Prospective Head Movement Correction for High-resolution MRI Using a Single Camera

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Introduction

The image quality of brain MRI scans can be compromised by head motion. Prospective motion correction based on external tracking systems has been proposed to ameliorate this issue. Stereo optical tracking systems have been shown to give good real-time motion correction with reasonable accuracy [1,2]. However, the accurate calibration for the stereo system as well as the calibration between the stereo and MRI system are rather complicated and time consuming. So a method that does not require calibration and can work with just a single video camera was proposed [3]. It needed, however, a tracking target to be fixed on the forehead of the volunteer. We therefore propose here a motion correction method for MRI that doesn't need any tracking target but just uses facial features directly from the volunteer.

Method

The proposed method estimates 3D head motion from a 2D camera image of the subject's face by comparing it with a series of images acquired during a training scan with purposeful head motion. During the training scan, whole brain MRI EPI were acquired synchronously with the video images to estimate true head motion in the scanner coordinate system.

All experiments were performed on a GE (Milwaukee, WI, USA) 7T MRI system. An MR compatible infrared camera (MRC Systems GmbH, Germany) was fixed on a holder right above and in front of the head coil (Fig 1). Six infrared emitting diodes were used to illuminate the field of view. The distance from the camera to volunteer's face was around 8cm. The high spatial resolution of this setup (320 x 240 pixels, about 13 x 10cm^2 field of view focusing mostly on the nose of the volunteer) allowed the detection of sub-millimeter movements.

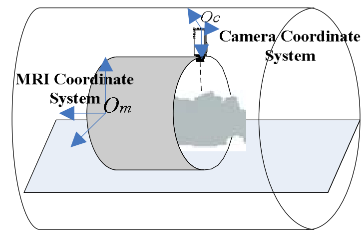


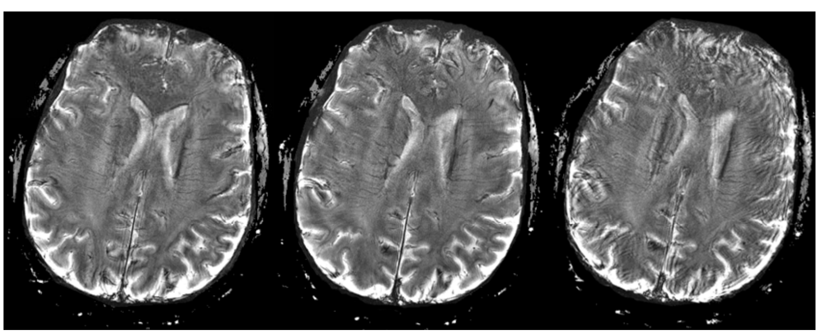
Figure 1: Experimental setup

During the training scan, the subject slowly moved his head in the directions that were least restrained, mainly rotations in the axial planes. The range of rotation was about 16 degrees and translation 17mm. A time-series of 145 EPI images (parameters: 128×96 voxels over 24×18 cm^2, 11 3mm slices with 0.5mm gap, TE 50ms, TR 1.2s) was acquired. From the EPI images, motion parameters in the MRI coordinate system (3 rotations and 3 translations) between each volume were calculated with 3D registration using SPM [4]. Since camera images were acquired simultaneously with EPI, each camera image in the training data thus corresponded to a motion vector. The training data were then sorted based on the motion parameters to help speed up the real-time search. An ROI region (the nose) was also selected based on these training camera images.

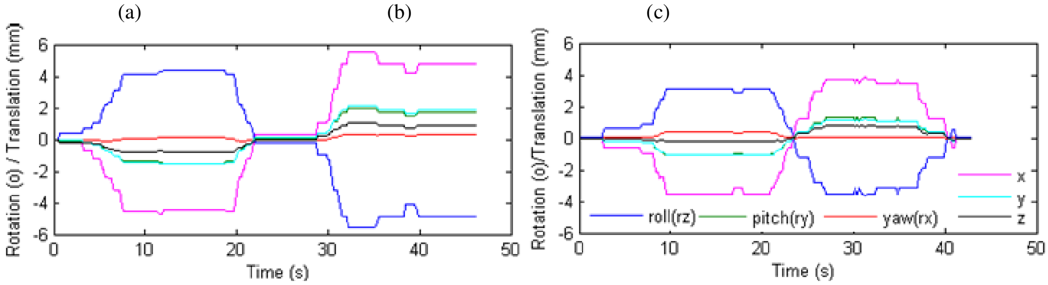
During the real-time scan, the correlation between the ROI of the newly captured camera image and the ones in the training camera images was calculated to find the most similar one. The corresponding motion parameters of that training image served as the estimation of the current head position. These motion parameters were then sent to the MRI scan computer at 6Hz speed. A gradient echo sequence (parameters: 512×384 voxels over 24×18 cm^2, 3mm slice thickness, TR=100ms, TE=30ms) was modified to incorporate the motion correction by adjusting gradient rotation and RF frequencies and phases before each RF excitation.

Results

Experiments were performed on a healthy volunteer with and without motion correction each with similar motion. Results are shown in Fig. 2. The image quality of (b) is similar to (a), and much better than (c). The results suggest that the new system has good precision to be used in high resolution MRI. Motion parameters shown in (d,e) were not smooth because of the not dense enough sampling of the training data acquisition.



(a) (b) (c)



(d) (e)

Figure 2. Prospective correction of large motion. (a) was acquired without intentional motion during the scan. (b c) were scanned in the presence of motion; (b) was acquired using the proposed method but (c) was without correction. (d,e) show the evolution of motion parameters during the acquisition of image (b,c), respectively.

Conclusion

We proposed a new motion correction method for MRI using single camera. Facial features were used directly for motion estimation. One drawback of the correlation method was its long computation time, which limited the motion parameter update rate to 6Hz. This might not be adequate for all types of motion. Faster search methods will be explored in the future to improve this.

References

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