Accelerated MR simulations of heart motion model using graphic processing unit technology

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Introduction

Magnetic Resonance Imaging (MRI) physics simulators have been used in the past for educational and research purposes. Current MRI physics simulators make several compromises and only few of them incorporate motion in their simulations due to the added computational power needed. Moreover, study of motion is usually confined to simple translational and/or rotational motion models whereas motion is being activated only during the read-out phase of the pulse sequence.

A MR physics simulator that supports simulations of realistic, motion-related cardiac MR experiments may help in evaluating cardiovascular MRI protocols and pulse sequences.

Methods

In this study, a previously developed MR physics simulation platform [1], by the name MRISIMUL, adapted so as to allow the temporal evolution of a heart motion model in space during the entire course of the MR pulse sequence. MRISIMUL allows its application in large-scale analysis without model simplifications by employing Graphics Processing Unit [GPU] technology.

For the simulation of heart motion, a mathematical model of myocardial deformation was applied on a cylinder based on work of Tecelao et al [2]. 1D myocardial tagging was introduced in a simple segmented CINE pulse sequence of 100 phases and 1 view per segment (total timesteps: 123456) and applied on the heart motion model (total voxels: 123456). The simulation was performed on a computer system with 4 Tesla C2075 GPU cards (448 GPU cores, 6GB global memory) and the kernel execution time was recorded.

[1] Xanthis, et al, IEEE Transactions on Medical Imaging, 2013
[2] Tecelao, et. al, Journal of Magnetic Resonance Imaging, 2006

Results

Myocardial tagging of the heart computer model on different phases of the cardiac cycle is displayed in Figure 1. The kernel execution time was recorded equal to approximately 419 minutes.

Conclusion

MR simulation of realistic heart motion-related experiment on multi-GPU system was presented in this study revealing new future capabilities on investigating motion artifact sources, developing new motion compensation techniques but also for training purposes.

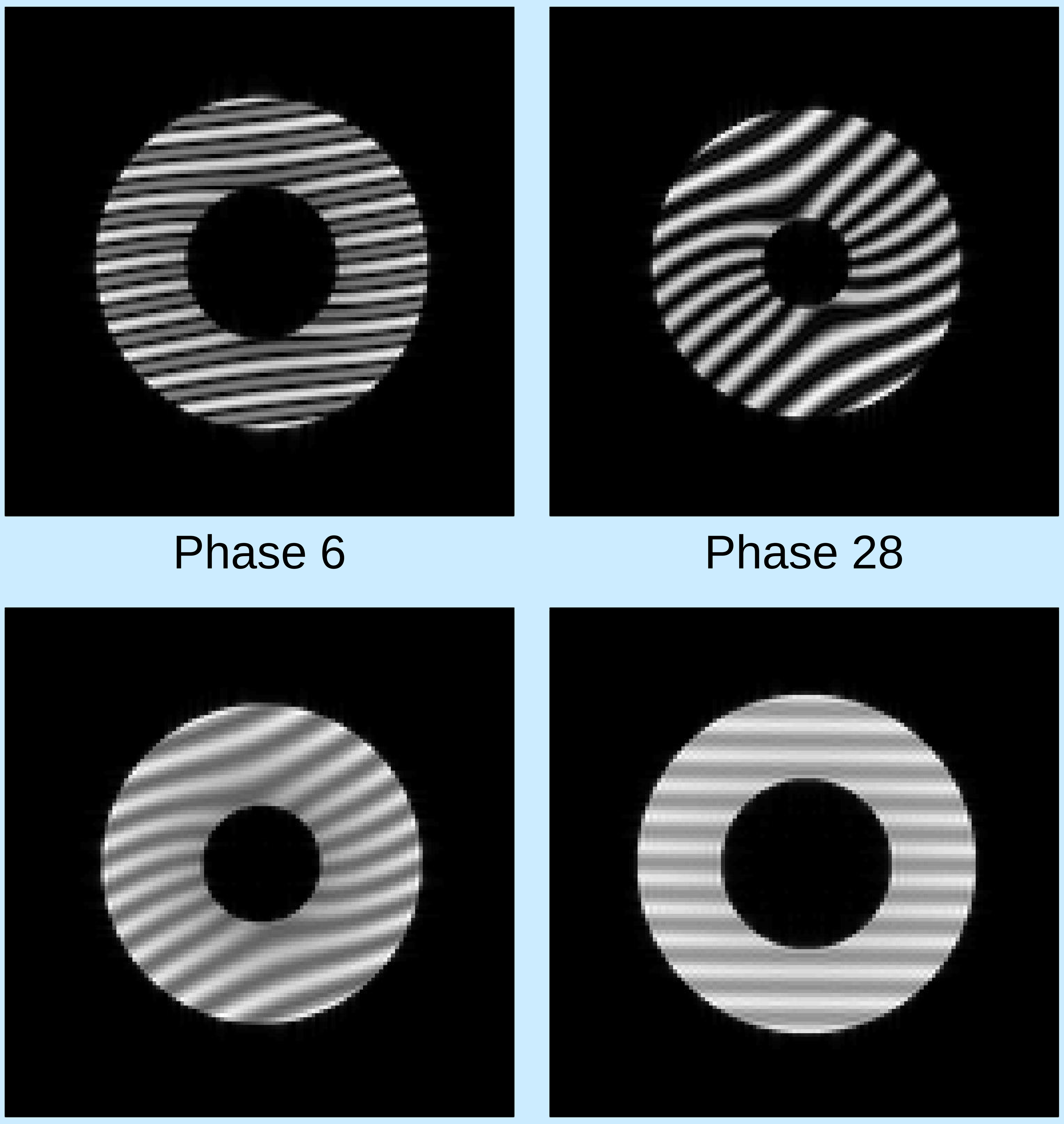

Figure 1. Series of images of the heart motion model throughout the cardiac cycle. SPAMM preparation with 90o RF flip angle has been introduced in a simple segmented CINE pulse sequence of 100 phases and 1 view per segment.