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A novel method for video-based cardiac gating in 7T MR angiography using a video of the foot

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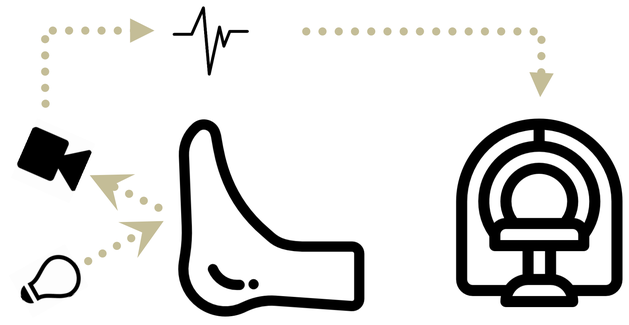
Introduction

- In many ultra-high-field MRI applications, cardiac gating presents a challenge: electrocardiography (ECG) suffers from magnetohydrodynamic artifacts [1] and pulse oximetry (PO) suffers from signal loss due to poor perfusion, especially during long examinations [2].
- In the past, we developed a prototype for video-gated MRI [3]. We used videos from the forehead and demonstrated feasibility of video-gated MRI, but the SNR of the video signal posed a challenge [4].
- Recently, it has been shown that applying force to the skin increases the SNR of the cardiac signal [5]. Hence, we proposed a novel setup for video acquisition from the sole of the foot in contact with a glass plate [6].

Fig. 1) Schema of proposed system



➢ In this work, we combine the open-source software [3] with a new acquisition setup [6] and perform MRA of the lower extremities [7].

Materials and Methods

– *Video acquisition* - A schematic visualization of the setup is depicted in Fig. 2: An off-the-shelf glass plate (A; 30x30x0.5 cm) is fixed on the patient table, and the foot (D) is placed against it. The sole is captured by a MR-compatible camera (C; 12M-i, MRC Systems, Heidelberg, Germany) placed at a distance of 10 cm and illuminated by a LED array (B; L-7113VGC-E, Kingbright, CA, USA; peak wavelength 518nm).

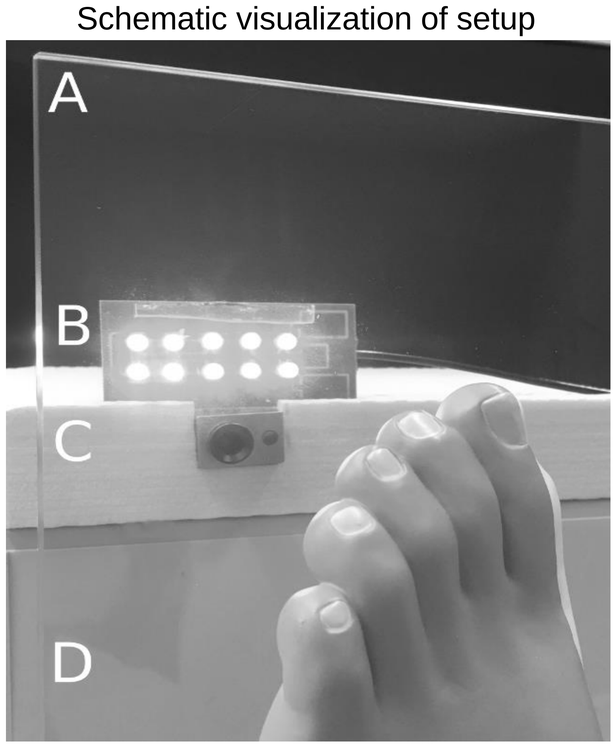
– *Video processing* - We used our open-source system for video processing and cardiac gating [3]; it processes the camera signal with approximately 25 FPS. A cardiac time signal was acquired by computing the average of all pixel values for each frame. The algorithm [4] automatically finds the largest peak in the signal's power spectrum within a range of 30-180 beats-per-minute and sends a trigger according to the peak's phase.

– *MRA acquisition* - Experiments were conducted on an ultra-high-field scanner (Magnetom 7T, Siemens Healthineers, Erlangen, Germany) with the MRA setup proposed by Fischer et al. [6]. The volunteer was positioned feet first on a sliding table. We acquired MRA images at three consecutive table positions, each covering 10cm with an overlap of approximately 2cm. The coil covered the thigh, kneecap, and shank so that different anatomical structures were acquired. For each table position, we first performed image acquisition with PO gating followed by video gating. The vendor-provided PO sensor (50Hz sampling rate) was applied on the index finger of the right hand.

– *Image processing* – Maximum intensity projection (MIP) images in coronal orientation were computed and exported to DICOM format using the MR vendor-provided software. MATLAB 2017 (MathWorks, MA, USA) was used to determine the overlap resulting from different table positions by visual inspection. Subsequently, individual MIP images were blended.

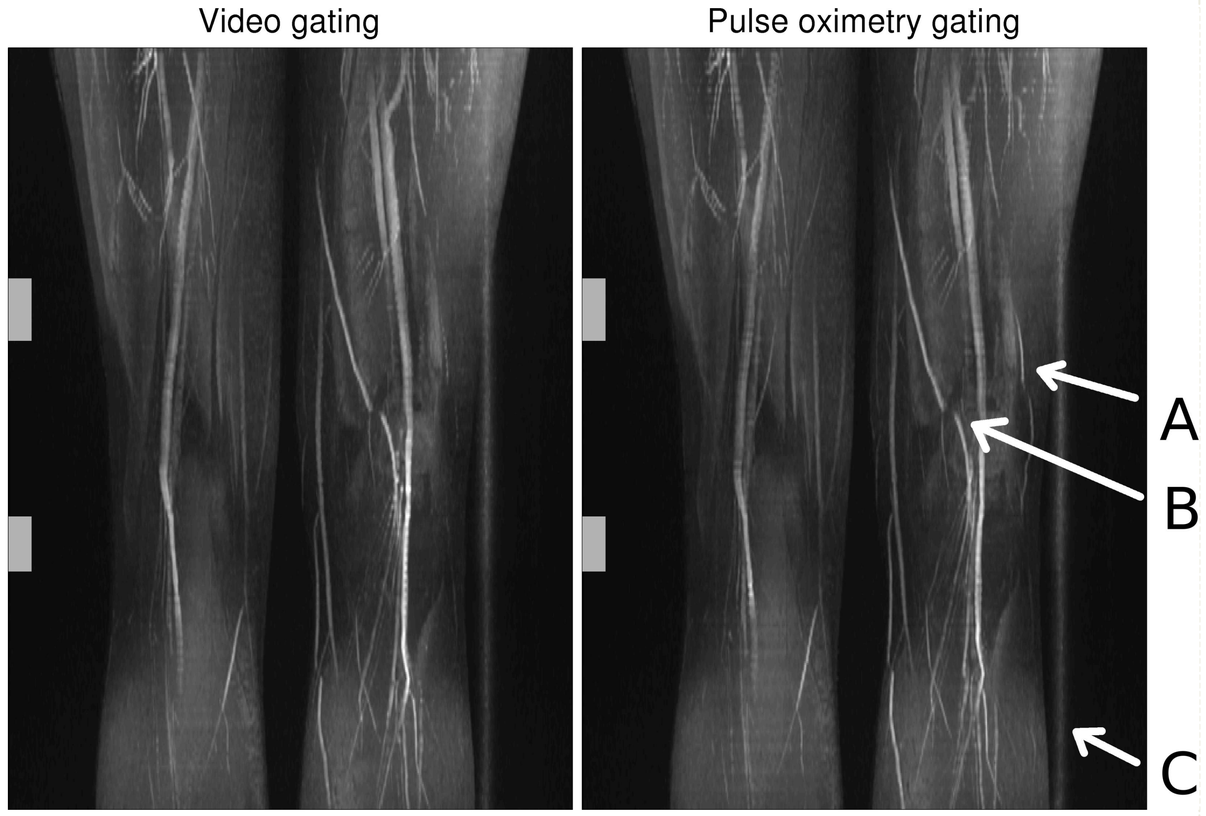
Fig. 2) Application to MRI

Schematic visualization of setup



Frame acquired with camera

Fig. 3) Results of MRA



Results

- Blended MIP images are depicted in Fig. 3: Images from both gating modalities show a uniform and intense delineation of the arteries as well as similar contrast.
- The thigh and kneecap regions acquired via video gating are very homogeneous, whereas in the PO-gated MIP there are more artifacts in the form of short signal declines as a result of inaccurate gating [3].
- There is a small vessel that is less clearly visible in the video-gated MIP (A), and there are identical artifacts in both images that are unrelated to gating (B, C).

Discussion and conclusion

- Conventional gating methods in ultra-high-field MRI are prone to either magnetohydrodynamic artifacts (ECG) or signal loss during long examinations (PO).
- Video-gated MRI could possibly overcome these limitations, and in previous work technically feasibility has been demonstrated [4,8].

➢ In this work we investigated the **practical feasibility of using a video of the foot for cardiac gating during 7T MRA.** Results with one volunteer show that **image quality is comparable to PO-gating**. In future work we aim to evaluate this novel method in a larger cohort.

References

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