Feasibility test of non-iterative reconstruction for high spatiotemporal resolution DCE

Zhifeng Chen[1], Ming Yang[2], Liyi Kang[3], Ling Xia[3], and Feng Liu[4]
[1]Zhejiang University, Hangzhou, Zhejiang, China, [2]Philips Healthcare, Jiangsu, China, [3]Zhejiang University, Zhejiang, China, [4]The University of Queensland, Queensland, Australia

Introduction

Dynamic contrast enhanced (DCE) MRI has been widely used in the diagnosis of liver lesions and diseases, including hepatic cirrhosis, hepatocellular carcinoma, etc. DCE-MRI requires high spatial-temporal resolution and high Signal Noise Ratio (SNR) to yield accurate dynamic quantification results. A variety of methods have been proposed to fulfill the requirements. All of the existing methods, such as conjugate gradient SENSE (CG-SENSE) [1], iGRASP [2] and L+S [3], iteratively minimize an energy function combining parallel imaging and sparsity constraints. The iterative reconstruction is computationally expensive, and hence impeded the clinical application. The target of this work is to investigate if a non-iterative scheme can save computational time and result in comparable image quality. Both the static image quality and temporal fidelity of the non-iterative method were compared with the iGRASP and L+S. The results demonstrate that comparable image quality can be generated with over 5-time faster reconstruction speed by using the non-iterative scheme.

Methods

We propose to apply non-iterative parallel imaging and fast denoising separately to avoid expensive computational cost [4]. To explain the proposed scheme, we take the DCE-MRI with golden angle radial acquisition as an example. GRAPPA Operator for Wider Lines (GROWL) [5] is utilized as the non-iterative parallel imaging scheme to result in the initial intermediate reconstruction. Then denoising along both temporal and spatial directions are applied to reduce the noise/artifact level. As a specific example, temporal total variation (TV) and isotropic spatial TV are adopted in our implementation [6, 7].

We use the same DCE-MRI liver data as the original iGRASP paper for the convenience of comparison (http://cai2r.net/resources/software). The entire data set are divided into 28 image frames, 21 radial spokes per frame.

For iGRASP and L+S implementation, we used the same parameters and implementation code as in their original literatures. In our non-iterative scheme, after GROWL operator is applied for parallel imaging result, spatiotemporal TV denoising constraints are applied respectively for denoising. All the algorithms are implemented under Matlab (R2012b) running on a HP Elite Desk 800 with quad Intel Core i5-4570 CPU 3.20GHz and 4GB of Memory.

In order to assess the temporal intensity fidelity, two regions of interest (ROI) containing aorta (AO) and portal vein (PV) were manually chosen in every image frame for temporal signal-intensity plot analysis, as shown in Fig.1 (d).

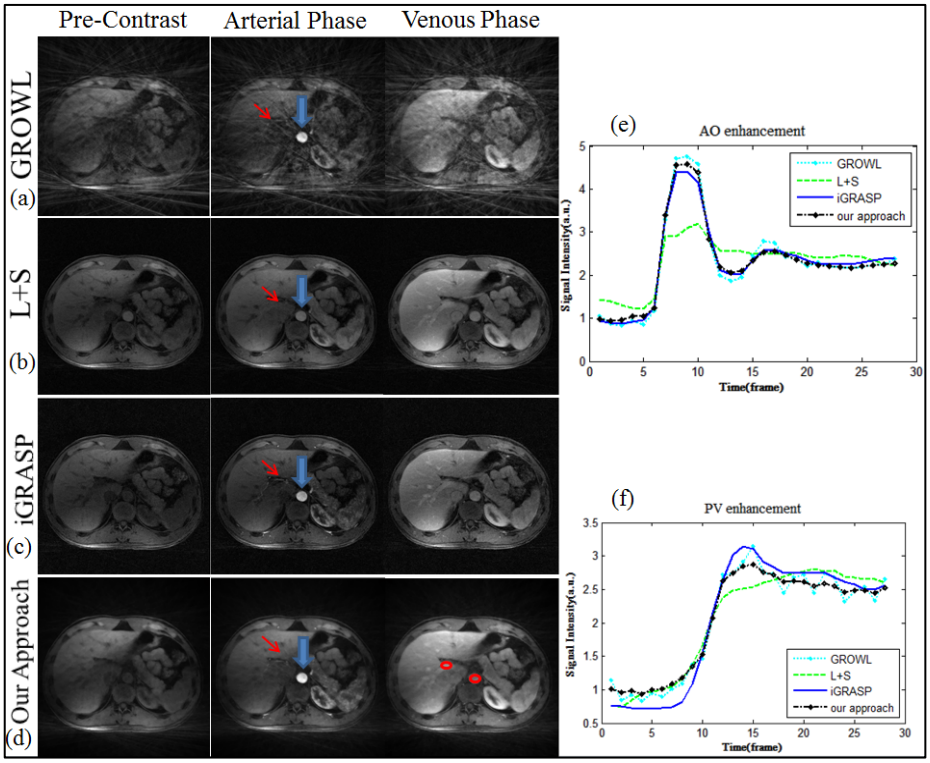

Fig.1 Result of reconstructed images and signal-intensity time courses

Results and discussions

Fig.1 (a) - (d) show the comparison of reconstructed images by various methods. Fig.1 (e) and (f) display signal-intensity time courses of two ROIs from each method to compare the temporal fidelity. The reconstruction time of iGRASP, L+S, and the non-iterative methods are 1309s, 479s and 235s individually. Compared to L+S, our approach is faster and more accurate. Compared to iGRASP, slightly lower quality, but much faster.

From the reconstruction result where the thin arrow point in Fig.1 (d), it can be seen that our approach preserves image details. Our approach gives image contrast of the aorta area consistent to GROWL and iGRASP, as shown in Fig.1, labelled by the wider arrow, while L+S result shows a slightly darkened aorta. The image quality of our result is comparable to iGRASP. In addition, our approach provides reliable time resolution as in the signal-intensity time courses in Fig.1 (e) and (f) which is almost comparable to iGRASP, slightly better than L+S. So the spatial and temporal resolutions offered by our approach are both comparable to iGRASP. While comparing the result of initial GROWL reconstruction with our approach, we can see that our denoising operator also works well. Most importantly, our method is computationally efficient, for the GROWL operator costs only 5s per frame.

Furthermore, our method can provide a flexible balance between spatial and temporal resolution, which allows a further fine-tune on demand.

Conclusion

Non-iterative parallel imaging and image denoising reconstruction can result in comparable image quality to iterative schemes with greatly reduced time cost. The proposed method improves the clinical applicability of high spatiotemporal resolution DCE.

References

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