Whole Blade Method for Robust PROPELLER DWI

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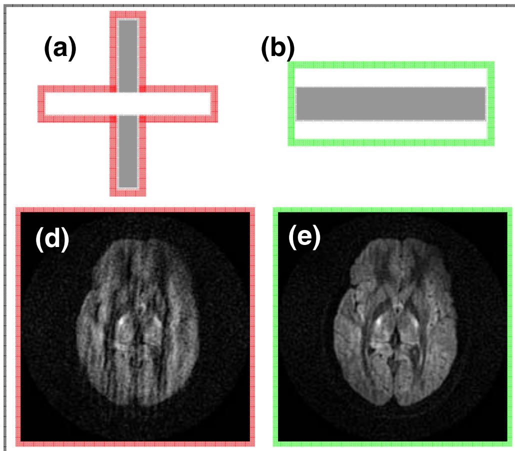
<u>INTRODUCTION</u>: Previous work for multicoil Diffusion Weighted PROPELLER FSE employs a "split blade" approach to compensate for the alternating motion related phase in even and odd spin echoes(1). This solution halves the effective blade widths, which make robust motion correction more difficult. Additionally, Figure 1 illustrates how a shift in k-space due to head rotation during DW gradient application may shift the k-space center near or beyond the edge of a narrow blade, resulting in image artifacts. The work proposed here is a new method for combining all echoes into one (wider) blade, which gives more robust signal, as illustrated in Fig. 1, as well as increasing the robustness of motion correction.



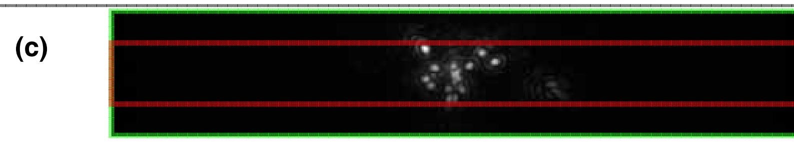


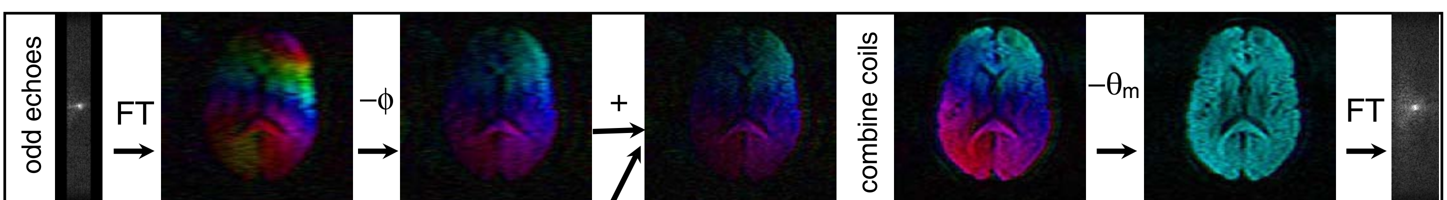
Fig. 1. K-space coverage of (a) split-blade and (b) proposed whole-blade approach (odd/even spin echoes fill in gray/white areas). A MIP in k-space (c) of 22 blades for one slice with L/R diffusion weighting shows displacement of k-space due to head rotation (scattered bright dots are k-space centers of different blades). The red and green boxes indicate signal captured in one blade for the split blade and the proposed (whole blade) method, respectively. Resulting images are shown for (d) split-blade (simulated) and (e) whole blade approach. All data for this figure were from a whole blade scan, 40 lines per blade, b = 1000 s/mm^2, 22 blades, 220 blade length = matrix diameter, 5mm slice thickness.

<u>DEFINITIONS:</u> $\boldsymbol{\theta_m(x,y,b)}$ = phase from bulk motion during DW gradients; also varies for every blade b (e.g. every TR)
$\boldsymbol{\theta_R(x,y,c)}$ = receiver phase; also varies for every coil c.
$\boldsymbol{\theta_T(x,y)}$ = transmit phase for refocussing pulse (= initial signal phase right after 90˚ rf)
$\boldsymbol{\theta_F(x,y,k)}$ = Fourier phase for encoding (also a function of k-space location k)

<u>METHODS</u>: This method follows earlier work(2) which alters even echoes by (1) reversing their applied phase encoding, (2) in recon flipping the data along k_x and then (3) conjugating the data, exploiting the relationship $f^*(x,y) = F^*(-k_x, -k_y)$. The odd echoes are used to fill the center of k-space (Fig. 1b), and the even echoes fill the outer edges. This results in

an image-space phase for collected <u>odd</u> echoes of $\boldsymbol{\theta_{ODD} = \theta_m(b,x,y) + \theta_T(x,y) - \theta_R(c,x,y) + \theta_F(x,y,k)}$, [1]
an image-space phase for <u>collected even</u> echoes of $\boldsymbol{\theta_{EVEN} = -\theta_m(b,x,y) + \theta_T(x,y) - \theta_R(c,x,y) - \theta_F(x,y,k)}$, and [2]
an image-space phase for <u>conjugated even</u> echoes of $\boldsymbol{-\theta_{EVEN} = \theta_m(b,x,y) - \theta_T(x,y) + \theta_R(c,x,y) + \theta_F(x,y,k)}$. [3]

For each coil, the non-diffusion weighted (b=0) blades ($\boldsymbol{\theta_m}$ = 0) are averaged to estimate $\phi(\mathbf{c,x,y}) = \boldsymbol{\theta_T(x,y) - \theta_R(c,x,y)}$. The two parts of each blade [center (odd echo) and edge (even echo)] are then transformed into image-space separately, and $\phi(\mathbf{c,x,y})$ is subtracted from the center data and added to the even data. The blade data are then added together, combined across coils, after which a standard method for estimating and removing $\theta_m(b,x,y)$ from each blade is employed, followed by conventional PROPELLER reconstruction.



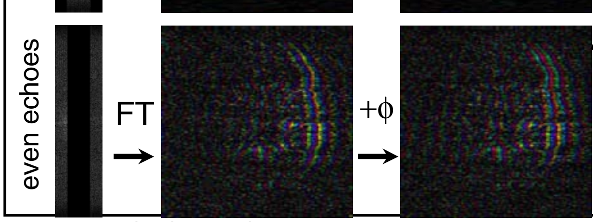


Fig. 2. New method for processing for each blade. Receiver phase Φ is removed from different parts of blade, which are then added back together, prior to coil combination and image-space phase (θ_m) removal. Each corrected blade is then used for conventional PROPELLER reconstruction.

<u>REFERENCES</u>: 1. ISMRM 2003, abstract #2126. 2. Mag Res Med 42: 963.
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