# Eulerian Video Magnification for Heart Pulse Measurements in MRI Scanners

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**Target audience:**

Clinicians and scientists interested in alternative pulse triggering or monitoring methods.

**Purpose:**

The goal is to offer an alternative to the conventional contact-based hardware for peripheral pulse triggering or monitoring (e.g. pulse oximetry) in MR scanners by using contactless video analysis. This approach offers several advantages: pulse oximetry is limited to certain application areas (usually the fingertip) and bears the risk of the probe failing due to movement of the patient or low perfusion of the hands during long-time recordings. These limitations can be overcome by the analysis of video signals, which do not depend on contact-based measurement hardware and can be applied to well-circulated body areas (e.g. the head). The setup incorporates the "*Eulerian Video Magnification*" approach published by MIT CSAIL[1] that can be used for motion and color amplification of video data.

**Method:**

The "*Eulerian Video Magnification*" algorithm consists of two sequential filtering steps: spatial filtering is applied to the individual frames of the video to suppress unwanted high-frequency components (e.g. camera noise); subsequently, the development of each pixel is analyzed over time and movements/color variations of interest can be amplified via different filtering techniques.

The algorithm was implemented in C++ using the OpenCV library, and two different test scenarios were used: one inside a 7T MR scanner room (Magnetom 7T, Siemens, Erlangen, Germany) using an off-the-shelf digital camera (RGB, 640x480, 30 FPS, see Fig. 1a) and the vendor-provided pulse oximeter (sampling rate 50 Hz) for pulse data logging; the other inside a 3T MR scanner bore (TIM TRIO, Siemens, Erlangen, Germany) during a routine brain measurement of a female volunteer using a MR-compatible camera system (MRC Systems 12M, Heidelberg, Germany; B/W, 720x576, 50 FPS half frame rate, see Fig. 1b) to acquire the video signal and the vendor-provided pulse oximeter for simultaneous pulse data logging.

**Results:**

The results of the C++ video algorithm were visually closely correlated with the pulse curve measured by the scanner. The pulse range [70, 100] bpm and [40, 70] bpm were amplified by appropriate filtering for the first and second test scenarios, respectively. An exact synchronization between the commencement of video recording and pulse oximetry was not yet possible (Fig. 2a and 2b).
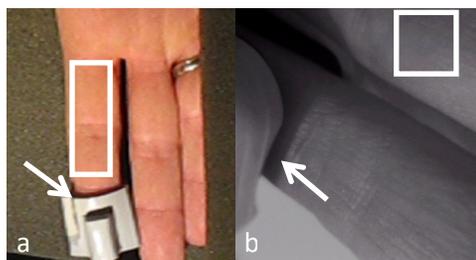


**Fig. 1:** *Video captured **a)** in the 7T MR scanner room with an off-the-shelf digital camera and **b)** during a 3T brain measurement inside the bore. Arrows mark the pulse oximeter probe; the white boxes represent the video algorithm ROI.*
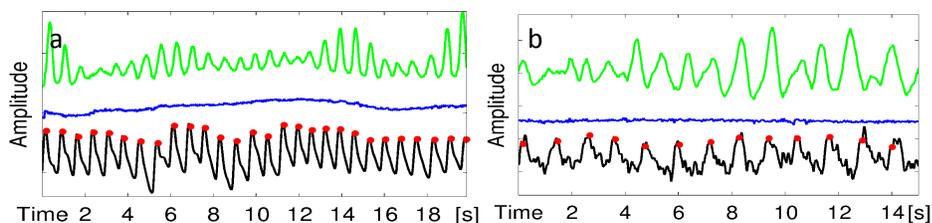


**Fig. 2:** *Pulse oximetry signal (black line) and time course of mean pixel intensity of the ROI seen in Fig. 1a, 1b. The intensities of the original video (blue) as well as the magnified video (green) are shown. The red dots mark the vendor-determined pulse trigger. a) Inside 7T magnet room, b) inside 3T scanner bore during brain scan.*

**Discussion and Conclusion:**

As can be seen from Fig. 2a and 2b, the pulse oximetry signal and the results of the video magnification algorithm correlate well; nevertheless, the latter exhibit a slight frequency disagreement and noise. Currently, the agreement between both signals is being analyzed as a function of the algorithm parameters and video properties. For clinical feasibility, the influence of patient movement on the magnified video signal and the real-time capability of the algorithm are of particular interest. So far, results have been obtained by offline comparison of the magnified video and pulse oximetry, whereas for real-time application the experimental setup, camera specifications, and efficient programming will be crucial.

A promising new approach for contactless heart pulse triggering, based on magnification of low-frequency color changes in video signals, is presented. The validation of real-time feasibility and compatibility with various MRI setups remains to be demonstrated.

**References:**

1: Wu H, et al. Eulerian Video Magnification for Revealing Subtle Changes in the World. ACM Transactions on Graphics. 2012; 31(4)