Anisotropic Field-of-Views for PROPELLER MRI

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Introduction

PROPELLER MRI acquires data on radial blades in k-space to correct for rigid-body motion during a scan [1,2], and is useful in applications such as diffusion-weighted imaging. We have created an algorithm that designs PROPELLER blades for anisotropic field-of-view (FOV) shapes. Shaping the FOV can reduce aliasing and the number of blades required.

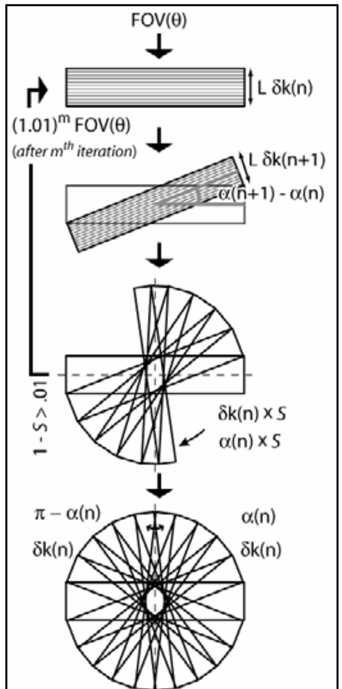

Figure 1: Design algorithm

Methods

The line spacing within a blade, δk, is the inverse of the maximum FOV perpendicular to the blade, and is varied to match the desired FOV size and shape. The blade angles, $\alpha(n)$, will be unequally spaced, so both $\delta k(n)$ and $\alpha(n)$ are sequentially designed, similar to the technique in [3]. Since $\delta k(n+1)$ and $\alpha(n+1)$ are unknown, they are jointly estimated and iterated upon to converge on a solution. This is constrained geometrically by $\alpha(n+1) - \alpha(n) = \tan^{-1}(L\ \delta k(n)) + \tan^{-1}(L\ \delta k(n+1))$, where L is the number of lines per blade, and also by $\delta k(n)=1\ /\ \mathrm{FOV}(\alpha(n)+\pi/2)$ to match the desired FOV. The desired FOV must have reflection symmetry about the x and y axes, and the design stops after a quadrant of blades is designed ($\alpha(n) \geq \pi/2$). The blades usually do not fit in a quadrant so $\delta k(n)$ and $\alpha(n)$ are scaled to fit exactly by S, where $S \leq 1$ to ensure the FOV does not shrink. When distortion caused by scaling is not tolerable ($1 - S > .01$), the FOV size is increased by 1% and the design is repeated until the distortion is small. If an iteration ever increases the number of blades, the previous design iteration is used. The blades are then reflected to form the complete set of blades. The non-circular overlapping region of all blades is used for bulk rotation and translation estimations in the PROPELLER reconstruction.

Results

Anisotropic FOV sampling patterns and the resulting point spread functions (PSFs), corresponding to the supported FOV, are demonstrated in Fig. 2. The FOV area per blade is approximately the same for all shapes. The phantom reconstructions in Fig. 3 both use the same number of blades and lines, but the elliptical FOV sampling does not have any aliasing within the object. The simulated brain reconstruction in Fig. 4 uses an oval FOV and motion correction.

Conclusion

The number of blades required for PROPELLER imaging can be reduced by tailoring the FOV shape to the imaged object, and this can be applied to all types of PROPELLER MRI.

References: [1] Pipe JG, MRM 42:963-9 (1999). [2] Pipe JG, Zwart N, MRM 55:380-5 (2006). [3] Larson PEZ, et al. Proc. 14th ISMRM, 340 (2006).

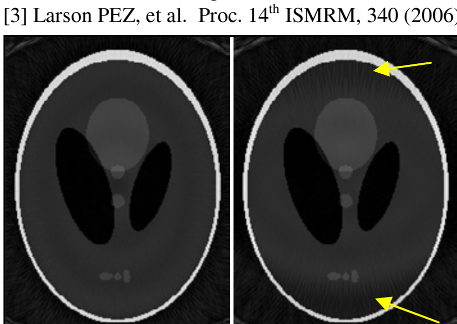

Figure 3: Elliptical (left) and circular (right) FOV, both with 16 blades and L = 20. The arrows indicate signal dropout.

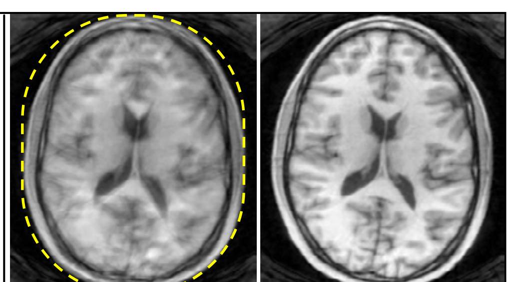

Figure 4: Reconstructions of simulated PROPELLER data with artificial motion without (left) and with (right) motion correction using an oval FOV with 31 blades and L = 12.

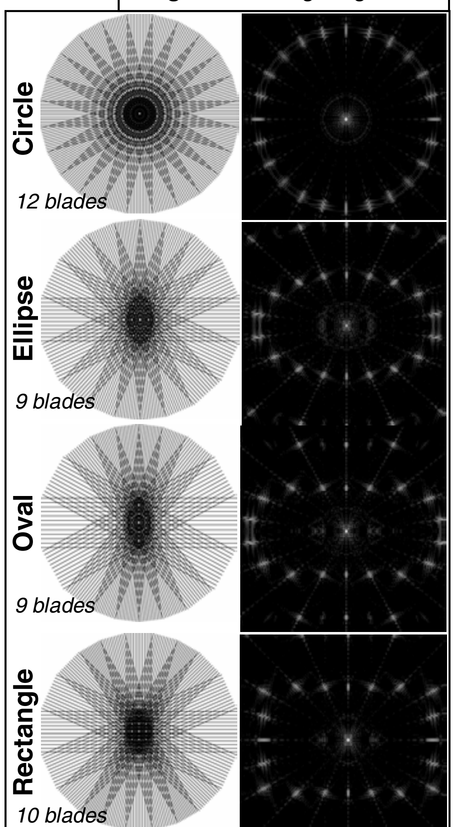

Figure 2: PROPELLER sampling patterns (left) and PSFs (right).