COMBINING COIL COMPRESSION AND DIRECT VIRTUAL COIL FOR DYNAMIC MRI USING AUTO-CALIBRATING PARALLEL IMAGING

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INTRODUCTION: Auto-calibrating parallel imaging (acPI) methods [1] have advantages over physically-modeled methods [2] in reduced FOV applications [3] or when it is difficult to accurately measure coil sensitivity maps, such as breath-hold exams. Although more recently proposed computationally efficient channel-by-channel acPI methods have been shown to provide improvements in reconstruction time [4], these methods may still have long reconstruction latency for challenging clinical protocols that use large channel counts, big matrix sizes and high parallel imaging factors. This problem rapidly worsens in dynamic MRI applications where view-sharing is typically used to further accelerate the temporal frame rate. Recently, Coil Compression (CC) [5-9] and Direct Virtual Coil (DVC) [10] techniques have been proposed independently to address this challenge. Here we demonstrate the feasibility of combining CC and DVC into a single reconstruction to achieve even higher reduction in computation time with no compromise in image quality.

THEORY: Using the concept in Ref. [6], CC and DVC are complementary in that, CC can be used to reduce the number of source channels from Nc (number of physical channels) to ccNc (number of virtual channels after CC), and DVC is used to reduce the number of target channel to 1. Fig. 1 shows the combined reconstruction, in which the acquired multi-channel data is first compressed to ccNc virtual channels and then reconstructed using a *k*-space kernel generated by merging acPI and *k*-space coil combination coefficients. In this work, the CC algorithm described in Ref. [9] was used because it computes spatially varying coil compression matrix (ccMatrix) with phase alignment for the acPI. Because the CC technique provides aligned phases, it is expected to be well matched to the DVC method that includes a phase determination step [11]. ARC (GE Healthcare) was used as the acPI implementation [4].

MATERIALS AND METHODS: Dynamic imaging datasets in two different applications were acquired on a 3T scanner (Discovery MR750, GE Healthcare, Waukesha, WI, USA) with 32-physical-channel, and were compressed to 8 virtual channels by CC. An acquisition matrix size of 400 × 300 × 140, 1.0 mm isotropic spatial resolution, R = 3(phase) × 2(slice) was used for peripheral MRA, and an acquisition matrix of 200 × 160 × 100, 2.0 mm isotropic, R = 2(phase) × 2(slice) for liver perfusion. Four reconstructions were performed for each dataset, channel-by-channel acPI (referred to as "none" hereafter), CC, DVC and CCDVC. Reconstruction time during each major step was measured. All reconstructions were performed offline on a Linux machine without multi-threading.

RESULTS AND DISCUSSION: Fig. 2 shows the four different reconstructions for the peripheral MRA case. The image quality is very similar for all reconstructions, as demonstrated by the difference image. Table 1 shows a considerable advantage in reconstruction time when combining CC and DVC. Generally speaking, CC can significantly reduce the calibration time (both acPI and DVC), as shown in Table 1. When using external calibration scheme for dynamic imaging where the calibration of CC, acPI and DVC can be performed only once and repeatedly used afterwards, the majority of the compute time will be on data synthesis, FFT and coil combination, and CCDVC is about ×18 faster than "none", as highlighted in Table 1. Fig. 3 shows the four reconstructions for the liver perfusion case, as well as the difference image.

CONCLUSION: We demonstrated the potential to combine coil compression and direct virtual coil techniques to reduce reconstruction time for dynamic imaging when using auto-calibrating parallel imaging. An even greater acceleration is reconstruction time can be achieved when combining CCDVC with external calibration.

REFERENCES: [1] Griswold et al. MRM 2002; 47:1202 [2] Pruessmann et al. MRM 1999; 42:952 [3] Griswold et al. MRM 2004; 52:1118 [4] Brau et al. MRM 2008: 59: 382 [5] Buehrer et al. MRM 2007; 57: 1131 [6] Huang et al. MRM 2012; 67: 835 [7] King et al. MRM 2010; 63: 1346 [8] Feng et al. MRI 2011; 29: 209 [9] Zhang et al. MRM Early View [10] Beatty et al. ISMRM 2008; p8 [11] Beatty et al. ISMRM; 2010; p2892

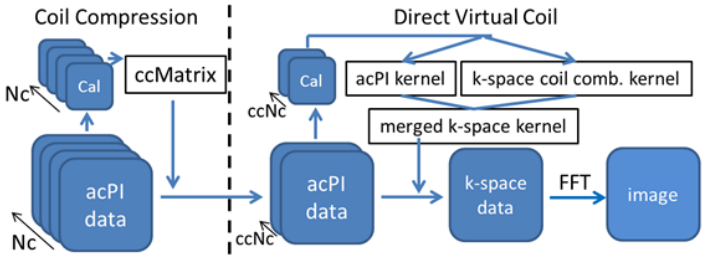

Figure 1. Diagram for combining CC and DVC.

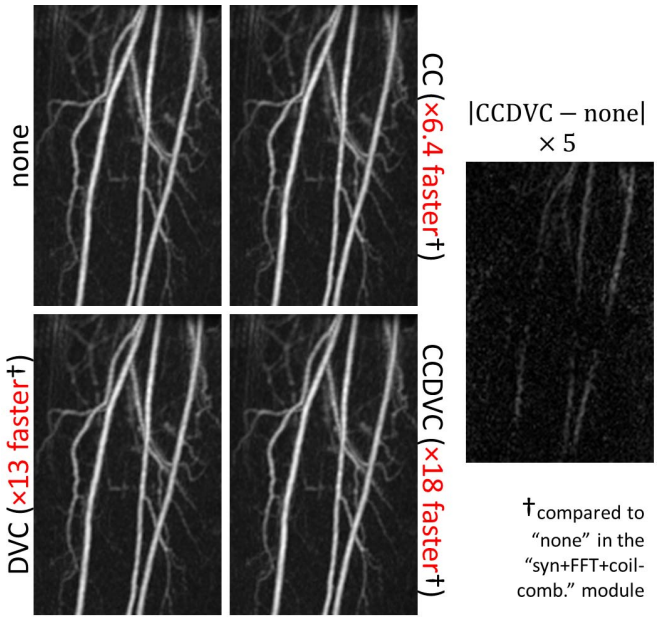

Figure 2. Reconstructions of a peripheral MRA data set.

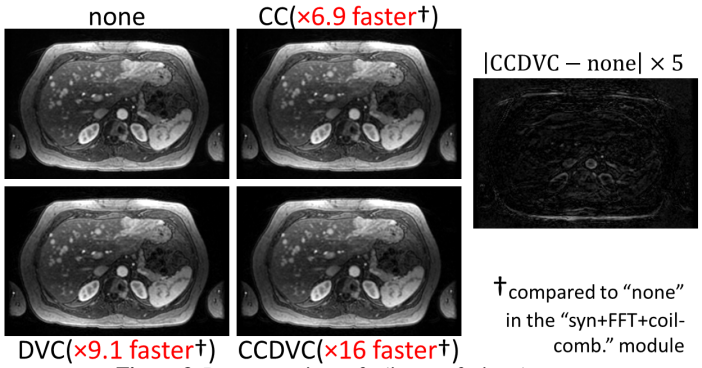

Figure 3. Reconstructions of a liver perfusion data set.

Table 1. Time (second) spent in each step of the reconstruction for the peripheral MRA data set shown in Fig. 2

	CC Cal	acPI Cal	DVC Cal	CC Syn	acPI (+DVC) Syn + FFT + coil comb.	Total Cal	Total Syn + FFT + coil comb.	Total
None	0	20.9	0	0	311.2	20.9	311.2	332.1
CC	6.027	1.776	0	6.654	42.31	7.803	48.964	56.767
DVC	0	20.8	18.85	0	23.72	39.65	23.72	63.37
CCDVC	6.128	1.765	10.77	6.599	10.61	18.663	17.209	35.872