A Prospectively Aligned And Motion Corrected Protocol For FMRI Studies

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Objective

Because of subject motion during the time course of a study, fMRI studies require retrospective motion correction. This applies to anatomical data sets as well as BOLD scans. Image degradation, additional workload and data amount are by-products of the post-processing step. If the image data could be acquired in such a way that all scans are aligned to each other these post-processing steps could be eliminated.

Based on Prospective Acquisition CorrEction (PACE) [1], we implemented a correction technique (AutoCorrect) that adjusts the slice prescription of each succeeding scan to the subject's current head position.

Methods

PACE was modified to store a reference volume to disk during a single volume EPI scan acquired at the beginning of the scan session. Every succeeding anatomical scan is preceded by a quick single-volume EPI scan to calculate the transformation matrix between the current head position and the reference. This transformation matrix is then applied to the slice prescription of the anatomical scan. In case of a BOLD scan, the first time point of the EPI scan serves as the correction scan and the transformation matrix is applied to the rest of the series. Further motion during the series is corrected by PACE.

We tested the technique by running a shortened fMRI study twice on a 1.5 T MRI system (Avanto, Siemens Medical Solutions, Erlangen, Germany). Besides the standard anatomical MPRAGE and BOLD scans, this study included a reference scan as well as correction scans before each MPRAGE (Figure 1). Automatic alignment [2] was used to ensure standardized positioning over multiple studies. Imaging parameters for the gradient echo EPI reference and correction scans were as follows: TE = 20.4 ms, TR = 2 s, matrix size: 64x64, 27 slices, FoV = 200 mm, 3.1 mm isotropic spatial resolution. To assess performance, additional MPRAGE and BOLD scans were performed without slice position correction. The subject was instructed to move the head during the BOLD scan.

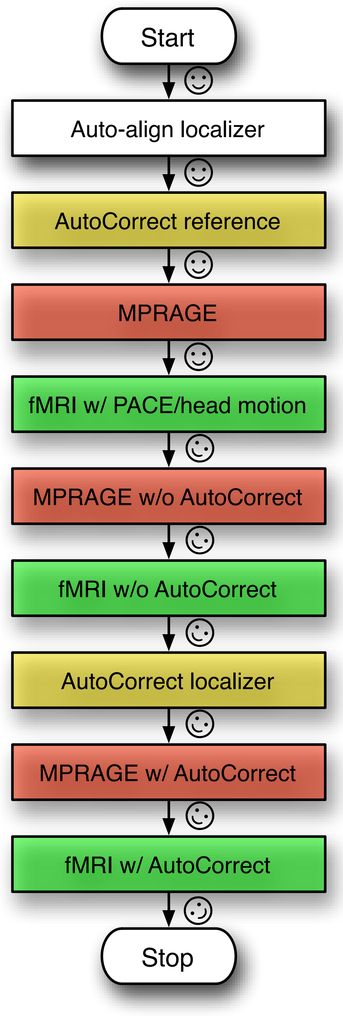

Figure 1: Series of scans used to evaluate AutoCorrect.

Results & Discussion

Figure 2 shows PACE motion correction parameters during the BOLD scan with head motion. The first MPRAGE scan (Figure 3, left, before head motion) as well as the difference images of corrected MPRAGE (middle) and uncorrected MPRAGE (right) show that the corrected slice prescription closely matches the original scan. Similar results were found for the BOLD scans. Figure 4 shows a slice of the first BOLD scan (left), as well as from the corrected (middle) and uncorrected (right) BOLD scans after the head motion.

For improved accuracy, non-EPI scans could replace the EPI based reference and correction scans. Alternatively, rapid navigator echo techniques could be used to calculate the transformation matrix [3].

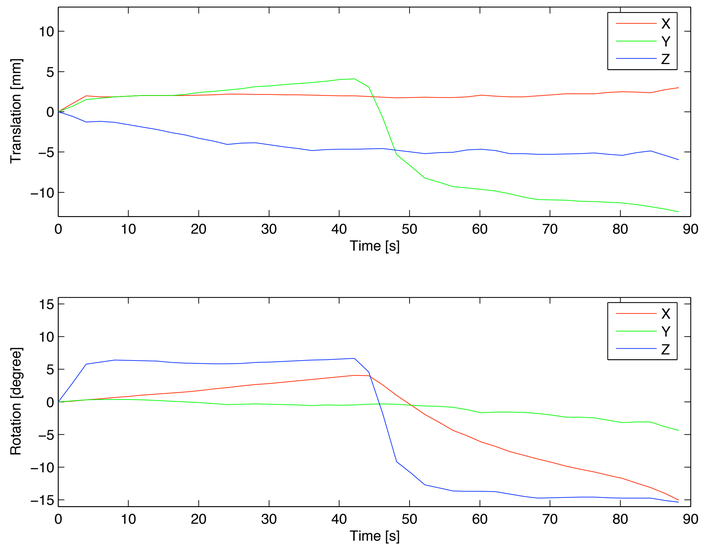

Figure 2: PACE motion correction parameters (top: translations; bottom: rotations) during BOLD scan with head motion.

Figure 3: Axial slice of MPRAGE scan before head motion (left) as well as difference image of corrected MPRAGE (middle) and uncorrected MPRAGE (right), both after head motion.

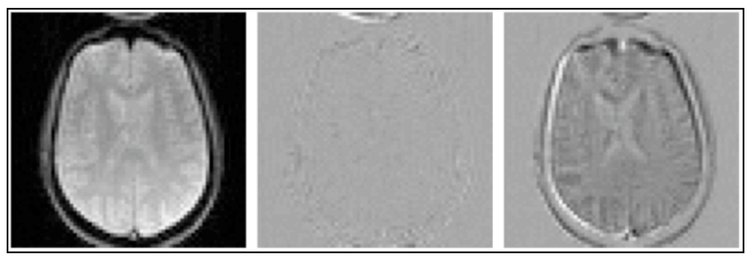

Figure 4: Axial slice of BOLD scan (left) as well as difference image of corrected (middle) and uncorrected bold scan (right), both after head motion.

Conclusion

We demonstrated that an fMRI study with consistent between-scan alignment can be performed without the need for retrospective motion correction.

References

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