DIRECT VIRTUAL COIL FOR DYNAMIC MR ANGIOGRAPHY AND PERFUSION

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INTRODUCTION: Channel-by-channel (CBC) data-driven parallel imaging (PI) [1,2] has become widely used for dynamic MR applications, such as time-resolved contrast-enhanced MR angiography (MRA) [3], and dynamic contrast-enhanced (DCE) MR perfusion imaging [4]. Compared to model based parallel imaging methods [5], data-driven approaches provide several advantages such as robustness to motion and reduced FOV acquisitions [6]. However, dynamic imaging with high spatial resolution, high parallel imaging factors and high channel count coil arrays remains challenging in clinical settings due to the long reconstruction times that scale with the square of the channel count [2]. Several approaches have been proposed to address this issue, including coil compression [7-11] and Direct Virtual Coil techniques (DVC) [12]. This work demonstrates the feasibility of the DVC technique to address these issues in the setting of 4D dynamic imaging used in multiple clinical applications.

MATERIALS AND METHODS: Figure 1 shows the reconstruction pipeline for the CBC approach vs. the DVC approach. DVC is essentially a method to perform coil combination in *k*-space by generating a set of *k*-space coil combination coefficients, and merging it with the PI unaliasing synthesis kernel. The use of the merged *k*-space kernel can significantly reduce k-space synthesis computation as well as FFTs.

Three clinical applications were chosen to demonstrate the feasibility and performance of DVC for dynamic contrast enhanced MRI/MRA: pulmonary perfusion (18 subjects), liver perfusion (11 subjects) and peripheral runoff MRA (10 subjects). Imaging was conducted on 1.5T (MR450w) and 3T (MR750) clinical MRI scanners (GE Healthcare, Waukesha, WI). For all studies, temporal view-sharing was used to generate raw data for each time frame. The same raw data sets were then reconstructed twice: once using CBC and once using DVC. All reconstructions were performed offline without threading, and external calibration scheme was used to eliminate unnecessary calibration computation. The compute time for PI synthesis, FFT and coil combination were measured for both methods. Time-resolved images reconstructed using CBC and DVC were visually compared and scored by two Board Certified radiologists (Radiologist A specialized in lung and Radiologist B in liver), using a 5-point scale: image 1 much better (clinically significant); image 1 slightly better (not clinically significant); equivalent; image 2 slightly better (not clinically significant); image 2 much better (clinically significant).

RESULTS: Example images and time course comparison are shown in Figure 2 and Figure 3 respectively. Differences in the reconstructed images from the two methods are negligible and in most cases difficult to detect. Time course measurements are in good agreement. Pulmonary perfusion images from all 18 subjects reconstructed by the two methods were scored as equivalent by radiologist A, with the DVC reconstruction time being 6.4× faster in the PI synthesis-FFT-coil combination module. Liver perfusion images from all 11 subjects were scored as equivalent by the radiologist B, with DVC being 12× faster. For all 10 peripheral run-off image sets, DVC images were scored as equivalent by both radiologists, with DVC being 15× faster. Similar performance is expected for implementation with parallel computing.

DISCUSSION AND CONCLUSION: It is feasible to achieve significant reduction in computation time using DVC, without compromise in image quality or time course measurement. With external calibration scheme, the calibration for parallel imaging unalising and DVC does not need to be performed for every phase, providing additional acceleration in compute time.

REFERENCES: [1] Griswold et al. MRM 2002; 47:1202 [2] Brau et al. MRM 2008; 59:382 [3] Zhang et al. JMRI 2007; 25:13 [4] Kanematsu et al. Radiology 2002; 225:407 [5] Pruessmann et al. MRM 1999; 42:952 [6] Griswold et al. MRM 2004; 52:1118 [7] Buehrer et al. MRM 2007; 57:1131 [8] Huang et al. MRM 2012; 67:835 [9] King et al. MRM 2010; 63:1346 [10] Feng et al. MRI 2011; 29:209 [11] Zhang et al. MRM Early View [12] Beatty et al. ISMRM 2008; p8

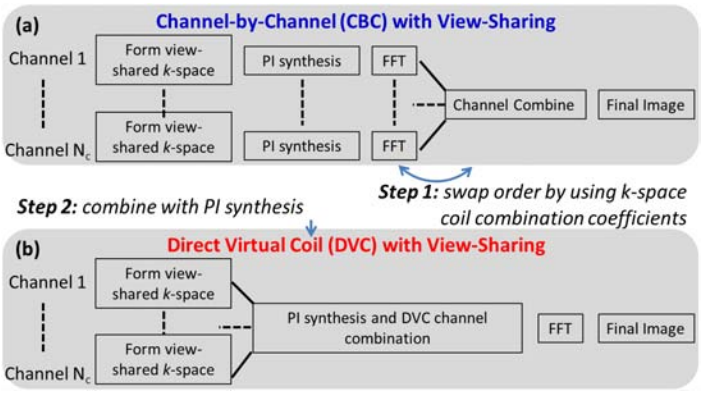

Figure 1. Reconstruction diagram for CBC (a) and DVC (b). Note that the PI synthesis and FFT are only performed once in DVC, as opposed to *Nc* (number of channels) times in CBC.

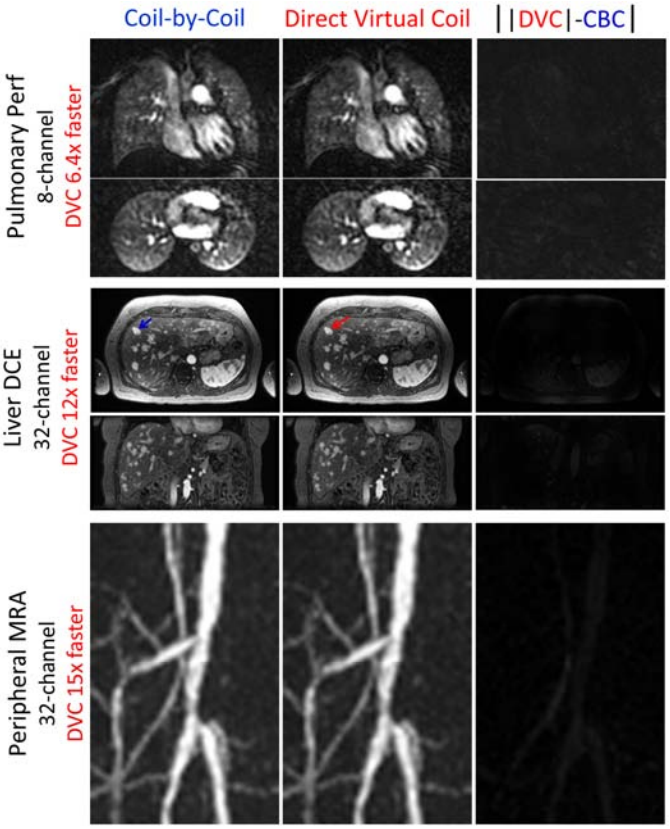

Figure 2. CBC, DVC and the difference images for the three selected applications, with numbers showing the recon time acceleration achieved by DVC in the parallel imaging synthesis and FFT steps.

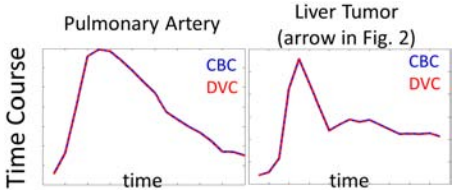

Figure 3. Comparisons of the quantitative time courses for pulmonary artery and a liver HCC tumor show good agreement between the two reconstructions.