High Resolution Respiratory Self-Gated Golden Angle Cardiac MRI: Comparison of Self-Gating Methods in Combination with k-t SPARSE SENSE

Jan Paul[1], Evica Divkovic[1], Stefan Wundrak[1], Peter Bernhardt[1], Wolfgang Rottbauer[1], Heiko Neumann[2], and Volker Rasche[1]
[1]*Internal Medicine II, University Hospital of Ulm, Ulm, Germany,* [2]*Institute of Neural Information Processing, University of Ulm, Ulm, Germany*

Purpose: Several methods for self-gating (SG) are described in literature. However, to our knowledge, no comprehensive comparison of these variants has been performed yet. We compare different respiratory self-gating methods from radial acquisition by means of increase in image sharpness relative to non-gated reconstructions. In addition, high temporal resolution iterative reconstruction of the gated data is investigated.

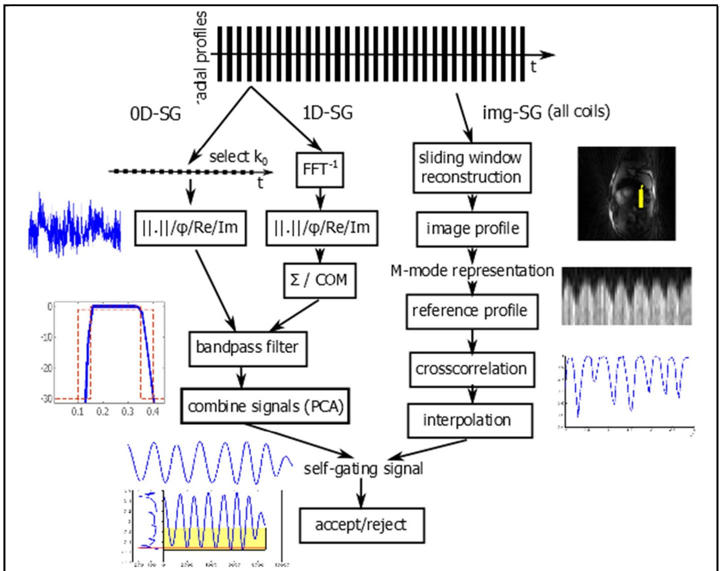

Figure 1: Generation of self-gating signals.

Methods:

Acquisition: In 5 healthy volunteers, short axis slices were acquired at a 3 T scanner using a 32-element cardiac coil. Radial golden angle FLASH acquisition [1] with TE = 1.31 ms, TR = 3.44 ms and a scan duration of 31 seconds yielded 8600 radial profiles. Data was measured with FOV = 340² mm², slice thickness = 8 mm, resolution of 2² mm², flip angle = 15 ° and bandwidth = 862 Hz/pixel. ECG was logged for retrospective cardiac triggering. A three-chamber view (3CH) of 1 additional volunteer was obtained at 1.5 T with a balanced but otherwise similar acquisition.

Self-Gating signals: 11 self-gating variants were compared, which can be categorized into 3 types (see figure 1):

- *Zero-dimensional self-gating (0D-SG)* uses the k-space center (k_0) of each profile. Magnitude $||k_0||$, phase $\varphi(k_0)$, real part $\Re(k_0)$ or imaginary part $\Im(k_0)$ of the k-space data can be selected.
- *One-dimensional methods (1D-SG)* calculate the signal from each radial profile *p* after 1D-IFFT. Sum or the center of mass (COM) is computed thereafter, resulting in $\Sigma||p||$, $\Sigma\varphi(p)$, COM($||p||$), COM($\varphi(p)$), COM($\Re(p)$), and COM($\Im(p)$).
- *Image-based self-gating (img-SG)* can be seen as a respiratory navigator applied retrospectively to a sliding window reconstruction. Crosscorrelation with a reference profile yields the SG signal.

Data selection and reconstruction: 20 % of the data (fixed "navigator efficiency") were accepted around the most occurring position of the self-gating signal. Data were reconstructed iteratively by a radial k-t SPARSE SENSE algorithm with adaptive temporal regularization [2, 3].

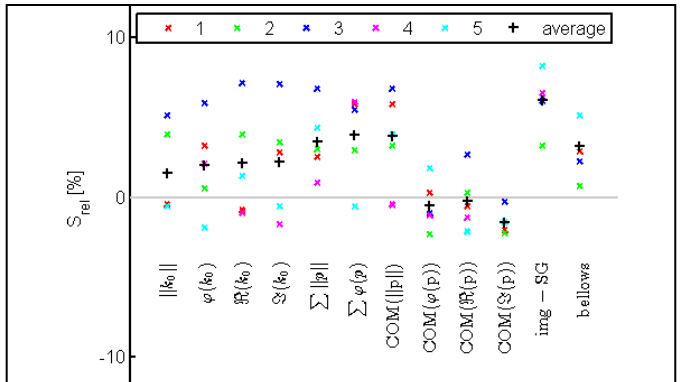

Figure 2: Increase in image sharpness for each method relative to non-gated reconstruction. Individual volunteers (colored x) and average (black +).

Analysis: Image sharpness was measured in a ROI around the heart as average image gradient after removing noise by applying a threshold. Sharpness was compared relative to non-gated reconstructions.

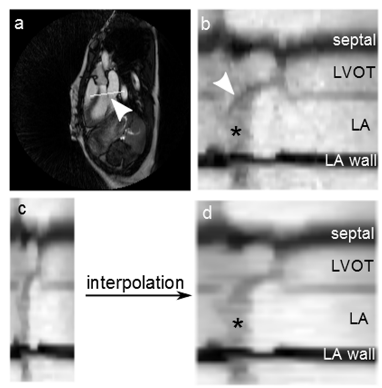

Figure 3: Motion of the mitral valve (arrow) is can be distinguished from blood flow (asterisk) in reconstruction with high temporal resolution (b), but not from low temporal resolution (c/d).

Results: Increase of image sharpness is provided in figure 2. Img-SG and $\Sigma||p||$ were successful in all volunteers. Most COM-based methods are inferior. High temporal resolution iterative reconstruction reveals detailed cardiac motion (see figure 3).

Conclusion: Respiratory self-gating improves image sharpness. Img-SG was the best method on average and superior to gating from respiratory bellows. Iterative self-gated high temporal resolution reconstruction reveals more details of heart motion.

References: **[1]** Winkelmann et al., IEEE TMI, 2007 **[2]** Wundrak et al, ESMRMB 2012, #691 **[3]** Feng et al, ISMRM 2012, #81.