Non-gridded Poisson Disk Sampling for Compressed Sensing Magnetic Resonance Image Reconstruction

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Compressed sensing (CS) methods can be used to reconstruct MRI signals from highly undersampled data [1]. Recent studies have shown that selecting gridded samples using a Poisson disk sampling pattern yields improved reconstructions over the traditional uniform random sampling of a Cartesian grid [2]. We extend this work by evaluating the effects of Poisson disk sampling of a continuous *k*-space on MR image reconstruction quality.

Our methodology consists of two stages: randomly sampling *k*-space and CS-MRI reconstruction. First, for a given number of samples and a minimum separation distance, we randomly select points on a rectangular, continuous space. We then assign those sample locations complex values corresponding to the *k*-space data of an analytic phantom. Second, we perform a CS-MRI reconstruction of the undersampled *k*-space data using a conjugate gradient approach [1]. We then compute the normalized l_2-norm distance between the reconstructed image and the true phantom.

We selected an analytic Shepp-Logan phantom [3] for our experiments. Furthermore, we chose a reconstructed image size of 128x128 pixels and a sampling rate of 42%. We varied the minimum separation distance from 0 (uniform random sampling) to 0.192 (the maximum separation distance). An example of the sampling patterns and the resulting reconstruction are presented in Fig 1(a). We performed five simulations for each separation distance and averaged the resulting l_2-norm distances. Fig 1(b) contains a plot of the l_2-norm distance versus the minimum separation distance.

Our results indicate that non-gridded Poisson disk sampling improves reconstruction quality over that of uniform sampling. Furthermore, there appears to be a cut-off minimal spacing at which reconstruction quality is improved. Our future work involves performing this experiment on real data and varying the sampling rate.

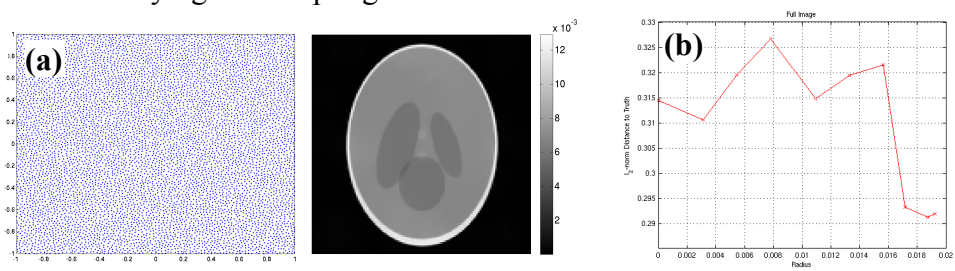

Fig 1: (a) Example of maximal Poisson disk sampling and the resulting CS-MRI reconstruction. (b) Reconstructed image error versus minimum separation distance.

[1] M. Lustig et al., MRM, 58(6), 2007. [2] M. Usman et al., SampTA 2006. [3] C. Koay et al., MRM, 58(2), 2007.