

Analysis of Variable Density FLORET trajectories

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INTRODUCTION: FLORET is an efficient 3D k-space trajectory[1], described in Fig. 1, which samples data twice, in orthogonal directions. The 2X oversampling doubles minimum scan time but has favorable characteristics for undersampling. Undersampled FLORET reduces overlap inefficiency, and has an incoherent aliasing pattern, favorable for simple reconstruction, as well as advanced reconstruction methods such as compressed sensing. This work specifically investigates the undersampling properties of FLORET, using a variable density Fermat base spiral - some comparisons are also made with the stack of spirals (SOS) trajectory.

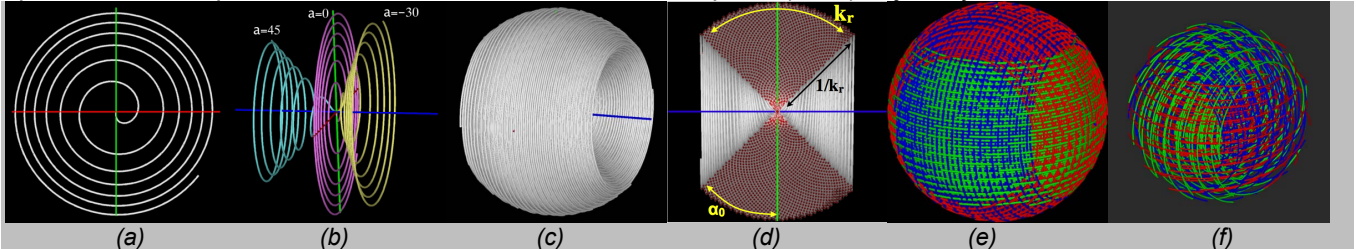


Fig. 1. A base (a) Fermat spiral is laid out on (b) successive cones (one spiral per cone); each spiral is successively rotated by the golden angle [2]. A set of these form (c) a hub, which when cut in half (d) illustrates uniform inter-trajectory spacing. Three orthogonal hubs (e) sample k-space twice in orthogonal directions. Undersampling (f) is incoherent, and also reduces overlap.

SIMULATION: SOS & FLORET trajectories were designed for a 24cm FOV with 240 (cylinder) and 275 (sphere) matrices, respectively, for equivalent resolution. ADC time was fixed at 14.2msec, and the number of interleaves was reduced by R relative to the number needed for critical sampling. Unity was gridded in k-space (after density correction) using a gridding kernel reflecting data correlation from a 24cm FOV, and the resulting volume was summed to estimate the total fraction of the volume sampled vs. # interleaves. For 1000 interleaves or less, SOS and FLORET sample roughly the same volume - this corresponds to $R \geq 2.5$ for SOS, and $R \geq 5$ for FLORET.

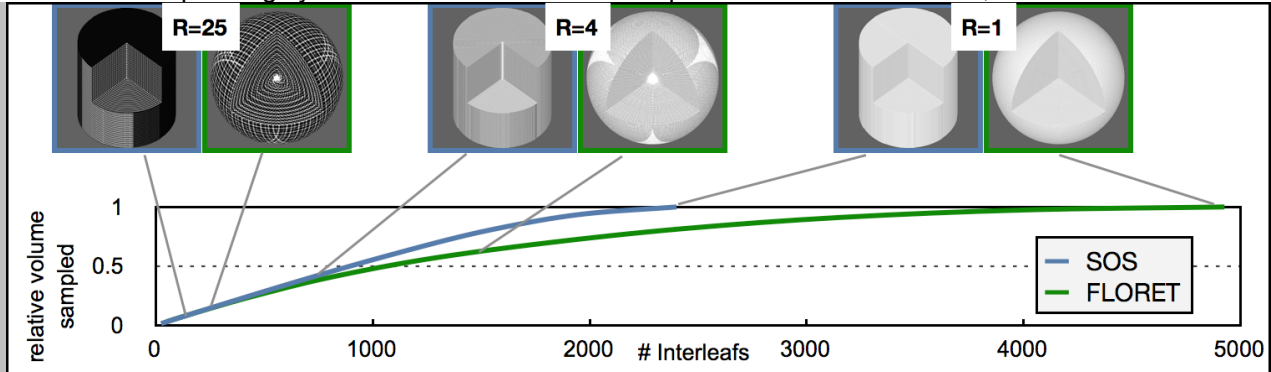


Fig. 2. FLORET and SOS sampling efficiency vs. # of interleaves. Images (top) illustrate the sampling patterns for SOS (cylinder) and FLORET (sphere), while the fraction of the volume sampled is plotted for various levels of undersampling.

DATA: FLORET 3D trajectories were designed for a 240mm FOV with 1mm resolution, with ADC 4msec (TR 17 msec), to run on a GE 3T scanner. The inner 10% radius of k-space was critically sampled, then sampling was increased linearly to a radius of 30%, after which it was held constant for a resulting $R=1, 4, \text{ and } 9$.



Fig. 3. FLORET images with $R =$ (a) 1, (b,c) 4, and (d,e) 9 (scan time 2' 53", 58", and 26"). Images are reconstructed (a,b,d) without and (c,e) with CG-SENSE[3] using an 8-channel head coil (note there was no coil support for S/I unaliasing).

CONCLUSION: A variable-density FLORET trajectory was created and analyzed for sampling efficiency. In-vivo data illustrate the incoherent sampling pattern obtained from undersampling in all dimensions. Undersampled FLORET is a very efficient center-out 3D trajectory.

REFERENCES: [1] Pipe et. al., ISMRM 2010 Annual Meeting, abstract 4974, [2] Winkelmann et al, 2007, IEEE TMI, 26:68-76, [3] Pruessmann et. al., Mag Res Med 2001 46(4): 638-51.