3D PROMO MRI with Automatic Initial Navigator Placement

Dan Rettmann[1], Xiaodong Tao[2], Jun Xie[3], and Ajit Shankaranarayanan[4]
[1]*Global Applied Science Laboratory, GE Healthcare, Rochester, MN, United States,* [2]*GE Healthcare, Beijing, China, People's Republic of,* [3]*MR Engineering, GE Healthcare, Waukesha, WI, United States,* [4]*Global Applied Science Laboratory, GE Healthcare, Menlo Park, CA, United States*

Introduction: Significant artifacts can arise in MRI if the subject is moving during imaging. Many techniques to address this issue have been proposed. More recently, 3D PROspective MOtion (PROMO) correction, which uses image-based navigators with anatomical masking and an Extended Kalman Filter (EKF) algorithm to track and correct for patient motion in real-time, has been shown to perform well in a challenging pediatric patient population[1-2]. A quantitative evaluation of the performance of the PROMO method under known motion conditions was reported[3] and it was found that the slice positioning of the 3-plane spiral navigators can affect the accuracy of the motion estimates. It was concluded that for reliable detection of rotation about the Z-axis (along the bore) the anatomy imaged by the axial navigator plane should be the least circularly symmetric. Estimation of the other two (X & Y) rotation metrics was less sensitive to the (sagittal & coronal) navigator plane positioning.
Previously, the initial position of the 3-plane spiral navigators was dependent on the positioning of the center of the imaging volume. For this work, modifications were made to the PROMO real-time processing application to use the parameters computed during the mask placement phase to define a subject appropriate initial position for the axial 3-plane spiral navigator. A description of the changes and initial results are reported.

Methods: Real-time PROMO: An automatic scan plane planning method[4] was modified to improve the processing speed and optimized to be compatible with a spiral-based axial localizer volume. This algorithm was incorporated into the online real-time PROMO process, replacing the previous atlas-based brain-mask positioning algorithm, and was tested to verify that brain mask positioning, as determined by this algorithm, provided results comparable to the previous version (not shown). The algorithm works by determining a left-right (L/R) axis of symmetry using a mutual information based 3D rigid registration of the axial localizer volume and it's L/R flipped copy. The resulting transform is halved, applied to the axial localizer volume, and from that a representation of the subject's mid-sagittal plane (MSP) can be resampled. A mutual information based 2D rigid registration is then used to match the subject MSP to a template MSP. The final transformation used for brain mask placement is a composition of the two computed transforms. To address the initial navigator placement, the final transformation was used to map an ideal axial plane location, defined in the template MSP, to the subject space. This superior-inferior (S/I) offset is sent back to the pulse sequence so that it can be automatically applied to the axial plane of the 3-plane navigators that will be used for motion tracking during the main scan.
Pulse Sequence: A 3D FSE (Cube) PROMO pulse sequence was modified, replacing the acquisition of multiple 3-plane navigators that were previously used to determine initial mask placement with the acquisition of a stack of 18-24 (10cm thick) contiguous 2D axial spiral slices, generating the localizer volume previously described. It was also modified to receive and apply the S/I offset (determined from the aforementioned real-time processing of the localizer volume) to the axial slice of the 3-plane navigators.
Image Acquisition: Informed consent was obtained and volunteers were scanned under an IRB-approved protocol on 1.5T & 3T MRI scanners (MR450 & MR750, GE Healthcare, Waukesha, WI) using 8 and 32 channel head coils. To reduce scan time, a low resolution 3D FSE PROMO sequence using the following parameters: TR/TE 2500/71ms, BW ±62.5kHz, 24x21.6cm FOV, 128x128 matrix, sixteen 15mm thick sections, ETL 140, was used to acquire a number of datasets at various subject and prescribed volume positions. The parameters used for the 18-24 spiral axial localizer slices and the 3-plane navigators remained consistent with that typically used in a high resolution 3D FSE PROMO scan: TR/TE 13/0.9ms, flip 8˚, BW ±125kHz, matrix 2048x1, 32cm FOV, 128x128 reconstructed matrix. The axial spiral localizers had 10mm thickness while the 3-plane spiral navigators had 13mm slice thickness.

Results: The scan time of the contiguous axial localizer slices was 7 seconds. The processing time for the mask placement determination and complimentary S/I offset was 4.29±0.13secs. The top row of Fig 1 is an example of the axial navigator slices previously used, which depend on the location of the center of the prescribed imaging volume. The second row of Fig 1 shows a sagittal reformat of the axial localizer volume with the new position of the axial navigator plane depicted as a lightened horizontal region. The computed offset and resultant axial navigators using the proposed method are shown in the bottom row.

Discussion: Consistent axial navigator positions were computed for various imaging slab (and subject) positions. The new technique proved to be robust to anatomic positioning with comparable processing performance to the previous version. Further speedup (7 down to ~2.5secs) is likely possible through reduction of intentional (for T1 recovery) dead time in the TR of the spiral localizers and remains to be investigated.

References: [1] White et al *Magn Reson Med* 2010;63(1):91-105 [2] Kuperman et al. *Pediatr Radiol* 2011; Jul 21 Epub [3] Zhang et al. *Proc ISMRM* 2009 p4631 [4] Tao et al *Proc ISMRM* 2009 p2903

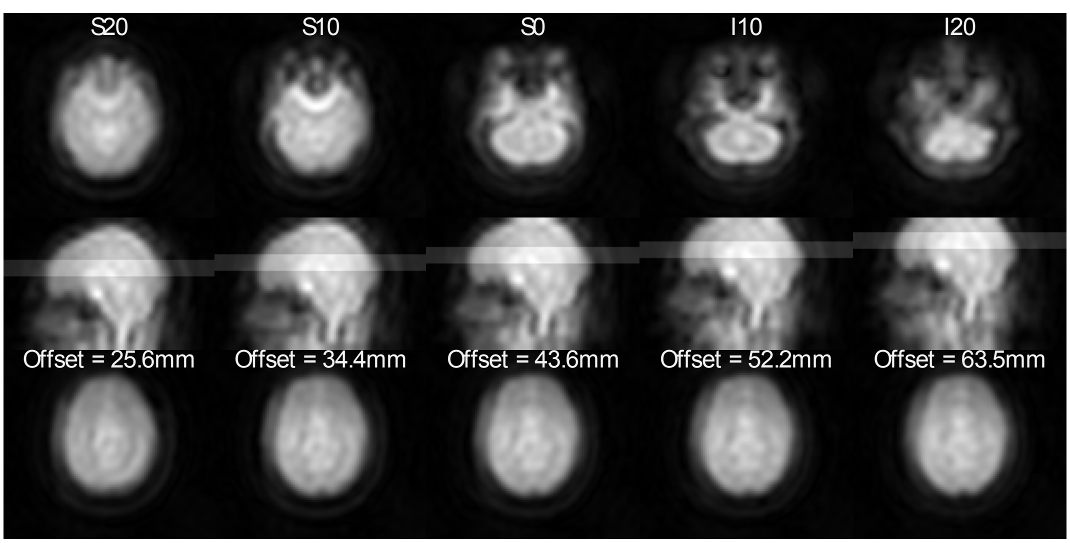

Figure 1: Images from a volunteer where the main imaging volume was prescribed at 5 different superior/inferior offsets, columns showing S20 to I20 in increments of 10mm. The top row shows the center slice from the axial localizers (position used by previous method). Sagittal reformats (middle row) of the axial localizer volume are shown with the brighter horizontal region representing the position and approximate thickness of the axial navigator plane as determined by the proposed method. A representation of the axial navigator with the algorithm calculated offset is shown in the bottom row.