Is HYPR Compatible with a Cartesian Acquisition?

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Introduction: Many applications in MRI involve imaging in situations where changes in most of the image are negligible, such as in contrast-enhanced MRA (CE-MRA). Mistretta et al [1] have recently shown that increased temporal resolution and increased SNR can be achieved from undersampled data while maintaining image quality by constraining an undersampled radial acquisition based on a composite derived from all frames of the data set. In Cartesian imaging, methods such as keyhole acquisitions [2] are used to acquire small portions of k-space, at the expense of image quality. This study seeks to determine if HYPR-equivalent processing can be extended to dynamic Cartesian scanning techniques.

Theory: The Cartesian equivalent of the HYPR technique achieves an increase in image quality by recognizing that the central k-space data in each dynamic frame is high SNR, but with low spatial resolution. However, this is similar to the situation faced in HYPR. Therefore, we used a similar constraining process as proposed in HYPR, as shown in Figure 1. The composite image contains the data from every full frame acquired. A temporal weighting matrix that represents the signal ratios between each dynamic frame and the composite for each frame is formed, and this mask is used to weight the composite image for that particular dynamic frame. In this way, one obtains the image quality primarily from the composite image, while the dynamic information from each frame is accurately reproduced.

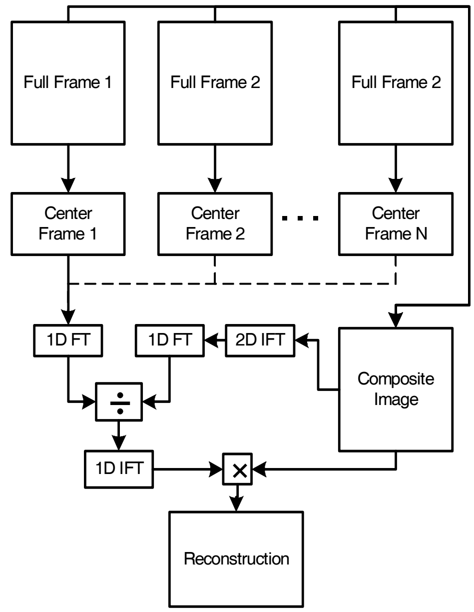

Figure 1: Cartesian HYPR Processing.

Methods: A numerical phantom consisting of several circular areas which varied with a linearly increasing then decreasing signal level was developed to evaluate the performance of this technique. 32 lines were extracted from the center of the k-space of each frame for Cartesian HYPR processing. The composite was formed from all 20 frames of the dynamic series. Subsequently, the Cartesian HYPR processing was applied to real human volunteer data acquired during a CE-MRA examination, acquired with a 3D time-resolved FLASH based MRA sequence. 32 lines were extracted from the center of the k-space of each frame for Cartesian HYPR processing. The composite was formed from 7 frames of the dynamic series.

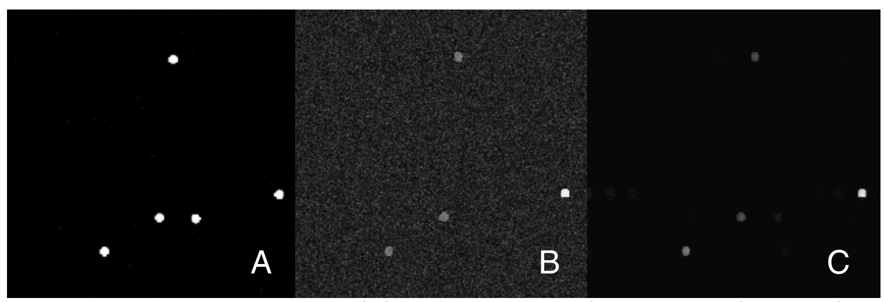

Figure 2: Numerical phantom A) Composite image from all time frames B) single time frame C) Same time frame reconstructed with Cartesian HYPR

Results: The Cartesian HYPR technique provided a large gain in SNR relative to traditional FFT of each frame in simulations of the numerical phantom with added Gaussian noise, The composite image and time frames with conventional and HYPR reconstruction can be seen in Figure 2. It can be clearly seen that the Cartesian HYPR technique (2C) performs better than the standard FFT reconstruction (2B) in the presence of noise. An example from a CE-MRA examination is shown in Figure 3. Compared to the standard FFT image (3A), the Cartesian HYPR image (3B) has better image quality, which is especially apparent in the background regions.

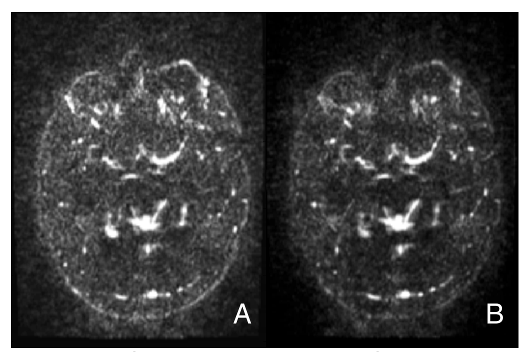

Figure 3: Cartesian HYPR with CE-MRA data. A) Fully sampled image C) Cartesian

Discussion: The feasibility of using HYPR with a dynamic Cartesian trajectory was studied for improving the image SNR in dynamic acquisitions. As in HYPR, the image quality appears to be that of an entire time series of acquisitions with the temporal resolution of a single acquisition without the use of parallel imaging, partial Fourier imaging, or other acquisition acceleration techniques. This study shows that HYPR processing should not be limited to radial trajectories, and could potentially be further developed for use in Cartesian acquisitions as well.

References: [1] Mistretta CA et al, MRM 55(1):30-40, 2006. [2] van Vaals JJ et al, JMRI 3(4):671-5, 1993.