A New K-space Trajectory for Compressed Sensing MRI
Ya Li1 and Ran Yang1

1School of Information Science and Technology, Sun Yat-Sen University, Guang Zhou, Guang Dong, China

INTRODUCTION
A new k-space trajectory for compressed sensing MRI (CS-MRI) is proposed in this paper. Our approach is motivated by the CS theory[1] which shows that random sampling pattern is preferred for better signal reconstruction performances. For MRI scanner, however, random sampling would yield longer sampling trajectory than spiral trajectory because of the hardware constraints. Several attempts by applying random under-sampling patterns along radial and spiral sampling trajectories were reported[2,3]. However, there is a difference between CS and MRI is often neglected, That is CS aims to reduce the number of sampling points, while the scanning time of MRI not only depends on the number of sampling points but also on the length and curvature of k-space trajectory. Inspired by this viewpoint, we introduce a new k-space trajectory for CS-MRI, which is a smooth, short, random-like and with variable density. Simulation results demonstrate its good image reconstruction performance from under-sampled k-space data by using CS algorithms.

METHODS
The new trajectory named as four leaved rose curve (FLRC), is defined by \( r = 2 \sin 3\theta \), where \((r, \theta)\) denotes the standard polar coordinates. It can be described in \((k_x, k_y)\) plane as \( k_x = 2/3(\sin 3\phi + \sin \phi) \), \( k_y = 2/3(\cos 3\phi - \cos \phi) \). The gradient waveforms of this trajectory can be expressed as \( g_x = a/(2\gamma)(3\cos 3\phi + \cos \phi) \), \( g_y = a/(2\gamma)(\sin \phi - 3\sin 3\phi) \). This trajectory is periodic with a period of \( 2\pi \), where \( a = 1/2\delta_r \) depends on the image resolution and the FOV, \( \delta_r \) is the image resolution, \( \gamma \) is the gyromagnetic ratio. When the hardware constraints is applied to the gradient design—peak gradient amplitude and its slew rate, we can get a practical trajectory around the origin, it can be described as: \( \text{ktraj} = k^* \exp(2\pi i [1:N]/N) \), where \( k = k_x + ik_y \), is the single shot trajectory, \( N \) is the number of multi-shots. Figure 1(b) shows the 15-shot trajectories. Figure 1(c) is the point spread function (PSF) of this15-shot trajectories, the maximum of the side-lobe is only 0.2347 which is smaller than the variable density spiral with the same number of sampling points.

RESULTS and DISCUSSION
Figure 3(a), (b) demonstrated the reconstructions respectively from variable density spiral and FLRC under the same number of sampling points and reconstruction algorithm. Simulations show that FLRC trajectory has better fidelity than spiral. There is existing artifacts which indicated by the red arrows in figure 3(a), in contrast, there is no obvious artifacts in figure 3(b). The good fidelity should be attributed to the following two aspects: 1).The locations of FLRC sampling points are much smaller than the spiral trajectory. Comparing the second column of figure 3 (a) with (b), we can find that these artifacts are different. For spiral, the artifact looks like more regular, however, it is noise-like for FLRC. 2).The FLRC trajectory has much smaller side-lobe of PSF than spiral trajectory. That means a incoherence which is the very important requirement for CS

CONCLUSION
The FLRC is a short, smooth, variable density and random-like trajectory, simulations show it is well-suited to CS-MRI. However, it has two disadvantages: firstly, there is oversampling in the periphery of the k-space. Secondly, it exists a few cross-points, which would reduce the sampling efficient.

REFERENCES