Uniform versus random undersampling strategies for accelerating dynamic MRI

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Encoding speed in MRI is inherently limited due to hardware and physiological constraints, which in turn poses challenges when imaging dynamic objects. The general sampling process in dynamic MRI may be viewed in *k-t* space as an extension of the spatial frequency domain *k* by a time axis *t*. Accordingly, in 2D dynamic imaging a three-dimensional *k-t* space is available for designing appropriate undersampling schedules. Two fundamentally different undersampling and reconstruction strategies have been pursued to recover missing information in dynamic MRI. The first strategies may be referred to as uniform undersampling along a sheared grid pattern in *k-t* space. With rectilinear sampling this will result in a simple aliasing pattern which permits solving the inverse problems on a scale given by the undersampling rate. A number of so-called *k-t* sampling methods and reconstruction techniques have been proposed (1-3) and will be illustrated in this talk. In contrast to uniform undersampling, Compressed Sensing requires incoherence between the sensing domain and the object or any transform thereof. Accordingly, random sampling schedules have designed to approach the requirement (4-6).
Using in-vivo MRI examples, it will be demonstrated that both undersampling and reconstruction strategies have their relative merits and limitations. Undersampling limits for typical clinical applications will be discussed along with examples showing image degradation once undersampling exceeds a critical factor.

(1) Kellman P, Epstein FH, McVeigh ER. Adaptive sensitivity encoding incorporating temporal filtering (TSENSE). Magn Reson Med. 2001;45(5):846-52.
(2) Tsao J, Boesiger P, Pruessmann KP. k-t BLAST and k-t SENSE: dynamic MRI with high frame rate exploiting spatiotemporal correlations. Magn Reson Med. 2003 Nov;50(5):1031-42.
(3) Huang F, Akao J, Vijayakumar S, Duensing GR, Limkeman M. k-t GRAPPA: a k-space implementation for dynamic MRI with high reduction factor. Magn Reson Med. 2005;54(5):1172-84.
(4) Lustig M, Donoho D, Pauly JM. Sparse MRI: The application of compressed sensing for rapid MR imaging. Magn Reson Med. 2007;58(6):1182-95.
(5) Gamper U, Boesiger P, Kozerke S. Compressed sensing in dynamic MRI. Magn Reson Med. 2008 Feb;59(2):365-73.
(6) Jung H, Sung K, Nayak KS, Kim EY, Ye JC. k-t FOCUSS: a general compressed sensing framework for high resolution dynamic MRI. Magn Reson Med. 2009 Jan;61(1):103-16.