2D-Selective RF Excitations Based on the PROPELLER Trajectory

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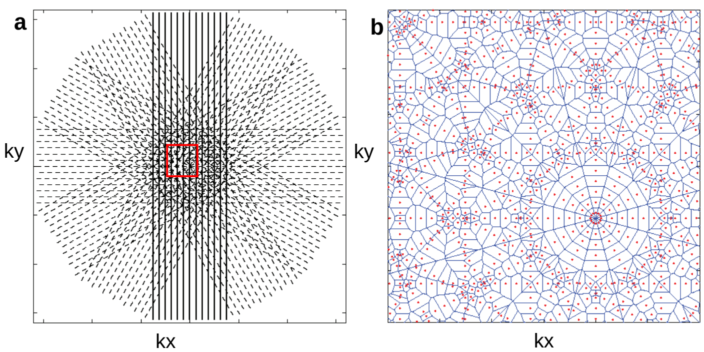
2D-selective RF (2DRF) pulses [1] are often segmented in order to shorten the duration of the excitation. For the commonly used blipped-planar trajectory this segmentation has the adverse effect that only one segment covers the center of k-space and delivers a significant flip angle. Here, 2DRF based on the PROPELLER trajectory [2] are presented. The trajectory consists of segments of parallel lines which are rotated to one another. The center of k-space is covered by all segments which yield larger flip angles for all segments. To minimize artifacts related to off-resonance effects like chemical shift or magnetic field inhomogeneities non-selective refocusing pulses were added [3,4].

Methods

In order to compensate for the non-uniform sampling of k-space by the PROPELLER trajectory (Fig. 1a), a Voronoi diagram (Fig. 1b) of the support points of the RF pulse is used to estimate the sampling density that is required to calculate the RF amplitude [5]. Measurements were performed on a 3T whole-body MR system (Siemens Magnetom Trio) using a standard twelve-channel head coil and a spherical oil phantom. Each of the six segments of the utilized trajectory consists of 13 lines. The chosen 2DRF trajectory had a resolution of 1x1 mm². A spin echo sequence at a resolution of 1x1x5 mm³ was used to acquire 2DRF profiles. Non-selective refocusing pulses were added to reduce the 2DRF's sensitivity to frequency offsets. The pulse sequence of one segment of the PROPELLER-2DRF resembles that of a blipped-planar trajectory (Fig. 1c). The additional non-selective refocusing pulses (Fig. 1d) lengthen the duration of the excitation from 25 ms to 56 ms.



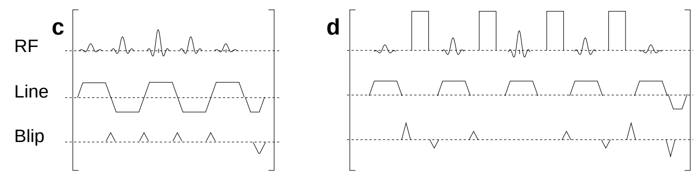


Figure 1: (a) PROPELLER trajectory with six segments, (b) corresponding Voronoi diagram of the red marked region, pulse sequence of one PROPELLER-2DRF segment (c) without and (d) with non-selective refocusing pulses.

Results and Discussion

As an example, Fig. 2 shows magnitude and phase images of three of the six segments of a circular excitation profile with a diameter of 30 mm. Complex averaging of the measured data over all segments results in the desired excitation profile (Fig. 2c). The side excitations are largely suppressed by the complex averaging to a maximum intensity of typically about 10% of the desired excitation profile. The excitation of arbitrarily shaped profiles with PROPELLER-2DRF is demonstrated in Fig. 2d with a brain-shaped profile at the size of 9x9 cm².

The MR images in Fig. 3 show the effect of a frequency offset and its compensation by the non-selective refocusing pulses. A frequency offset of 150 Hz which can occur in *in vivo* measurements as a consequence of magnetic field inhomogeneities leads to a displacement of the excitation profile for a single PROPELLER segment (Fig. 3b) and to pronounced blurring for the complete PROPELLER-2DRF (Fig. 3e), respectively. These effects can be compensated by the use of non-selective refocusing pulses (Fig. 3c and f).

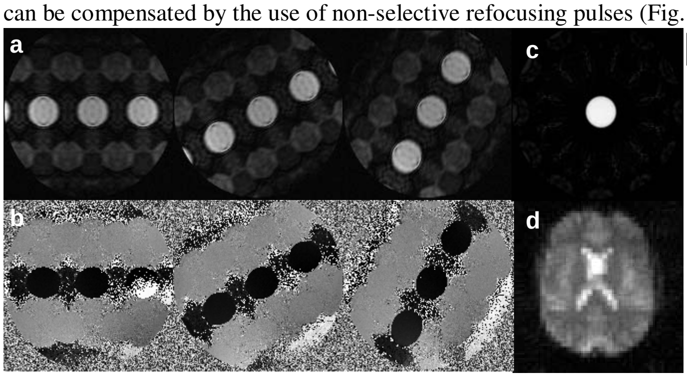


Figure 2: PROPELLER-2DRF of a circular profile:
(a) magnitude and (b) phase images for three of six segments and (c) magnitude of complex sum of all segments. (d) Brain-shaped excitation in an oil phantom with PROPELLER-2DRF.

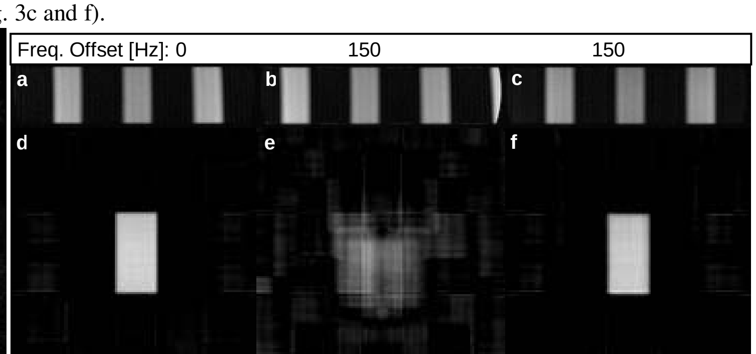


Figure 3: MR images of a rectangular-shaped excitation profile of 2x4 cm²: (a-c) one PROPELLER segment and (d-f) complete PROPELLER-2DRF. Non-selective refocusing pulses are used for (c) and (f).

References

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