Weighting Data to Achieve Short Echo Time Contrast in PROPELLER Imaging

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Introduction FSE PROPELLER is an effective technique for generating T2-weighted (T2w) images of the brain, especially in challenging cases with motion or pulsatile flow [1]. Generating motion-corrected T1-weighted (T1w) or proton density weighted (PDw) images using FSE PROPELLER is more challenging: PROPELLER motion correction performs much better with wide blades, however the short echo times (TE) and short echo train lengths (ETLs) used for T1w and PDw FSE acquisitions limit the blade width. Additionally, narrow blade acquisitions require a larger number of blades to cover k-space, which increases scan time, especially for long TR (PDw) acquisitions. Parallel imaging can ameliorate the problem by increasing blade width for a given ETL, but it remains challenging to achieve sufficient blade width with short ETLs [2].

In this work, we propose a technique for tailoring the image contrast of PROPELLER acquisitions by altering how the oversampled data is weighted. The conventional algorithm for weighting the data is designed to optimize SNR. Here, we present the design of a weighting scheme that sufficiently samples k-space while preferentially emphasizing data with the desired contrast. We demonstrate that this weighting scheme permits T1w and PDw images to be generated from longer ETL data, enabling the formation of images from fewer acquired blades.

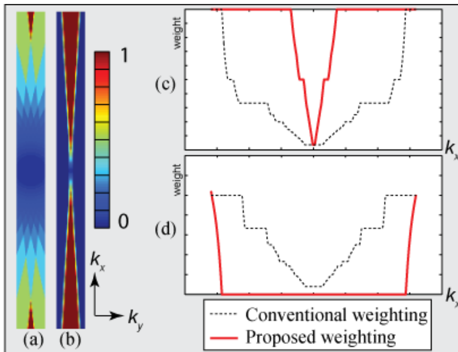

Figure 1: Illustration of Weighting Schemes
(a) Conventional weighting scheme for a single PROPELLER blade, designed to optimize SNR. (b) Proposed weighting scheme for a single PROPELLER blade, designed to better achieve desired contrast. (c) Cross section comparison of weighting for central echo (first echo). (d) Cross section comparison of weighting for later echo. The proposed weighting scheme puts greater weight on earlier echoes to achieve the desired contrast while still sufficiently sampling k-space.

Methods PROPELLER data was acquired on normal volunteers using standard 3T MRI systems (MR750 and Signa HDx, GE Healthcare, Waukesha, WI) and an 8 channel brain coil (MRI Devices, Waukesha, WI). A centric phase encoding scheme was used with ETLs of 29-35. Other imaging parameters included TE=8.3ms, TR=3s or 792ms for PDw and T1w respectively, FOV ~ 24cm x 24cm, 320 readout, 5mm slice, BW ±50kHz.

Data sets were reconstructed twice: once using a conventional weighting scheme designed to maximize SNR and a second time using the proposed weighting scheme to achieve the desired contrast. Both weighting schemes are illustrated in Fig. 1.

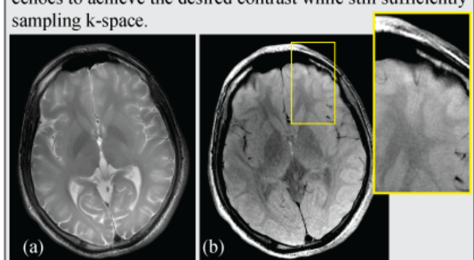

Figure 2: PDw Results
Alternate reconstructions from PROPELLER data with ETL 35, 25 blades, 320 readout, 3s TR.
(a) Conventional weighting; (b) proposed weighting. Reconstruction with the proposed weighting results in a PDw image, whereas conventional weighting is much more T2 weighted.

Results PDw image results for a 25 blade acquisition with an ETL of 35 are shown in Fig. 2. The long ETL with the conventional weighting scheme (a) results in significant T2 weighting, whereas the proposed weighting scheme (b) retains the desired PD weighting. The 25 blades were acquired in 75 seconds. To achieve the same resolution with a Cartesian scan within the same scan time would require an ETL of 13.

T1w image results for a 70 blade acquisition with an ETL of 29 are shown in Fig. 3. While the conventional weighting scheme (a) does not yield useful contrast, the proposed weighting scheme (b) results in a T1w image.

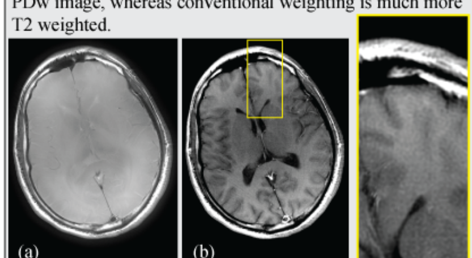

Figure 3: T1w Results
Alternate reconstructions from PROPELLER data with ETL 29, 70 blades, 320 readout, 792ms TR.
(a) Conventional weighting; (b) proposed weighting. Proposed weighting reconstruction results in a T1w image, whereas the contrast resulting from the conventional data weighting suffers from late echo time contamination.

Discussion The density weighting used to reconstruct PROPELLER data can have a significant impact on the resultant image contrast. By considering the desired contrast when designing the weighting scheme, it is possible to achieve contrast such as T1w and PDw that are otherwise hard to achieve with wide blades. Since the weighting is no longer SNR optimal, this contrast tailoring comes at the expense of some SNR. The proposed data weighting scheme does not require parallel imaging, but it can be used with parallel imaging to further increase blade width and reduce T2 decay. Being able to use longer ETL data to achieve short echo time contrast enables short scan times that are challenging to achieve even with Cartesian acquisitions, while retaining the robustness of PROPELLER imaging. We believe that this initial feasibility study shows promising results and that the technique warrants further study, including characterizing the tradeoff between contrast tailoring and SNR and optimizing blade count and ETLs for specific applications.

References [1] Pipe et al. MRM 1999;42:963-969. [2] Holmes et al. ISMRM 2011, p. 4584