Improved Dynamic Imaging with PS-Model-Based Sparse Sampling

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Introduction The Partial Separability (PS) of spatiotemporal signals has been exploited effectively for sparse (k, t)-space sampling in dynamic MRI [1]. It has been successfully applied to real-time cardiac MRI and myocardial perfusion [2,3]. In the conventional PS model-based sampling scheme, the navigator data (collected to define a temporal subspace) are reordered in every navigator cycle by using a projection strategy (see Fig. 1a). This reordering method assumes that temporal signal changes are negligible within the navigator cycle. However, this assumption may result in an suboptimal temporal subspace. To address this issue, we present a sliding window method for reordering the navigator data. *In vivo* cardiac imaging results demonstrated that the proposed method could produce much better reconstructions with higher temporal resolution.

Theory and Method In dynamic MRI, the measured signal $s(k,t)$ can be represented as $s(k,t)=\int_{-\infty}^{\infty}\rho(r,t)e^{-i2\pi k\cdot r}dr$, where $\rho(r,t)$ is the desired spatiotemporal images. The PS model assumes that $s(k,t)$ can be expressed as $s(k,t)=\sum_{l=1}^{L}c_l(k)\varphi_l(t)$, where L is the model order, $\{c_l(k)\}$ are the spatial basis functions, and $\{\varphi_l(t)\}$ are the temporal basis functions. Two datasets are collected, one with extended k-space coverage to provide the desired spatial resolution and the other (called navigators) with high temporal resolution to define the temporal subspace. A practical PS model-based sparse sampling scheme is shown in Fig. 1. Note the interleaved sampling of image and navigator data. Only one phase-encoding line of the navigator data is acquired in 2 TR. In order to estimate the temporal subspace accurately, it is desirable to collect several navigator phase-encoding lines at multiple k-space locations. In the conventional PS model, Q navigator lines are projected onto the first line in each navigator cycle (see Fig. 1a). And the temporal resolution of the conventional PS model is equal to Q*2TR. In this work, we use a sliding window method to rearrange the navigator data. In the proposed method, the adjacent navigator lines are re-used and projected onto the line at each 2TR (see Fig. 1b). Thus, the temporal resolution would be improved to 2TR.

Fig 1. Two different navigator data processing method in PS model. (a) Conventional projection method (b) Proposed sliding window method

Fig. 2. Comparison of the images reconstructed by (a) retrospective ECG triggering, (b) the conventional PS method and (c) the proposed method. (d) temporal evolutions of the left ventricle chamber in three methods.

Results The proposed method was implemented on a Siemens Trio 3.0 T scanner and demonstrated experimentally in cardiac imaging. The scanning protocol of a customized FLASH sequence includes: TR = 4.2 ms, TE = 2.1 ms, flip angle = 15°, matrix = 138x192, FOV = 244x340 mm^2, slice thickness = 8 mm, 5 phase-encoding lines in the navigator cycle. In order to evaluate the performance of the proposed method, the retrospective ECG triggering with the commercial FLASH sequence and the conventional PS method with the customized FLASH sequence were also conducted by using the same scanning protocol. Experiment results were shown in Fig. 2. It is clearly seen that the quality of reconstructed images have no significant differences among three methods. We also evaluated the temporal evolutions of the area of left ventricle chamber. In Fig. 2d, we can see that the proposed method captured 100 cardiac phases, while the conventional method captured only 20 cardiac phases. More cardiac phases have been captured and higher temporal resolution has been achieved by the proposed method.

Conclusion This abstract presented an improved method for PS model-based dynamic imaging with sparse sampling of (k, t)-space. Experimental results from cardiac imaging show that higher temporal resolution can be achieved by the proposed method.

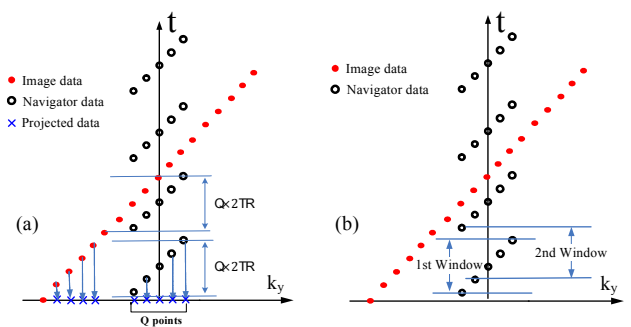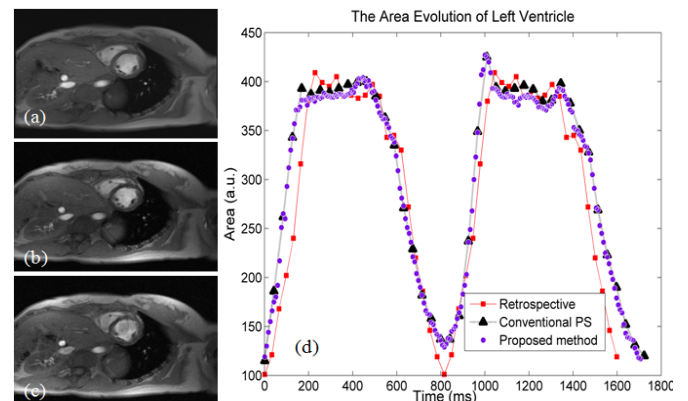**Reference** [1] Liang, Z.-P. IEEE-ISBI 2007. pp. 988-991. [2] Brinegar, C. et al., IEEE-EMBS 2008. pp. 3381-3384. [3] Brinegar, C. et al., Magn Reson Med 64:1162-1170, 2010.