Towards a real-time prospective 3D fat navigator: investigating the limits of parallel imaging.

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Purpose. Motion correction is foundamental for maintaining consistent high quality in MR neuroimaging. In this study we investigate the feasibility of a 3D fat navigator (FatNav) in a perspective setting, where the correction is performed in a real-time feedback loop. Navigator data from a fat signal have a number of advantages with respect to water's. Firstly, fat data is highly sparse and allows for high acceleration factors with parallel imaging techniques as observed in [1]. Additionally it consists mainly of a sharp, high contrast skull-shaped structure that lends itself well to volume registration. Lastly, fat signal acquisition does not perturb water magnetization in any amount that would lead to a significat SNR loss. In order to develop a perspective 3D FatNav, one of the key issues is to keep both the acquisition and reconstruction time for the navigator data as low as possible. In fact, the quicker is the feedback loop the more general is its applicability. To this end, we investigate how the data and resulting motion estimates degrade at higher acceleration factors. As opposed to [1], we utilize a simple, non iterative GRAPPA algorithm to ensure that reconstruction time is the fastest possible.

Methods. Data was acquired on a 3T GE scanner using a 32 channel Nova coil array, by a 3D GRE sequence with 10° non-selective fat excitation with a FOV of 280mm and isotropic voxels of ~5.83mm. A total of 14 acquisitions were performed on one healthy volunteer which was instructed to assume different head poses between scans. Each kspace volume's data array of size 48x48x48 was decimated in the ky-kz plane as to simulate GRAPPA acquisitions at various acceleration factors and then reconstructed using weights estimated from the first scan alone. Specifically, the considered configurations had overall acceleration factors R of 16, 24 and 32 factored as 4x4, 4x6 and 4x8 respectively, along the ky and kz directions. Also, note that the corresponding navigator modules are expected to have a duration of approximately 70ms, 56ms and 35ms respectively. Successively, the fully sampled and the reconstructed volumes were registered against the first fully sampled volume using the SPM realigning functions in order to obtain the corresponding translation and rotation estimates.

Results. In fig. 2.a, several slices of the first volume, used for weight estimation and reference for volume registration, are shown. Along the reference volume, slices of two different volumes are shown both fully sampled and at different acceleration factors. It can be noted that the volume in fig 2.b, whose head pose is closer to the reference degrades less at higher as R increases than the volume in fig 2.d whose pose is wildly different. Finally, the results from the motion estimation are shown in Fig. 1, where estimates from accelerated and fully sampled data is compared to each other. Here, the validity of the motion estimates from fully sampled data that is used as a gold standard can be assessed from fig 2.c where the standard deviation of the corresponding realigned volumes is depicted.

Conclusions and discussion. Judging from the slices depicted in fig 2, it is apparent that the proposed acquisition scheme shows promise for a perspective 3D navigator. The reconstruction appears to be rather robust even with head poses that are very different from the calibration data's. Still, artifacts are somewhat significant at R=32 and result in a bias error. It remains to be tested if the application of a Kalman filter, as in [2], can help mitigate the issue. From the results obtained so far, it seems that the best compromise between accuracy and scan time is at R=24. With such acceleration, 3D volumes can be acquired twice per second with an increase of scan time of ~10%.

References. [1] Gallichan et al., ISMRM 2013 [2] White et al., MRM 2010

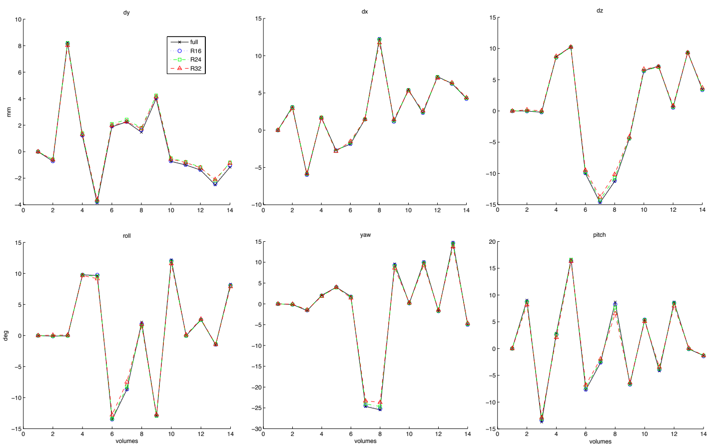

Fig. 1. Motion estimates at different acceleration factors.

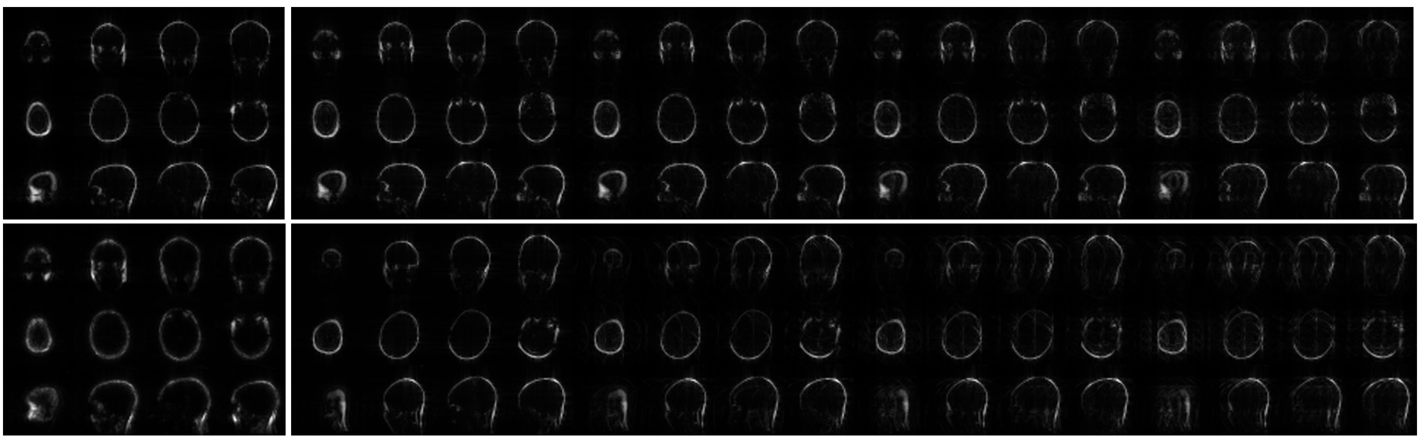

Fig. 2. a) Reference volume. b, d) volumes of two different head poses at different acceleration factors: fully sampled and with R = 16, 24 and 32 from left to right. c) standard deviation of the realigned, fully sampled volumes.