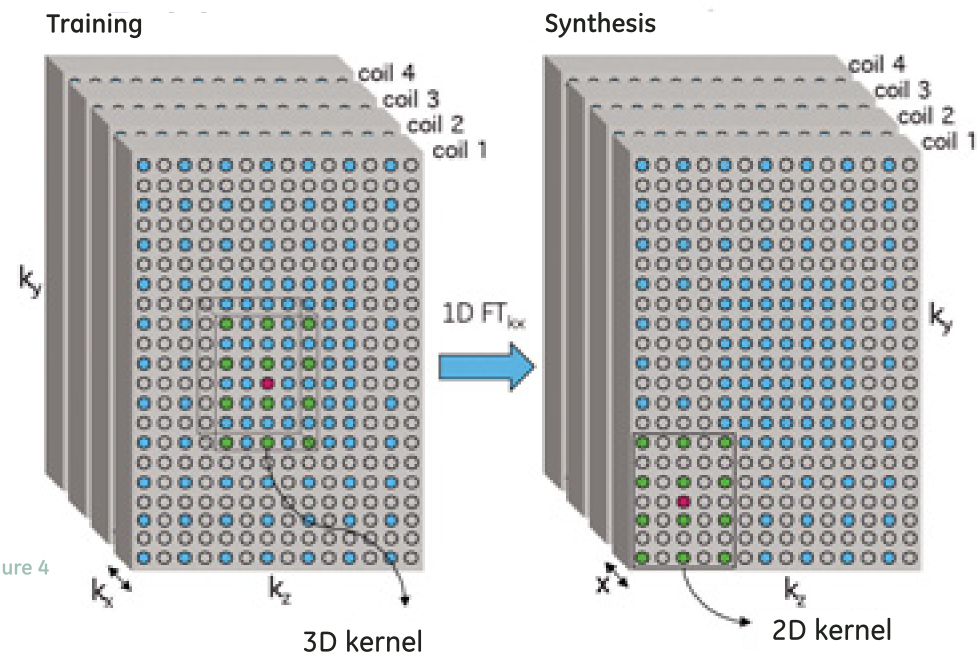


Figure 4

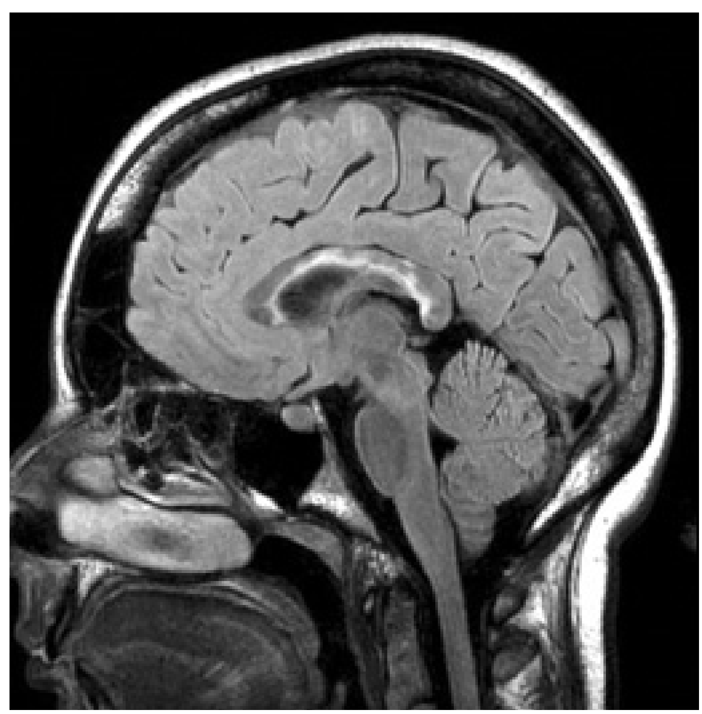
ARC training phase is performed as a 3D kernel in k-space, whereas the synthesis phase is performed as a 2D kernel is hybrid (x, ky, kz) space, reducing computation time.

Benefits

With ARC, clinicians can expect improved image quality and patient throughput, increased spatial resolution or volumetric coverage, depending on the application. Imaging FOV can be prescribed close to or even smaller than the anatomy of interest, enabling higher spatial resolution and diagnostic confidence. ARC's reliability for tight FOV prescription allows the technologist greater tolerances for FOV placement which can reduce the opportunity for error. Autocalibration improves workflow and further reduces the opportunity for error, making the scanning process easier for the operator. ARC is robust against motion, reducing residual aliasing artifacts that would otherwise result from a mismatch between the calibration and accelerated scan.

Patients may experience shorter exam times and a lower likelihood for repeat scans due to error or poor image quality. Ease of use and less opportunity for error typically enables the technologist to produce more consistent scans that are less sensitive to prescription errors. Referring physicians are likely to receive more definitive reports with better image quality.

ARC is available on the Signa® HDxt platform for use in conjunction with GE's signature volumetric imaging application Cube.™ ■



Courtesy of Lawrence N. Tanenbaum, MD, Edison Imaging.

1mm lesions with Cube on Signa 3.0T.

References

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