High Resolution DTI using Highly Undersampled Variable Desnity Acquisition and iCORNOL Reconstruction

Wenchuan Wu[1], Sheng Fang[2], Chun Yuan[1,3], and Hua Guo[1]

[1]Center for Biomedical Imaging Research, Department of Biomedical Engineering, School of Medicine, Tsinghua University, Beijing, China, People's Republic of,

[2]Institute of nuclear and new energy technology, Tsinghua Univerisity, Beijing, China, People's Republic of, [3]Department of Radiology, University of Washington, Seattle, WA, United States

INTRODUCTION

High resolution diffusion tensor imaging is a desirable technique to improve the depiction of neural anatomy structures. Earlier work has shown that the feasibility of achieving high resolution diffusion tensor imaging using an interleaved variable-density spiral (VDS) [1] readout trajectory and iterative phase correction algorithm (SNAILS technique) [2]. However, this technique requires long acquisition time even for low directional resolution, such as 6 directions. With parallel imaging [3], the acquisition speed can be increased, but higher acceleration factor for parallel imaging introduces amplified noise which then hinders the practical application. CORNOL reconstruction [4] has been proved to be effective in noise suppression and image structure preservation for high acceleration acquisitions. This study combines highly accelerated parallel imaging and VDS for high resolution DTI. Improved CORNOL (iCORNOL) which is tailored for VDS DTI is employed for artifacts suppression. To our knowledge, it is the first time to develop high spatio-temporal resolution DTI on Philips 3T MRI scanner.

METHODS

An interleaved VDS [1] diffusion weighted sequence was implemented on a Philips 3T clinical scanner (Achieva, Philips, Best, The Netherlands) equipped with a high performance gradient set (60mT/m per gradient axis, slew rate 200mT/m/msec). Brain images were acquired from three healthy volunteers using an 8-channel head coil. Scan parameters were: b = 600 s/mm^2, FOV = 220 × 220 mm^2, matrix size = 256 × 256, slice thickness = 5 mm, TR/TE = 2500/80ms, α = 3 (α is the parameter controlling the sampling density), number of interleaves = 24, readout duration for each interleave = 16.9ms (3456 points), acquisition bandwidth = 100 kHz, diffusion encoding directions = 6. All subjects provided informed written consent.

For parallel imaging, reduction factor was 4. iCORNOL (refer to our another abstract 4341 for technical details) reconstruction was compared with conjugate gradient SENSE (CG-SENSE)[5]. All reconstruction methods were combined with direct phase subtraction.

RESULTS AND DISCUSSIONS

The first row in Fig.1 shows b0 image, diffusion weighted image, trace map and FA map from fully sampled data. 2nd row in Fig.1 shows results from undersampled data reconstructed by CG-SENSE. With a reduction factor as high as 4, aliasing artifacts are unacceptable. Additionally, CG-SENSE reconstruction introduced significant noise which decreases the accuracy of

Fully Sampled data

CG-SENSE

iCORNOL

b = 0   DWI   Trace map   FA map

Fig.1

high resolution diffusion tensor imaging. This problem can be better visualized from the FA map, from which no contrast information can be acquired. 3rd row of Fig. 1 shows the iCORNOL reconstructed image using the same set of under sampled data as 2nd row. Blurring and aliasing artifacts are largely alleviated, structure information and contrast are mostly preserved. Moreover, SNR loss is much smaller compared to images reconstructed from CG-SENSE. Parallel imaging based on SENSE reconstruction provides a choice to reduce the total scan time but may introduce amplified noise that can dramatically degrade the quality of final images, regularization alleviates the problem by imposing priors on parallel imaging reconstruction. iCORNOL, which is exclusively tailored for VDS, uses intrastructure smoothness to preserve the image structure and reduces noise, and achieves significant improvements of image quality in this experiment.

VDS is one of optimal choices for multi-shot diffusion weighted imaging due to its self-navigating capability and insensitivity to motion. Another advantage of variable density trajectory is the incoherent undersampling artifacts, which make it suitable for nonlinear reconstruction methods. One drawback of VDS is its sensitivity to eddy current. This problem could be lessened by measuring spiral trajectories, which were widely studied.

CONCLUSIONS:

A high spatio-temporal resolution DTI sequence was implemented on Philips 3T clinical scanner and iCORNOL was applied for the highly accelerated acquisition reconstruction. Previous studies using parallel imaging method for high resolution DTI had a reduction factor up to 3 [6]. Our preliminary results demonstrated that scan time can be further reduced by a factor of four with well-reserved structure details and considerable high SNR. Further studies are needed to optimize the sequence parameter and reconstruction algorithm.

REFERENCE: [1] Dong-hyun Kim et al. MRM 2003; 50:214-219. [2] Chunlei Liu et al. MRM 2004; 52:1388-1396 [3] Pruessmann KP et al. MRM 1999; 42:952-962. [4] Sheng Fang et al. MRM 2010; 64:1414-1426. [5] Pruessmann KP et al. MRM 2001; 46:638-651; [6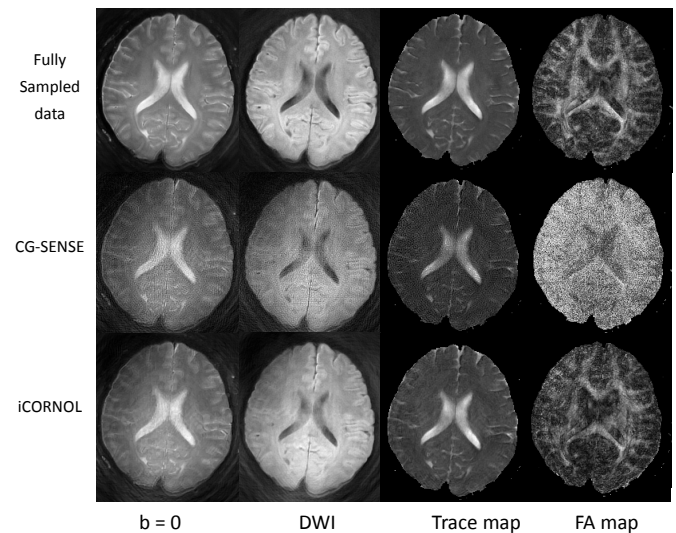] Chunlei Liu et al. MRM 2004; 52:1388-1396.