Motion Phantom for real-time MRI

Sebastian Schaetz[1], Markus Untenberger[1], Aaron Niebergall[1], and Jens Frahm[1]
[1]Biomedizinische NMR Forschungs GmbH, Max Planck Institute for Biophysical Chemistry, Göttingen, Lower Saxony, Germany

Target Audience: Researchers working on real-time MRI methods; Researchers looking to acquire motion images

Purpose: Qualitative and quantitative assessment of real-time MRI methods requires the simulation of in-vivo measurements with adjustable, well-defined motion. Phantoms designed for this task usually utilize electric motors[1]. An entirely metal-free motion phantom design based on a simple pneumatic rotary motor is introduced and preliminary results are presented.

Methods: A motion phantom is built from acrylic glass and polyacetal. Two nozzles pipe pressured air (100-300kPa) across a slotted rotor that is mounted to a drive shaft. Four gear wheels transmit the fast rotary motion to a disc holding test tubes filled with 0.2ml water. The test tubes are positioned at different distances from the center of rotation. Rotational speed is set by varying the air-pressure with a fine-adjustment valve. The phantom is monitored with an off-the-shelf webcam. Using the camera's real-time video feed, an image-processing algorithm calculates the rotational speed of the phantom based on the visibility of a red marker placed on the rotating disc.

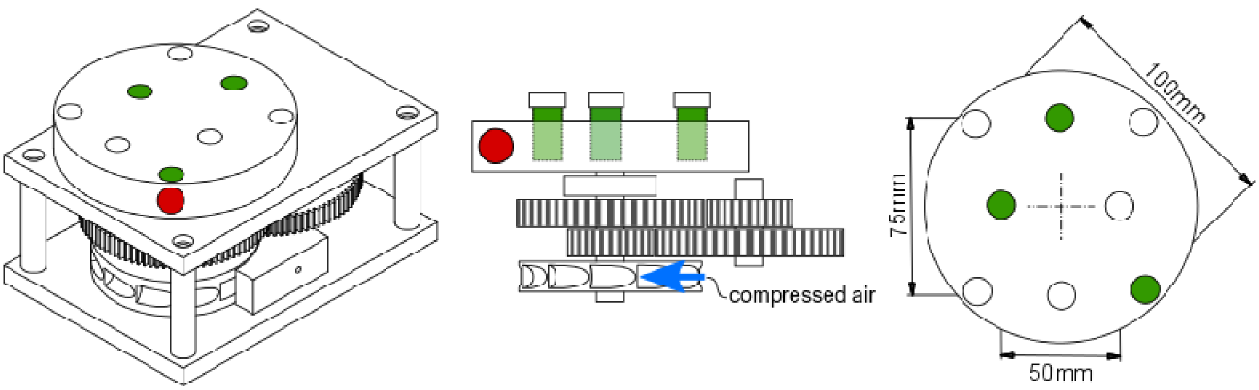

Figure 1: Mechanical drawing of motion phantom showing slotted rotor, gear wheels (ratio 1:9), rotating disc and positions of test-tubes.

In this work the phantom is set to three different rotational frequencies. A Siemens Tim Trio system with a radial FLASH[2] sequence and a 32 channel head coil is used for data acquisition. Imaging parameters are TR/TE/alpha/bandwidth=2.28ms/1.48ms/8°/1950Hz/Px, 2x2x5mm^3 spatial resolution, a FoV of 256x256mm^2 and 9 spokes per frame (temporal resolution 20ms). Images are reconstructed with a non-linear inversion algorithm that jointly estimates coil sensitivities and image content[3] (Newton-steps 6, temporal regularization 0.8).

Results:

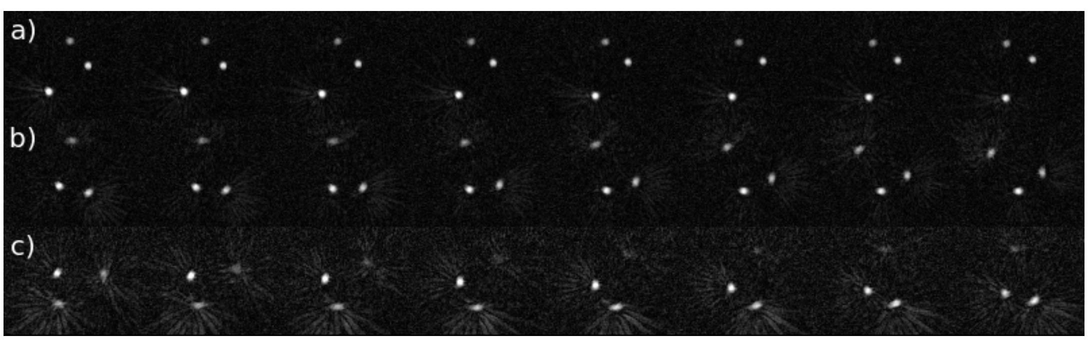

Figure 2: 8 frames taken from 3 time series with the rotational frequency set to a) 0.5Hz, b) 1Hz and c) 1.5Hz. The frames show a time series of 160ms. Streaking artifacts intensify with increasing rotary frequency. Rotation is counter-clockwise, time elapses from left to right and images are windowed accordingly.

Discussion: Our motion phantom is capable of accurately simulating motion at speeds between 0.05 and 0.5m/s. Distances measured in the MR images agree with the rotational frequency measured with the optical recordings. Initial qualitative results show that, as expected, motion blurring and streaking artifacts increase with rotational velocity (compare Figure 2).

Conclusion: The motion phantom presented here is a suitable and easy to use tool for both qualitative and quantitative evaluation of real-time MRI methods. Next steps include further tests with different sequence and reconstruction parameters as well as differently shaped objects. A comprehensive analysis of the large number of resulting time series will require an algorithmic quantification of image quality. This evaluation will help to validate real-time MRI methods and we also hope to transfer novel insights to the more complex in-vivo measurements.

References: **1.** Huber, Michael E., et al. *Journal of Cardiovascular Magnetic Resonance* 2.3 (2000): 181-187. **2.** Zhang, Shuo, et al. *Journal of Magnetic Resonance Imaging* 31.1 (2010): 101-109. **3.** Uecker, Martin, et al. *Magnetic Resonance in Medicine* 60.3 (2008): 674-682.