Direct Virtual Coil (DVC) Coil Combination for Non-Cartesian 4D Flow Imaging

Kang Wang[1], Ann Shimakawa[2], Kevin M Johnson[3], Philip J Beatty[4], Oliver Wieben[3,5], and James H Holmes[1]
[1]Global Applied Science Laboratory, GE Healthcare, Madison, WI, United States, [2]Global Applied Science Laboratory, GE Healthcare, Menlo Park, CA, United States, [3]Medical Physics, University of Wisconsin-Madison, Madison, WI, United States, [4]Sunnybrook Research Institute, Toronto, ON, Canada, [5]Radiology, University of Wisconsin-Madison, Madison, WI, United States

INTRODUCTION: Non-Cartesian Phase-Contrast VIPR imaging has been demonstrated to provide 4D flow MRI with large volumetric coverage and high spatial resolution [1,2]. However, adoption into clinical practice, maintaining acceptable reconstruction latency may be challenging, particularly when imaging with high channel count coil arrays. In addition, a robust complex coil combination algorithm is typically required for multi-channel phase contrast imaging in order to combine images into a single channel before any phase processing. To address reconstruction time, several techniques such as coil compression [3-7] have been proposed and its feasibility has been demonstrated for conventional Cartesian imaging. However, non-Cartesian coil compression is still challenging. Furthermore, a complex coil combination algorithm is still needed even when coil compression is used. Recently, a *k*-space based coil combination technique called Direct Virtual Coil (DVC) was developed [8] and its utility for non-Cartesian imaging has also been demonstrated [9]. Since DVC is essentially a *k*-space complex coil combination technique, it provides great potential to address both the computation time challenge and the need for a robust complex coil combination algorithm. The purpose of this work is to demonstrate the utility of DVC for non-Cartesian phase-contrast imaging, specifically, PC-VIPR.

MATERIALS AND METHODS: PC-VIPR data sets obtained from three (3) healthy subjects were used to demonstrate the feasibility of the DVC technique for PC-VIPR. Informed consent was obtained prior to all scanning. All scanning were performed on a 3.0T clinical scanner (Discovery MR750, GE Healthcare, Waukesha, WI, U.S.A.), with either an 8-channel head coil, or 32-channel head coil, or 20-channel torso array.

RESULTS: Figure 1(a-c) shows the PC angiographic images from the 8-channel head exam, in coronal, sagittal and axial planes, demonstrating isotropic resolution and good depiction of the vasculature. Figure 1(d) shows the magnitude of the derived coil combination images. Figure 2 shows the PC angiographic images from the 32-channel head exam. Figure 3 shows the average velocity images along X, Y and Z direction from the 20-channel liver exam. Since velocity images are proportional to the phase difference between the flow-encoding images, this demonstrates DVC's capability of performing coil combination with preserved phase.

DISCUSSION AND CONCLUSION: In this work, we demonstrated the feasibility of using DVC coil combination for non-Cartesian phase sensitive applications, specifically PC-VIPR. While there are some disadvantages with the non-Cartesian DVC approach proposed in Ref. [9], such as the increased combined kernel size that lessens computational advantage to combining multi-channel data onto a single grid, the capability of performing coil combination with preserved phase is essential to reduce the channel dimension before any phase processing and speed up the reconstruction.

REFERENCES: [1] Gu et al. AJNR. 2005;26:743 [2] Johnson et al. MRM 2008; 60:1329 [3] Buehrer et al. MRM 2007; 57: 1131–1139 [4] Huang et al. MRM 2012; 67: 835–843 [5] King et al. MRM 2010; 63: 1346–1356 [6] Feng et al. MRI 2011; 29: 209–215 [7] Zhang et al. MRM Early View [8] Beatty et al. ISMRM 2008; p8 [9] Beatty et al. ISMRM 2011; p2858

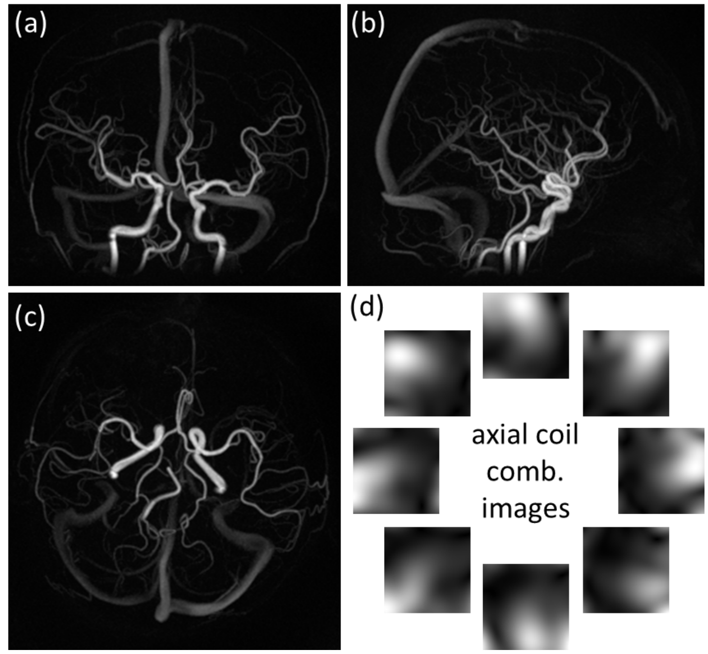

Figure 1. (a-c): Coronal, sagittal and axial angiographic images from a PC-VIPR 8-channel head exam. (d): the coil combination images generated from the DVC calibration. FOV = 22.4 cm, 0.7 mm isotropic spatial resolution, venc = 60 cm/s.

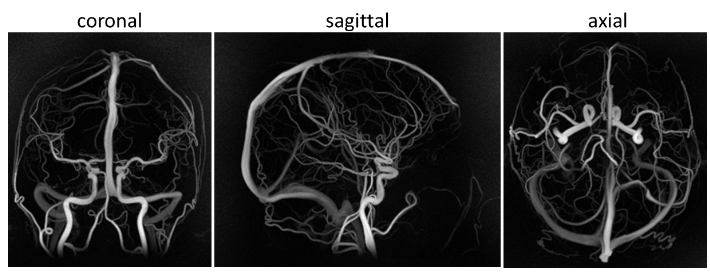

Figure 2. Coronal, sagittal and axial angiographic images from a PC-VIPR 32-channel head exam. FOV = 22.4 cm, 0.7 mm isotropic spatial resolution, venc = 60 cm/s.

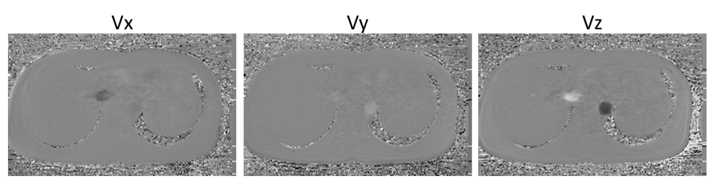

Figure 3. Average velocity images from an abdominal scan. The DVC coil combination is capable of preserving the phase of the coil combined image, and thus compatible with non-Cartesian phase sensitive application. FOV = 33.3 cm, 1.3 mm isotropic spatial resolution, venc = 60 cm/s.