In vivo accelerated, motion-corrected free-breathing 3T intravascular MRI

Shashank Sathyanarayana Hegde[1], Yi Zhang[1,2], and Paul A Bottomley[2,3]
[1]Radiology, Johns Hopkins University, Baltimore, Maryland, United States, [2]Electrical and Computer Engineering, Johns Hopkins University, Baltimore, Maryland, United States, [3]Radiology, Johns Hopkins University, Maryland, United States

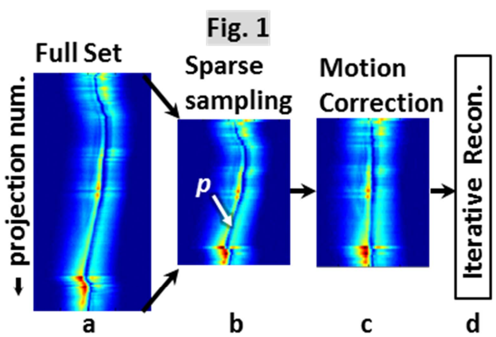
Audience: Interventionalists interested in high-resolution intravascular MRI.

Purpose. High resolution (sub-mm) intravascular MRI (IVMRI) is susceptible to degradation by routine physiological motion, and requires high-frame rates for true endoscopy (1). Conventional cardiac gating techniques reduce motion-sensitivity, but restrict the speed of image acquisition to the subject's heart-rate. Ungated acquisitions could overcome this restriction and allow frame-rate reduction based entirely on signal-to-noise ratio (SNR) considerations, but require additional methods for motion compensation. Here, using ungated radial IVMRI acquisitions in rabbit aorta *in vivo* we: (A) apply compressed sensing techniques to show effective frame-rate acceleration factors of up to four-fold; and (B) reduce sensitivity to motion by applying motion correction techniques at the frame rate of each projection (TR) prior to reconstruction, instead of to the image as a whole, post-reconstruction.

Methods: IVMRI was performed on a Philips 3T scanner in a rabbit aorta *in vivo* using a 1mm diameter 3T loopless antenna receiver, and radial k-space traversal. The projections were under-sampled either uniformly or using variable density schemes. For motion correction, we note that in each projection, there is intense signal surrounding the probe, while the probe itself produces no signal. Further, there is a phase reversal that occurs at the probe. These singularities at the probe's location were detected using a signal derivative algorithm, and used to align all the projections. Projections which are severely affected by motion were discarded or replaced by an average of the preceding and successive projections. Iterative reconstruction (2, 3) was then applied to the reduced projection dataset separately or combined with the motion-corrected scheme to produce an effectively faster motion-corrected image (Fig.1).

Results: Radial compressed sensing produces images showing *in vivo* structures with only 1/4th of the original data (Fig. 2b). Motion correction reduces streaking artefact compared to conventional reconstruction (Fig. 2c vs. 2a). Since the motion correction algorithm acts on each projection, it was also applied to radially under-sampled data sets (not shown). Sparse sampling techniques were applied to *in vivo* Cartesian data to provide three-fold effective speedup in a conventional cardiac-gated setting (4).

Conclusions: 3T IVMRI detectors are ideally suited to compressed sensing and motion correction strategies based on their intrinsically radial and sparsely-localized sensitivity profiles and high SNR. The benefits are faster free-breathing IVMRI with reduced motion sensitivity, while retaining the high-resolution (200μm) image information.



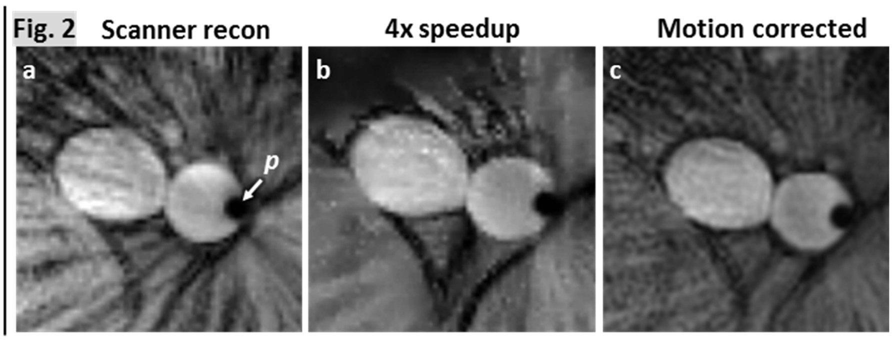


Figure 1: Acceleration and motion correction method showing **(a)** azimuthal projection amplitudes. **(b)** The projections are undersampled to a reduced dataset. **(c)** Motion correction consists of detecting probe *p* in each projection (signal void) and re-aligning every azimuthal projection on *p* and/or eliminating projections with excessive motion. **(d)** Images from the sparsely sampled motion-corrected projections are reconstructed using iterative techniques. **Figure 2: (a)** *In vivo* rabbit aorta acquired with an intravascular probe *p* and without any cardiac gating shows streaking from regular physiological motion. (0.2x0.2x5mm^3 voxel, balanced GRE, FA 90°, TR/TE 700/6ms). **(b)** *In vivo* structures are retained in a 4-fold under-sampled compressed sensing reconstruction, effectively providing a 4-fold speedup. **(c)** Motion-corrected images show reduced streaking everywhere. An *r*-dependent image intensity correction centered on the probe has been applied to all *in vivo* images for visualization (1).

References: **(1)** Sathyanarayana S, et. al., JACC Card Im. 2010; 3:1158-1165. **(2)** Block et. al, Magn Reson Med 2007; 57: 1086-1098. **(3)** Lustig et. al, Magn Reson Med, 2007;58:1182-1195. (4) Hegde S.S., et. al., Proc. ISMRM 2013: p. 473. *Support: NIH R01 EB007829.*