The Investigation of T2 PROPLLER Motion Estimation Efficiency

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Introduction: T2 PROPELLER (Periodically Rotated Overlapping Parallel Lines with Enhanced Reconstruction)[1] is widely used in clinical scans, providing images with significantly less motion artifacts. In PROPELLER, rotation estimation is performed with the magnitude of the overlapped center k-space, followed by translation correction using the rotationally corrected center k-space. The performance of PROPELLER motion correction algorithm was initially investigated to reduce motion artifacts with simulated Shepp-Logan phantom data [2] and simulated Turboprop acquisitions [3]. To achieve better clinical T2 PROPELLER images with less motion artifacts, in this work, the efficiency of PROPELLER motion correction with respect to field of view (FOV), views per blade and k-space coverage is analyzed using invivo data to guide protocol setup.

Methods: T2 PROPELLER volunteer data (40 views per blade, 17 slices, 512x512 matrix size) were acquired for FOV 24cm and 32cm using a GE 3T scanner. For each dataset, rotation angles were estimated using different numbers of center k-space views, from 8 to 40 with the skip of 4. The relative rotation error was calculated as the estimation difference between using partial k-pace views and all k-space views. Similarly, translation motion was estimated with different numbers of center views, and the relative translation error was calculated in the same way as relative rotation errors. To eliminate the variation introduced by rotation correction, the rotation angles estimated using all views were corrected before translation estimation. Totally 14 volunteer data sets were studied, including still and motion brain images in axial, coronal, and sagittal planes.

Results: Figure 1 compares the relative rotation errors of FOV 24cm (in blue) and FOV32cm (in red) as functions of the number of views per blade and k-space coverage (defined as views per blade divided by FOV). It is observed that the rotation estimation accuracy depends on structural rotation variation of the image. Rotation correction fails for rotationally invariant images, such as images of a sphere phantom. As for the volunteer data studied, for the slices with less rotational variation (such as outer slices), the overlapped curves in Figure 1 (a) demonstrate that k-space coverage is the major consideration of rotation errors; Figure 1(b) shows that given the same number of views per blade smaller FOV yields less rotation errors. For those slices with more rotational variation (such as center slices), the overlapped curves in Figure 1(d) demonstrate the number of views per blade is determinant of rotation accuracy. The translation estimation is not sensitive to the number of views per blade, as shows in Figure 2 that the translation trajectories estimated with different numbers of center views are close to each other, because the phase information used in translation estimation embeds across k-space. The relative translation errors for all the data studied were less than 0.5% FOV when the number of views per blade was greater than 24. Figure 3 image (a) and (b) estimated the blade motion (both rotation and translation) with 32 and 12 center views respectively. As can be seen, image (a) has less motion related artifacts (highlighted with red circles) than (b).

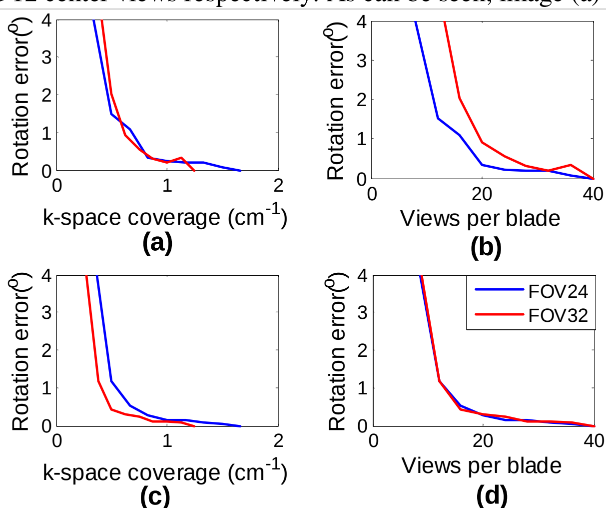

Figure 1. (a) and (b) plot the relative rotation errors of a typical slice with less rotational variation as a function of k-space coverage and views per blade respectively. (c) and (d) plot the relative rotation errors of a typical slice with more rotational variation as a function of k-space coverage and views per blade respectively. Blue and Red curves represent errors of FOV 24 and FOV 32 respectively.

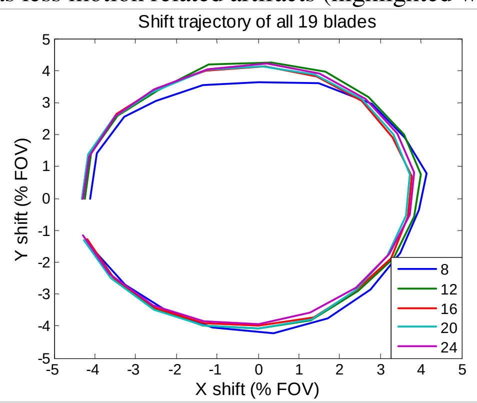

Figure 2: Translation motion trajectories of all 19 blades estimated with 8, 12, 16, 20, and 24 views in the center k-space.

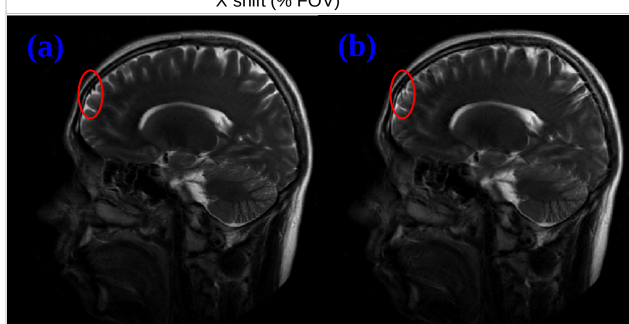

Figure 3. (a) and (b) estimated motion parameters with center 32 and 12 views per blade respectively.

Conclusions: Based on this study, tight FOV is recommended in a T2 PROPELLER scan for better rotation estimation. Furthermore, at least 24 views per blade and 1 cm^{-1} k-space coverage are required to obtain brain images with little motion artifacts.

Reference: [1] J. G. Pipe, MRM pp963-969, 1999 [2] A. A. Tamhane, ISMRM 2005 p2237 [3] A. A. Tamhane, ISMRM 2006 p1037