Interpolated Parallel Imaging Compressed Sensing

Yong Pang[1] and Xiaoliang Zhang[1,2]

[1]*Radiology & Biomedical Imaging, University of California San Francisco, San Francisco, CA, United States,* [2]*UC Berkeley/UCSF Joint Graduate Group in Bioengineering, Berkeley & San Francisco, CA, United States*

Introduction: The interpolated compressed sensing [1] has been introduced to further reduce the acquisition time and improve the contrast to noise ratio (CNR) for multislice 2-dimensional MR imaging by using the raw data from the neighboring slice multiplied by a proper weighting function. In this project, we further applied this method to the combination of parallel imaging and compressed sensing, which is named interpolated parallel imaging compressed sensing (iPICS) for multi-slice 2-dimensional parallel MR imaging. The raw data of each slice from each channel is multiplied by a weighting function and then used to estimate the missed k-space data of the neighboring slice from the same array channel, which helps improve the image quality of the neighboring slice. In-vivo MR of human has been used to investigate the feasibility of the proposed method, showing obviously increased SNR and CNR compared with conventional parallel imaging method.

Theory and method: The flowchart of the interpolated parallel imaging compressed sensing (iPICS) is shown in Fig.1:

1. SENSE undersampling strategy was firstly used to undersample the k-space for each channel;
2. The low resolution images were acquired to estimate both the sensitivity map of each channel and the weighting function of iCS;
3. Variable-density sampling scheme and Mote-Carlo incoherent sampling strategy were used to undersample the *k*-space samples for each slice from each channel;
4. The k-space data from one slice was multiplied by the weighting function and interpolated into the k-space of the neighboring slice to estimate the missed phase-encoding lines;
5. Non-linear conjugated gradient was used to perform image reconstruction for iCS for each slice from each channel;
6. The reconstructed iCS images from each channel and the sensitivity maps were used together to perform SENSE reconstruction to get the final image.

To investigate the feasibility of the proposed method, a healthy human knee was used in in-vivo MR imaging at GE whole body 7T scanner with the following imaging parameters: TE=7ms, TR=100ms, matrix size =256×256, field of view (FOV) =14cm, slice thickness =3mm, number of excitation=1. In plane resolution was 0.54mm, phase encoding is S/I direction. The iCS undersampling rate is 1/20 for each even slice while 1/4 for each odd slice, while the SENSE undersampling rate is 1/2. Therefore the total undersampling rate for iCS is 1/40.

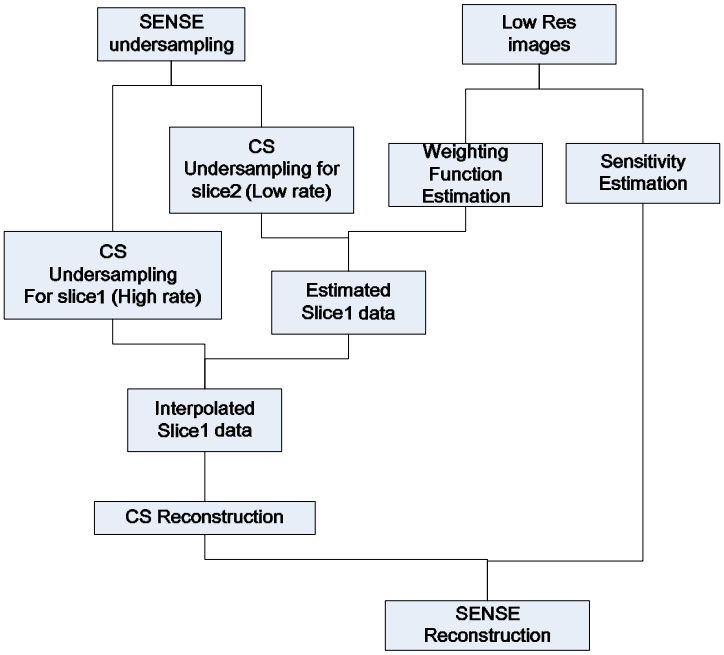

Fig.1 Diagram of the proposed iPICS method for accelerated imaging.

Results: Fig.2 shows knee MR image on axial plane by using iPICS reconstruction. The left 8 images are the individual image from each channel of the 8-channel coil, while the middle image is the result reconstructed from iPICS with 1/40 undersampling rate. The image on right is reconstructed using the conventional parallel imaging method with 1/6 acceleration rate. The image error is evaluated by using:

$$IE = \sqrt{\sum_j \frac{(I_j^{Ref} - I_j^{us})^2}{(I_j^{Ref})^2}} \quad (1)$$

, where I^{Ref} represents the signal intensity of the jth pixel in the full k-space reference image, and I^{us} represents the signal intensity of the jth pixel in the undersampled images using conventional or iPICS methods. It is demonstrated that the image error has been decreased while the CNR has been greatly improved by using iPICS.

Conclusions and discussions: The iPICS reconstruction method has been proposed in this work to improve the CNR, reduce the image error and shorten the acquisition time for the significantly undersampled sparse MRI. The missed k-space data from each channel are estimated using the neighboring slice k-space lines, resulting in higher CNR and smaller image error without acquiring more k-space data. In-vivo MR images of human foot has demonstrated the feasibility of the proposed method.

References: [1] Lustig M, et al, Magn Reson Med 2007; 58: 1182-1195. [2] Jung H, et al, Magn Reson Med 2009; 61: 103-116. [3] Pang Y, et al, ISMRM 2012; p2275.

Acknowledgements: his work was partially supported by NIH grants EB008699 and P41EB013598, and a QB3 Research Award.

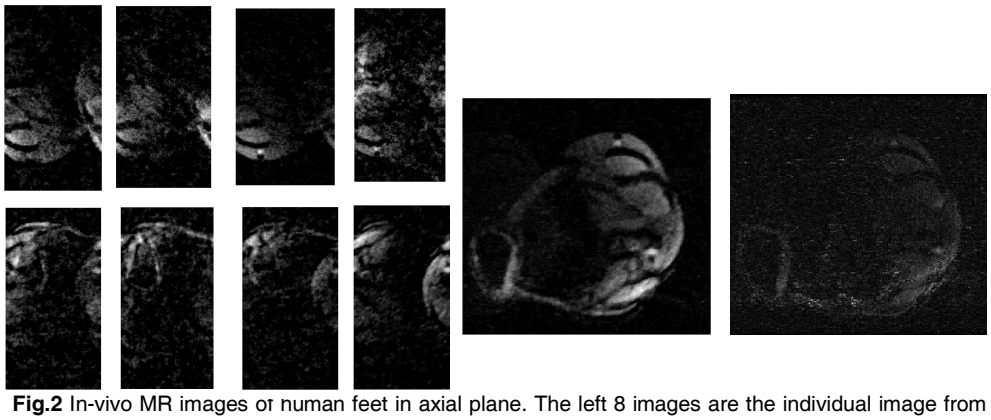

Fig.2 In-vivo MR images of human feet in axial plane. The left 8 images are the individual image from each channel of the 8-channel coil, while the middle image is the result reconstructed from iPICS with 1/40 undersampling rate. Right image is reconstructed using SENSE at acceleration factor of 6.