Noncontact physiological measurements using video recording inside an MRI scanner

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Target audience: MR physicists and researchers working on correcting physiological noise.

Purpose

Previous investigations showed that physiology parameters such as heart rate and respiratory rate can be measured using noncontact video recording[1]. This method is potentially useful in the MRI enviroment because it is an optical-based remote sensing which minmally interfers with the fast switching MRI gradient system. However, this method requires normal ambient light as illumination source[2]. It is generally a low-light enviroment inside a conventional MRI scanner. This study attempts to evaluate the feasibility of the noncontact measurement method inside the MRI enviroment and optimize the computation algorithm for MRI applications.

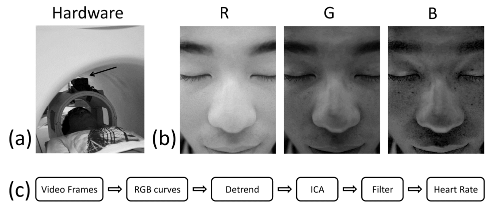

Figure 1 (a) Position of the camera (b) Separating RGB color channels (c) Data analysis flow diagram

Methods

We performed this study in a mock MRI scanner in Taiwan Mind and Brain Imaging Center, National Chengchi University. We used a conventional digital camera (16M pixels, 4/3-inch CMOS sensor, focus length: 20mm, aperture size: F1.7) for video recording. Figure 1(a) displays the position of the camera mounted at the top of a head coil. Three volunteers participated in this experiment. During experiments, we asked the subjects to keep their heads still and recorded one minute video for each session. The video file format was 640×480 MPEG-4. During the experiment, an operator recorded the radial pulse of the volunteer's wrist using the pads of two fingers.

After experiments, we transferred the video files to a personal computer and performed data analysis using MATLAB® (Mathworks, Natick, MA, USA). Figure 1(c) shows the flow of image analysis. First, the three color channels, red (R), green (G) and blue (B) were separated. For each time frame, we averaged all the pixel intensities of the three images and produced three values. The procedure produced 3 signal-time curves corresponding to 3 color channels. We then used spline-based fitting to estimate the baseline drift of each curve and detrended the three curves by removing the baseline drifts from the raw signal curves. The three detrended curves underwent independent component analysis, component selection process and bass-pass filtering (0.1 - 5 Hz). Finally, we used peak detection to identify local maximum of the pulsatile curve to calculate heart rates (beats per minute) using 60 divided by time interval between two adjacent peaks.

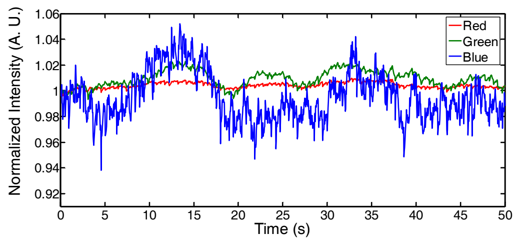

Figure 2 Normalized intensity of 3 color channels

Results

Figure 2 demonstrates the curves normalized to their initial values. Notice that the blue-channel curve fluctuates prominently. Figure 3 demonstrates the detrending procedure (top: estimating baseline drifts, bottom: the detrended curve). Figure 4 displays temporal heart-rate variations obtained from one of the volunteers.

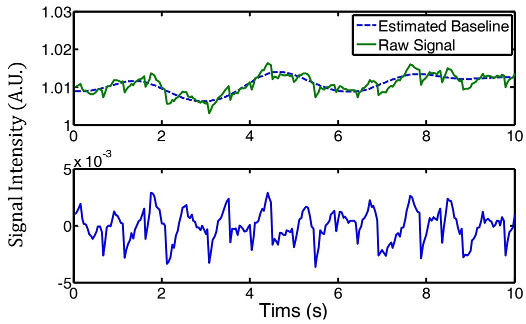

Figure 3 (top) Estimating baseline drift of the signal-time curve (bottom) the curve after baseline-drift removing

Discussion

This study attempts to use video recording as a tool for physiology monitoring in an MRI scanner. During a cardiac cycle, facial skin blood perfusion changes alter optical path of ambient light emitted to the subject's face. Using a conventional digital camera to capture the changes of the reflected light and using ICA analysis to remove other sources in light, we identify that this method is feasible in a low-light MRI bore. This method is an optic-based technique which avoids the problem associated with switching gradient system. This method requires off-line computation and thus is not suitable for real-time applications such as triggering cardiac imaging or cine flow measurements. Nonetheless, it is potentially useful in physiology noise corrections such as the RETROICOR method[3] to remove cardiac-related noise in resting state fMRI experiment. We performed the experiments in a mock MRI system, which is the limitation of this study. Utilizing a MRI-compatible digital camera for video recording during scans merits further investigations. In conclusion, physiology monitoring using video recording is a potential useful tool in MRI applications.

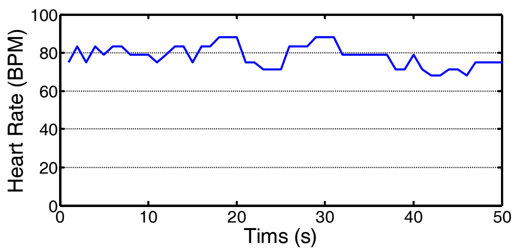

Figure 4 An example of the obtained heart rate changes during the experiment.

References

[1] Poh MZ, McDuff DJ, and Picard RW, "Advancements in Noncontact, Multiparameter Physiological Measurements Using a Webcam," IEEE Trans Biomed Eng. 2011 Jan;58(1):7-11.

[2] Verkruysse W, Svaasand LO, and Nelson JS "Remote plethysmographic imaging using ambient light" Opt Express. 2008 December 22; 16(26): 21434–21445.

[3] Glover GH, Li TQ, Ress D. "Image-based method for retrospective correction of physiological motion effects in fMRI: RETROICOR." Magn Reson Med. 2000 Jul;44(1):162-7.