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INTRODUCTION Since the development of Generalized Autocalibrating Partially Parallel Acquisition (GRAPPA) [1], several algorithms have been proposed to incorporate it into the dynamic MRI applications. TGRAPPA tries to reduce the ACS acquisition by forming a composite frame via adding several neighbouring time frames, which are sampled in an interleaved pattern [2], and its image reconstruction of each frame is performed in a one-dimensional (1D) fashion by interpolating the linear correlation of the acquired data along phase encoding direction. Using the same composition and sampling scheme, *k-t* GRAPPA introduces a 2D reconstruction format, which interpolates the linear correlation of the acquired data in both phase-encoding and temporal directions [3]. The same as original GRAPPA [1], both these methods use moving average kernels with finite impulse response (FIR) for interpolation. We propose a novel 3D Infinite Impulse Response (IIR) temporal GRAPPA method. Different from [1]-[3], this method reconstructs the unacquired data points by interpolation along phase encoding, frequency encoding and temporal three directions, and uses autoregression (AR) moving average kernels with infinite impulse response in the interpolation. The AR part of the IIR kernel uses the previously reconstructed data points for further reconstructions, which captures more precisely the data acceleration along three directions and renders further reduction of required ACS lines and significant improvement of reconstructed images.

METHOD A breath-hold cine acquisitions with 35 cardiac phases was acquired on a healthy male volunteer using a Siemens 1.5T Avanto scanner with eight-element surface array (Nova Medical, Wilmington, MA). This array had four anterior coils plus four posterior coils. The acquisition used a segmented prospective ECG triggered true-FISP sequence with following sequence parameters: readout flip angle = 50^o, FOV = 380mm x 285mm, slice thickness = 6mm, image matrix size = 384 x 108 (readout x phase-encodings), spatial resolution = 2mm x 2.6mm, echo time (TE) = 1.34 ms, repetition time (TR) = 2.69ms. The acquired cardiac dataset was fully sampled. Certain phase-encoding lines were deliberately removed to simulate the accelerated imaging procedure and desired undersampling patterns.

The 3D IIR-GRAPPA method can be conducted in a two stage reconstruction procedure. In stage I, a noncausal FIR interpolating kernel is obtained by fitting a group of selected data points to an ACS data point (Fig. 1A). Multiple FIR interpolating kernels are obtained by fitting all ACS data points and a coefficient vector is calculated in a least-square estimation based on all FIR interpolating kernel coefficients. In stage II, a causal IIR interpolating kernel is fitted, which enables the algorithm to utilize previously reconstructed data points. Due to the nature of the reconstruction process, only reconstructed data can be reused in the subsequent reconstructions, a causal cubical selection of data points are chosen to fit into an ACS data point (Fig. 1B). In order to avoid the transient response in the temporal direction, a few time frames are fully sampled at the beginning and the end of each examination. The number of fully sampled frames required depends on the number of frames involved in each reconstruction. Given both the FIR and IIR kernel coefficients, the unacquired data points are reconstructed by interpolating the acquired data points in their neighbourhood using the kernel models.

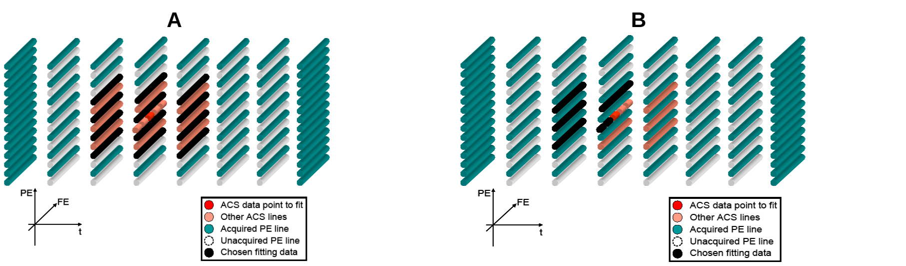

Figure 1. 3D IIR-GRAPPA kernel model fitting. **A**: an illustration of the data fitting pattern for the noncausal FIR part of the model. **B**: an illustration of the data fitting pattern of the causal IIR part of the model.

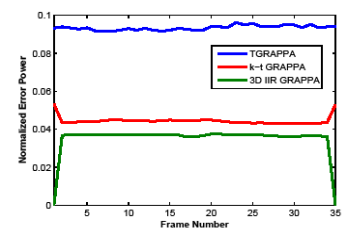

Figure 2. Normalized reconstruction error for all frames**.**

RESULTS Figure 2 and Figure 3 demonstrate the effectiveness of the proposed method by comparing the reconstruction result to its counterparts generated by TGRAPPA and k-t GRAPPA both numerically and visually, respectively. Although TGRAPPA achieves the highest acceleration rate (R = 2), the quality of the reconstructed images is significantly degraded by serious visual artefacts, as shown in Fig. 3A. For k-t GRAPPA and 3D IIR GRAPPA, they produce better reconstructions than that of TGRAPPA. However, to achieve images with such quality, 16 ACS lines were acquired for each frame (totally 560 ACS lines) in k-t GRAPPA, which significantly reduces the effective acceleration factor to 1.5. Whereas, for 3D IIR-GRAPPA method, it generates better images than those of k-t GRAPPA, and requires much fewer ACS lines. Only 120 ACS lines are used including the reference frames (Frame 1 and Frame 35) in 3D IIR GRAPPA. The effective reduction factor is about 1.8 for 3D IIR GRAPPA.

CONCLUSION The 3D IIR-GRAPPA offers a novel *k*-space reconstruction method for dynamic-parallel MR Imaging. The method has the following features: The proposed method takes the previous reconstructions into account when new reconstructions are calculated, which maximize the use of the acquired data and fully exploit the correlations information embedded in all spatial and temporal directions. It has been shown in Figures 2 and 3 that this method provides better reconstructed images with less visual artefact and optimal acceleration factor.

References [1]M.A. Griswold et al, Magn. Res. Med. 2002, 47:1202-1210 [2] F.A. Breuer et al, Magn. Res. Med. 2005, 53:981-985 [3] F. Huang et al, Magn. Res. Med. 2005, 54:1172-1184.

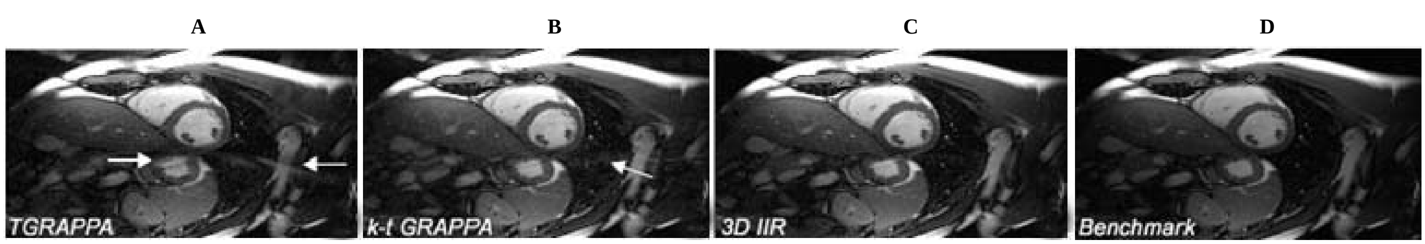

Figure 3. A: TGRAPPA reconstruction with acceleration factor 2 **B:** k-t GRAPPA result with R = 1.5 **C:** 3D IIR-GRAPPA result with R = 1.8, **D:** Benchmark image generated by fully-sampled k-space.