

Investigation of Number of Direction Selection for Joint Reconstruction in Multiple-direction Diffusion Imaging

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TARGET AUDIENCE: Researchers and clinicians interested in image reconstruction for DTI/high angular diffusion imaging

PURPOSE: To accelerate acquisition of diffusion weighted imaging, especially high angular diffusion imaging, several reconstruction methods utilizing correlation among images of different diffusion directions have been proposed, such as distributed compressed sensing [1] and low rank model [2]. While these methods assume images of different directions share common information, none of them presents a criterion to determine how many directions should be chosen to for the reconstruction of one specific direction. Theoretically it may not be appropriate to combine all directions acquired together; otherwise the existence of anisotropic diffusion from other directions may cause blurring artifacts and thus affect the accuracy of results. In this study, we compare the performance of common information enhanced reconstruction method when different number of directions are combined.

METHODS: A series of 32-direction brain DW images acquired using RESOLVE technique on a 3T Siemens scanner (Siemens, Erlangen, Germany) were used as the references. Simulated k-space data were obtained as following. The reference images were firstly multiplied by simulated 8-channel coil sensitivity maps and then Fourier Transformed. Next, the k-space data were artificially undersampled with Poisson disk sampling pattern, as shown in Fig. 1 (B). The sampled k-space locations were randomly distributed so that each direction provided complementary information for the other directions.

Three different methods, key-hole, image ratio constrained reconstruction (IRCR) [3] and Common-Information enhanced SPIRiT [4] (CI-SPIRiT) were used to reconstruct the DW images from the undersampled data. CI-SPIRiT uses IRCR results as initialization of SPIRiT for the image reconstruction, of which the details can be found in our abstract (abstract No. 6920) this year. Different direction numbers were tested to find the optimal combination for the image reconstruction. For the diffusion direction selection, we gradually expanded the adjacent region around one specific direction to increase the number of combination.

RESULTS AND DISCUSSION: Reconstructed images of one representative direction with different reduction factors using three methods are shown in Fig. 2. Using key-hole and IRCR, the images suffer from strong blurring even at low reduction factors, and blurring becomes even worse when the reduction factor becomes higher. Using CI-SPIRiT, blurring is detectable only when $R>6$. Fig. 3 shows normalized root mean square error (NRMSE) from CI-SPIRiT reconstruction results using different combined direction numbers (ranging from 1 to 30) and different reduction factors. This result indicates that inaccurate results will be obtained when too many directions are used for the reconstruction of one specific direction. Specifically, when $R=3$ and 4, NRMSE will increase when the combination number is larger than 10, with optimal number=6 and 8 respectively; for $R=6$ and 8, no obvious change exists when the number is larger than 10, because the image has already been severely blurred.

CONCLUSION: In order to take advantage of other direction information in common information enhanced reconstruction, care should be taken to include other directions data for the calculation of DTI or high angular diffusion imaging.

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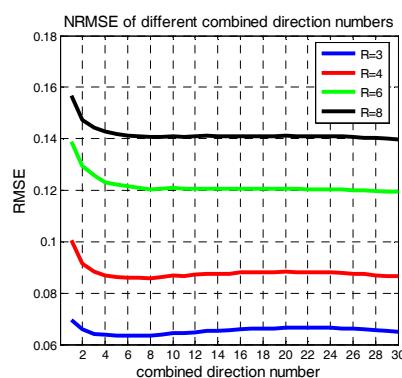


Fig. 3 Comparison of NRMSE using different combined directions numbers.

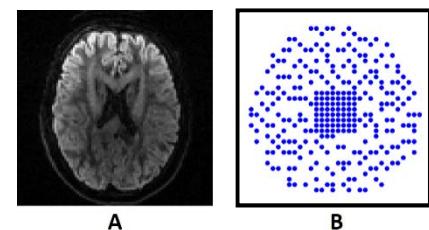


Fig. 1 A) Reference DW image of one selected direction; B) Poisson disk sampling pattern.

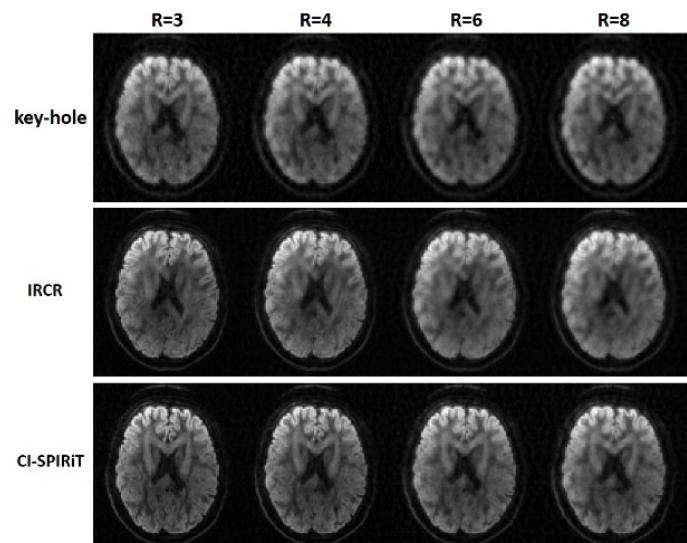


Fig. 2 Comparison of results by three methods using different reduction factors.