## High Frame Rate Cardio-respiratory Imaging using Model-based Reconstruction

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# INTRODUCTION

Generalized Reconstruction by Inversion of Coupled Systems (GRICS) (1) has been developed from a mixed approach of motion correction (2) and parallel imaging (3) to correct motion artifacts in free-breathing MR acquisitions. Recently, this reconstruction method, constrained by physiological signals, such as respiratory belt amplitude, has been presented for ECG triggered black blood images (1). GRICS can be generalized to correct other types of artefacts (4). But GRICS algorithm also provides a motion model that could be used to produce a dynamic series of images. Other innovative options have been proposed to develop the reconstruction of dynamic series such as modeling the motion (5) or fast acquisition methods using k-t space (6). Functional cardiac assessment plays a major role in cardiac MRI and 2D balanced-SSFP sequences are generally used for this purpose. GRICS algorithm has therefore been extended to 2D SSFP sequences. Using the provided motion model, high frame rate dynamic movies of free breathing heart beating subject have been built.

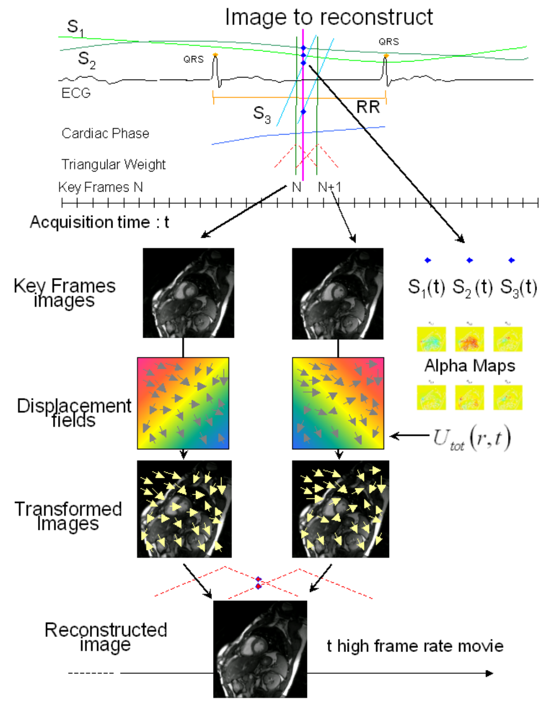


Figure 1: High frame rate movie reconstruction schema

# METHODS

18 slices in main heart orientations were acquired on a 1.5 T Signa HDx MR system (GE Healthcare, Milwaukee, WI). A healthy volunteer underwent 18 multi phase balanced-SSFP acquisitions in free breathing (TR 3.85ms, TE 1.68ms, 40cm FOV, 256x256 matrix, 45° flip angle, 8mm slice thickness, 40 temporal phases for a total of 40s). The sequence was modified with k-space acquisition reordering: this was to enable a wider time distribution. Identical slices were acquired in breath-hold using the conventional 2D balanced-SSFP. Physiological signals were collected using a modified version of the Maglife (Schiller Médical, Wissembourg, France) patient monitoring system and a signal analyzer and event controller (SAEC) (7). For 2D image reconstructions, three input signals were directly used, including two respiratory belts (thorax and abdomen). ECG recording was used to determine the R waves and cardiac phase of each k-space line acquisition. K-space lines were then gathered in 14 sets for independent reconstruction of each key frame of a mean cardiac cycle.

Multi-slices reconstruction using GRICS algorithm was performed for the whole heart acquisition in free breathing. For each slice, the 14 key frames and their corresponding motion models were reconstructed independently. For a key frame a multi resolution GRICS reconstruction (1) was performed using the local linear cardiac phase variation and the respiratory belts as input constraints. Then for each slice the first 16 seconds of physiological recording resampled at 25 Hz were used to build the real-time mode movie. For each frame, the two nearest key frames were deformed by the corresponding motion model and weighted with their relative distances to build the final images (Fig 1).

# RESULTS

The GRICS reconstruction provides as intermediate results 14 key images and their corresponding distortion model parameter maps for each one of the 18 slices. From these results, movies of 400 images representing the first 16 seconds of the corresponding free-breathing acquisition have been generated in DICOM format and visually compared with standard CINE breath-hold acquisition. A manually drawn profile across the left ventricle was generated to be matched with corresponding physiological records (Fig 2). In time-mode profile the variation of LV cavity correlated with breathing can be observed.

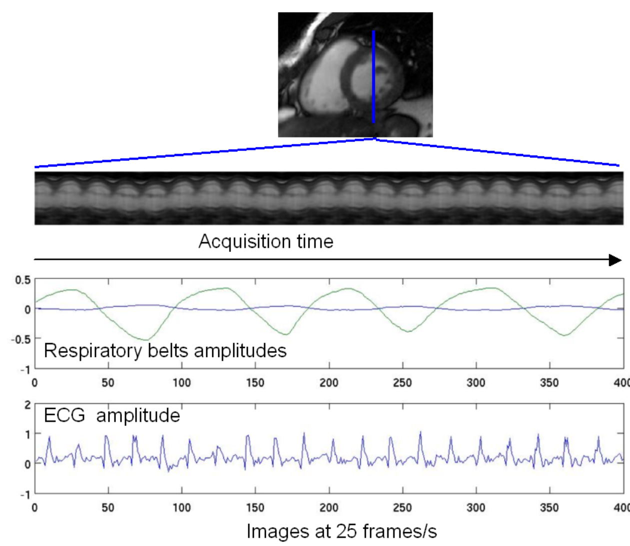


Figure 2: Display of the profile form a short-axis slice during the 16 seconds long high frame rate movie, with corresponding physiological signals (ECG and respiratory belts).

# CONCLUSION

As in (1), GRICS images are sharper than averaged Fourier reconstruction. This result demonstrates the ability to build from physiological recording and MRI acquisitions high frame rate movie in real-time mode and standard clinical resolution using GRICS reconstruction algorithm. The image quality is similar to breath-hold CINE acquisitions, which open new possibility of thoracic biomechanical study.

# REFERENCES

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