# Sub-volume utilization method for retrospective motion correction in long acquisition fMRI

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## Objective

Motion of subject is the significant issue of the image distortion in fMRI, especially for studies with very long acquisition times such as sleep study. Motion between volumes can generally be retrospectively corrected through the use of a volume registration technique, but motion within a volume cannot be corrected by the technique. This study presents a retrospective motion detection and correction strategy for interleaved EPI sequences using a sub-volume utilization method (1). Since most sporadic motions occur over a short time period during a volume scan, motion artifacts are more likely to affect a portion of the volume rather than the whole volume. The basic idea of the proposed algorithm was to divide the whole interleaved volume into two sub-volumes and determine whether each sub-volume is corrupted by motion.

## Methods

Ten healthy volunteers (M=10, mean age=25.8+-2.7 years) participated in this study. All subjects underwent fMRI scanning with a 3.0-T MRI scanner to obtain T1-weighted image with a magnetization-prepared rapid acquisition gradient echo (MP-RAGE) sequence, and T2*-weighted image with single-shot echo-planar imaging sequence. More than 1,000 EPI volumes were acquired over a long period while a subject was sleeping. From the obtained interleaved EPI volumes, we extracted two sub-volumes: odd- and even-slices of each volume (i.e. odd sub-volume and even sub-volume). We defined the measure of discontinuity as follows (1): $\partial Ci=1/(N-2)\sum||[Si(n+1)+Si(n-1)]/2-Si(n)||$ If discontinuity of a volume was above a threshold, the volume was regarded to be corrupted by motion and discontinuities for sub-volumes were calculated. If discontinuities for both sub-volumes were high, the whole volume was discarded altogether. Otherwise, a sub-volume with lower discontinuity was interpolated into a whole volume to replace the original volume.

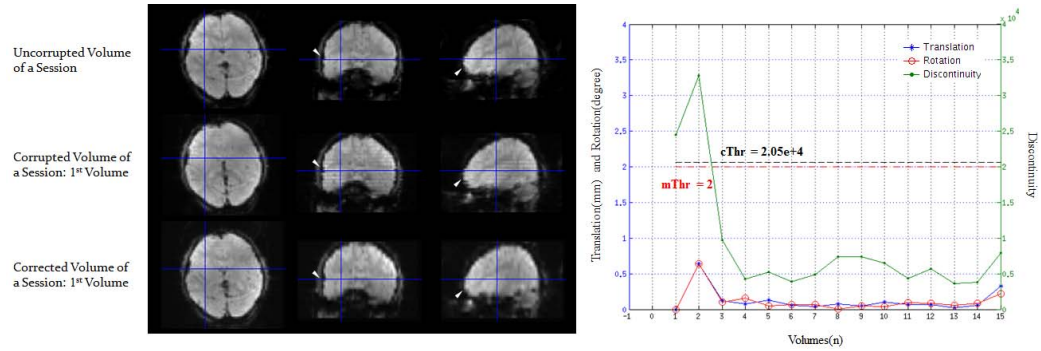


Figure 1. Motion of the 1st volume of a session was detected and corrected only by sub-volume utilization method. Realignment is usually performed with respect to first volume or mean volume. The proposed discontinuity measure can be used to detect motion in the reference volume, which is difficult to detect by realignment parameters alone.

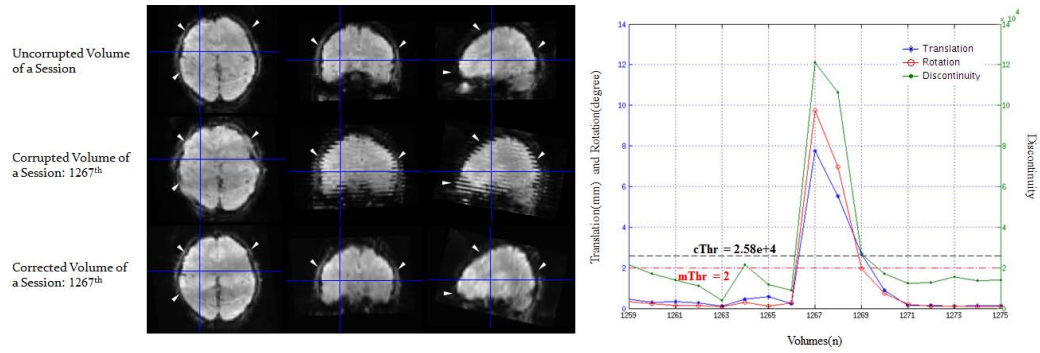


Figure 2. Using both discontinuity measure and realignment parameter, motion of the 1267th volume was detected and corrected. Motion correction was performed by sub-volume utilization that interpolates the selected sub-volume

## Results

We detected the motion between volumes from image registration (2), and the motion within each volume from discontinuity of odd and even sub-volume. We used the proposed method for calculating intra-volume discontinuity to detect motion within a volume and correct affected volumes using sub-volume utilization. We were also able to detect inter-volume motion using realignment parameter (3) and correct affected volumes using sub-volume utilization. Overall, the proposed discontinuity measure was useful for detecting intra-volume motion and realignment parameter was useful for detecting inter-volume motion.

## Conclusion

Our proposed retrospective motion correction method can be used in interleaved EPI sequence to significantly improve the corrupted whole volumes and reduce the number of volumes that needs to be excluded. Through sub-volume utilization, this method was able to correct intra-volume motion detected by discontinuity measure and inter-volume motion detected by realignment parameter. Intra-volume and inter-volume motion detection were complementary and supported each other's limitations. As such, the method used in this study to correct data for the motion of subject might provide benefits in the fMRI analysis.

## References

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