CASI-SENSE: A novel reconstruction strategy for 3D single breath-hold isotropic cine imaging

Nils Nothnagel[1], Rodrigo Fernandez-Jiménez[2], Gonzalo Lopez-Martin[2], Manuel Desco[3], Valentin Fuster[2], Borja Ibañez[2], and Javier Sánchez-González[1]

[1]*Philips Healthcare Spain, Madrid, Spain,* [2]*Atherothrombosis in Experimental Imaging, Centro Nacional de Investigaciones Cardiovasculares (CNIC), Madrid, Spain,* [3]*Departamento de Bioingeniería e Ingeniería Aerospacial, Universidad Carlos III, Madrid, Spain*

Background

There are two limiting factor that reduce the applicability of cardiac magnetic resonance imaging (CMRI). The first one is that CMRI examinations require much scanner time and many survey planning scans until the relevant information is acquired. The second one is the high training degree required from technicians to be able to perform cardiac examinations with the right cardiac orientations, making difficult to spread CMRI in clinical environments. To avoid this limitation, 3D non-angulated isotropic cardiac imaging in a single patient breath-hold will be desirable. This contribution presents a strategy that allows acceleration factor of 15 with almost real-time reconstruction for 3D isotropic cine MRI.

Methods

The principle of the proposed reconstruction technique is shown in **Figure 1**. During acquisition the dynamic region is selected inside the Field-of-View (FOV) as has been previously proposed [1][2]. In the dynamic region, the cardiac motion is confined across different cardiac phases while the static region is assumed the remains stable. Dynamic region is updated for every cardiac phase while static region is just sampled once. For reconstruction purposes, the dynamic region is set to zero in the full sampled static phase and back transformed to k- space. This modified k-space version is subtracted from all cardiac phases removing the contribution from the outer part of the dynamic region in all the coil images. Finally, conventional SENSE reconstruction is applied to the reduced dynamic FOV.

With this strategy the net acceleration factor (*NAF*) for 3D acquisition can be computed as:

$$NAF = \frac{\mathrm{N_{Phases}}}{\frac{1}{\mathrm{SENSE\ Factor}} + \frac{(\mathrm{N_{Phases}} - 1)}{\mathrm{DynamicAF}}},$$

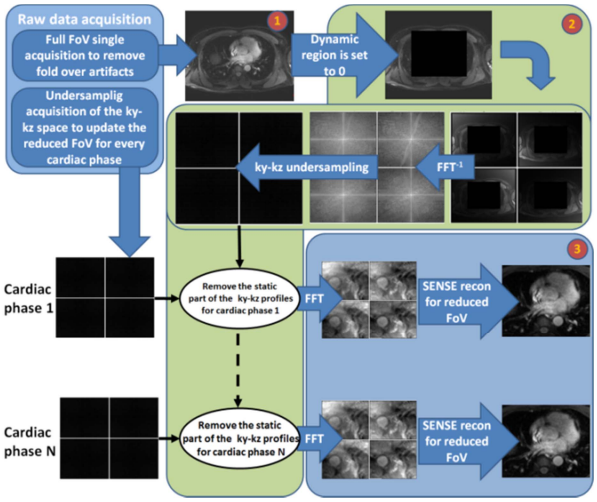

Figure 1 Schematic representation of all the reconstruction steps using the static information and SENSE acquisition at the same time

where N_{Phases} represents the total number of cardiac phases, *SENSE Factor* represents the acceleration factor due to parallel imaging in the static region, and *DynamicAF* represents the acceleration factor for the moving region.

For in-vivo validation, 3D cine data were acquired on a 3T-Philips Achieva system with a 32-channel phased-array cardiac coil (Philips Healthcare, Best, The Netherlands). After gadolinium administration, a free-breathing 3D-TFE balanced sequence was acquired (16 cardiac phases, acquired voxel size 2.0 x 2.0 x 2.0 mm^3 , FOV 340 x340x270 mm^3 , TR = 2.7 ms, TE= 1.36 ms, reconstruction matrix 172 x 170). Total acquisition time of 300s. The same data set was retrospectively subsampled with a SENSE Factor of 4 and DynamicAF of 16 reaching a net acceleration factor of 13.5 (R=13.5 with a final acquisition time of 22.26s).

Results

Figure 2 demonstrates the feasibility of the proposed reconstruction scheme on *in vivo* setting (pig), reaching at good image quality with an acceleration factor R=13.5 in a complete cine 3D data set. Moreover, the reconstruction time for the 3D volumes along 16 the cardiac phases was less than 3 minutes.

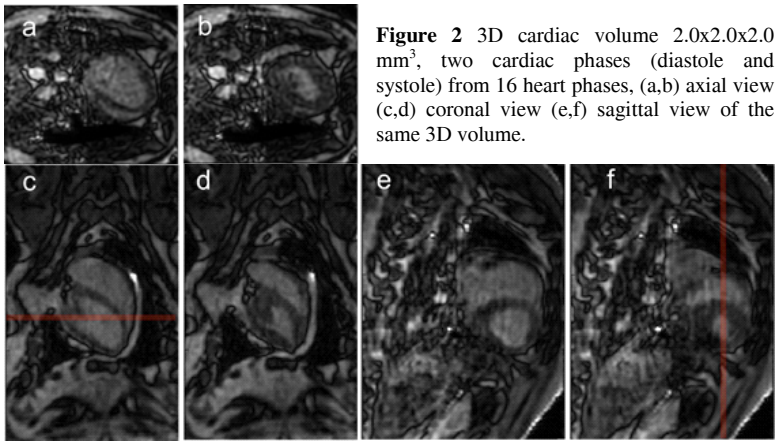

Figure 2 3D cardiac volume 2.0x2.0x2.0 mm^3, two cardiac phases (diastole and systole) from 16 heart phases, (a,b) axial view (c,d) coronal view (e,f) sagittal view of the same 3D volume.

Conclusions

We have shown that the 3D isotropic acquisition in a single breath-hold is feasible using highly undersampled acquired data (R=13.5). Moreover, proposed reconstruction methodology for this acquisition allows image generation of the whole dataset in less than 3 min allowing its inclusion in clinical routine. Further research needs to be done for clinical validation.

Fundings

NN is funded by EU CardioNeT, grant agreement number 289600, FP7-PEOPLE-2011-ITN. This study forms part of a Master Research Agreement (MRA) between CNIC and Philips Healthcare

References

[1] M.E. Brunner et al., MRM 51:331–342 (2004)
[2] L.H. Hamilton et al., MRM 65:1062–1075 (2011