'TURBOPROP+': ENHANCED TURBOPROP DWI WITH A NEW PHASE CORRECTION

Chu-Yu Lee[1,2], Zhiqiang Li[3], James G. Pipe[2], and Josef P. Debbins[1,2]
[1]*Electrical Engineering, Arizona State University, Tempe, AZ, United States,* [2]*Neuroimaging Research, Barrow Neurological Institute, Phoenix, AZ, United States,* [3]*MR engineering, GE Healthcare, Waukesha, WI, United States*

Introduction: Compared with conventional DW-PROPELLER (multishot FSE), Turboprop [1] gives increased sampling efficiency, a wider self-navigated region, and reduced specific absorption rate (SAR) by incorporating the GRASE [2] readout to collect gradient echoes around the primary spin-echo. However, phase errors using the GRASE readout, which are exacerbated with preceding large diffusion gradients, induce image artifacts in Turboprop [1,3]. To mitigate this issue, X-prop [3] and Steer-prop [4] techniques have been proposed, which keep the gradient echoes encoded into separate blades (Fig. 1a). In this work, we introduced a method to correct the off-resonance phase in Turboprop, called 'Turboprop+'. The results suggest that Turboprop+ has greater immunity to the artifacts from off-resonance phase, compared with X-prop.

Method: As shown in Fig. 1b, at 1st TR, calibration blades were acquired in the central K-space to measure the off-resonance phase for each gradient echo, assuming the phase varies slowly in image space. At subsequent TRs, each sub-blade was encoded by different gradient echoes, a way that makes the off-resonance phase consistent in a sub-blade. The off-resonance phase of each sub-blade can then be removed by the measured off-resonance phase from the calibration blades using image-space phase correction [5]. After the phase correction, sub-blades were concatenated into one wider blade. The remaining reconstruction was the same as for conventional DW-PROPELLER.

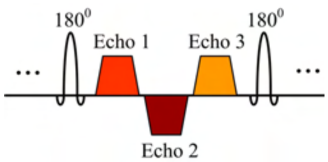
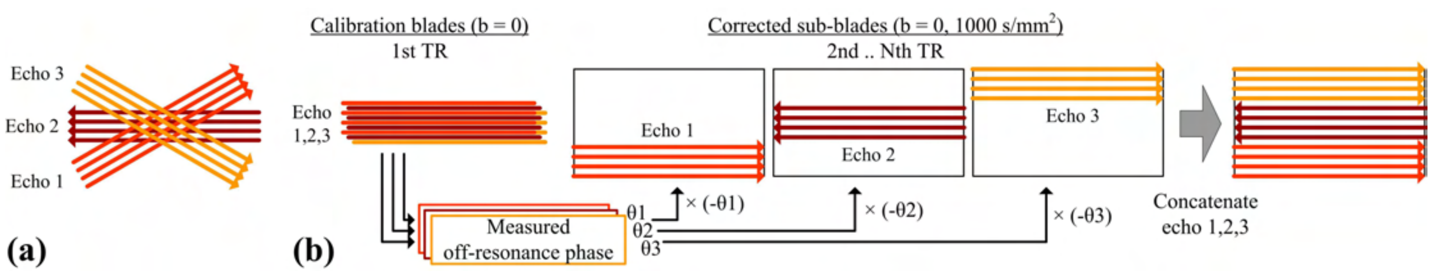


Figure 1: Depiction of K-space sampling schemes (turbo factor = 3). **a:** X-prop. **b:** proposed Turboprop+: calibration blades are acquired in the central K-space for each gradient echo, creating off-resonance phase maps, used to remove off-resonance phase from each sub-blade before the concatenation of sub-blades.



Experiments: Pulse sequences were implemented on a GE Signa HDx 3T scanner. 3-axis DWI: b = 0, and 1000 s/mm^2 (x, y, z) was acquired from a healthy volunteer using conventional DW-PROPELLER (baseline for comparison), X-prop, and Turboprop+. Parameters were: FOV of 240 mm, 20 slices with thickness/gap of 5/1.5 mm, 192 diameter matrix, R = 2 [6]. Conventional DW PROPELLER: ETL of 24, TE/TR = 137/11500 ms, BW = ± 62.5 KHz. X-prop and Turboprop+: ETL of 10, TE/TR = 138/5200 ms, BW = ± 100 KHz.

Results and Discussion: Fig. 2 shows the comparison between X-prop and the implemented Turboprop+. Turboprop+ exhibited fewer artifacts in the regions of temporal lobes and around nasopharynx, with a minor (20sec) increase in scan time. The differences may be primarily due to the mitigated T2* signal loss in Turboprop+, since the data blade with the minimal off-resonance phase (e.g. echo 2 in Fig. 1b) was assigned to the center of k-space, and data blades with larger off-resonance phase (echo 1, 3 in Fig. 1b) were assigned to the outer k-space.

Conclusion: The proposed phase correction was shown to effectively decrease the off-resonance phase errors in Turboprop even when the turbo factor is high (turbo = 7). This improvement allows Turboprop to retain all its benefits: reduced scan time, SAR, and bulk motion sensitivity (wider blade width), with the off-resonance artifacts being minimized in Turbo-prop+.

References: [1] Pipe JG, et al, MRM (55), 380-385, 2006. [2] Oshio K, et al, MRM (20), 344-349, 1991. [3] Li Z, et al, MRM (66), 341-347, 2011. [4] Srinivasan G, et al, 2010 ISMRM Proc, p. 81. [5] Pipe JG, et al, MRM (47), 42-53, 2002. [6] Li Z, et al, MRM (65), 638-644, 2011.

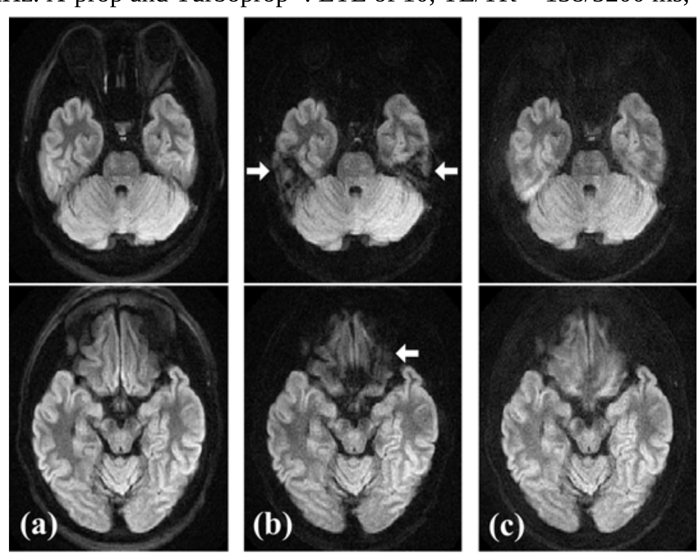


Figure 2: 2 out of 20 slices of isotropic DWI by **a:** conventional PROPELLER (turbo = 1), **b:** X-prop (turbo = 7), and **c:** Turboprop+ (turbo = 7). Scan time: PROPELLER (5' 22"), X-prop (1' 29"), and Turboprop+ (1' 49").