An Improved TRICKS Method for Dynamic Contrast-Enhanced Tumor Imaging

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INTRODUCTION: 3D dynamic contrast-enhanced (DCE) imaging is a widely used technique for tumor diagnosis. A major challenge in this application is to fast sample the dynamic signal variations while keeping the spatial resolution. TRICKS is a reduced-encoding imaging method where k-space data are temporally subsampled during data acquisition and then recovered by linear interpolation before image reconstruction. Significant errors can be introduced by the linear interpolation when underlying signal variations show nonlinear behavior, for example, in DCE experiments where the signals show a rapid enhancement phase followed by a slow decay phase. This abstract presents a new image reconstruction scheme to improve the TRICKS method. Using a nonlinear interpolation scheme, the new method can capture dynamic signal variations more accurately. Experimental results from a DCE mice tumor study are presented to demonstrate the effectiveness of the proposed method.

METHOD: As in TRICKS, the k-space is divided into several groups, for example, group A covering the central k-space, groups B and C covering the outer k-space. A is sampled in every data frame while B and C are sampled less frequently, for example, in every *M* frames. By subsampling the out k-space, the frame rate can be correspondingly accelerated. Denote *i* as the frame index. TRICKS interpolates data B using $B(i)=(1-\alpha)B(i')+\alpha B(i'+M)$ where *i'* is the index of the nearest previous data frame, $\alpha=(i-i')/M$ is the linear interpolation coefficient. In the proposed method, B and C are not linearly interpolated in this fashion. Instead, two coefficients β and γ are generated by fitting the following two linear systems: $A(i)=\beta A(i')$ and $A(i)=\gamma A(i'+M)$. Then data B is interpolation using $B(i)=[\beta B(i')+\gamma B(i'+M)]/2$. Note that β and γ do not correspond to the time as in the original TRICKS method. In addition, both coefficients are complex numbers which are capable of correcting the global phase difference between the data sets. After all missing data groups are interpolated, the conventional Fourer reconstruction is used to generate the high resolution image sequence and subsequent kinetic analysis may be carried out if necessary.

RESULTS: The proposed method has been tested using real MR data sets. A typical set of results is shown in Fig. 2. The original data sets were collected on a SISCO 4.7 T / 33 cm bore system using a rapid T1-weighted gradient echo sequence (FOV = FE 24 cm / 512 × PE 6 cm / 128; averages = 2; TR = 63 msec; TE = 4.3 msec; thk = 2 mm; slices = 7) during a DCE mice tumor study. Figure 1 shows a representative 2D slice with the highlighted tumor region. To use the proposed method to process the measured data, we subsampled the measured data frames with *M=14* except for the 16 central dynamic encodings. The dynamic data sets are nonlinearly interpolated as described and a sequence of images are then generated. Two other methods, Keyhole and the TRICKS method are also used to reconstruct the images. The results are compared to the "ground truth" obtained from Fourer transformation of the original data sets. After image reconstruction, the dynamic enhancement curves corresponding to the highlighted region in Fig. 1 are generated. As shown in Fig. 2, the proposed method reconstructed the dynamic signal variations most closely to the "ground truth".

CONCLUSION: We have developed an improved reconstruction scheme for dynamic imaging of tumors using the TRICKS data acquisition scheme. Experimental results have shown that the scheme is capable of reconstructing high resolution image sequences and captures dynamic signal variations with higher accuracy than the existing methods. The proposed improvement may be potentially used in a number of 3D dynamic imaging applications, such as time-resolved MRA, contrast uptake studies, and fMRI.

Figure 1. A 2D slice showing the location of the highlighted tumor region.

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REFERENCE

[1] Korosec FR, Frayne R, Grist TM, Mistretta CA. Magn Reson Med 1996;36:345–351.

[2] Carroll TJ, Korosec FR, Petermann GM, Grist TM, Turski PA. MR angiography. Radiology 2001;220:525–532.

[3] Brummer ME, et. al, Proc. 11th SMRM, 1992; 4236.

[4] Aref, M., Brechbiel, M. & Wiener, E. C. (2002) Investigative Radiology 37, 178-192.

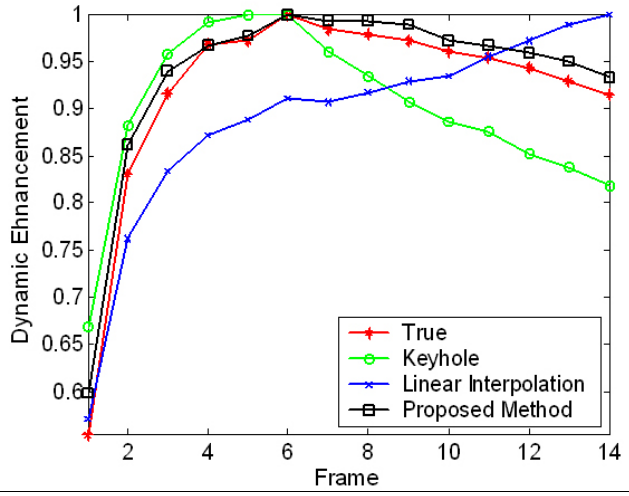

Figure 2 Dynamic signal enhancement curves due to the contrast agent injection. Curves reconstructed using three methods (Keyhole, TRICKS with linear interpolation and the proposed method) are compared with the "ground truth".