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Space-time variant weighted regularization improves motion reconstruction in compressed sensing accelerated cardiac cine MRI

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Topic: Preclinical Studies and Basic Science / Motion, artefacts, quality control

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Purpose / Introduction

In compressed sensing (CS) dynamic MRI, temporal sparsity is commonly exploited [1] introducing a temporal regularization that affects the dynamic behavior of the images in moving regions. While previous works proposed to combine different sparsity terms accounting for dynamic and static regions in the image [2], in this work we propose a methodology to dynamically adapt the temporal regularization according to the presence of motion. The proposed method is based on a robust registration technique for non-rigid motion estimation [3] a Variable Density k-space sampling [4]. It is applied to highly accelerated breath-hold cine data.

Subjects and Methods

A regular temporal Total Variation (tTV) CS reconstruction is used as base reconstruction, with the regularization weight λ chosen to maximize subjective visual quality. Motion is estimated using the method described in [3]. The deformation field obtained is used to leverage λ spatially and along time between λ_{max} –chosen to minimize reconstruction artifacts regardless of motion– and λ_{min} ––chosen to maximize the quality of motion reconstruction––. The method is compared with 1) standard tTV-CS 2) manual selection of a dynamic region and 3) the application of reference deformation fields.

Results

Figure 1 shows the reconstructed images and their temporal evolution. Regular tTV-CS shows high over-regularization in the temporal profiles. The proposed method provides more natural temporal profiles while preventing residual undersampling artefacts.
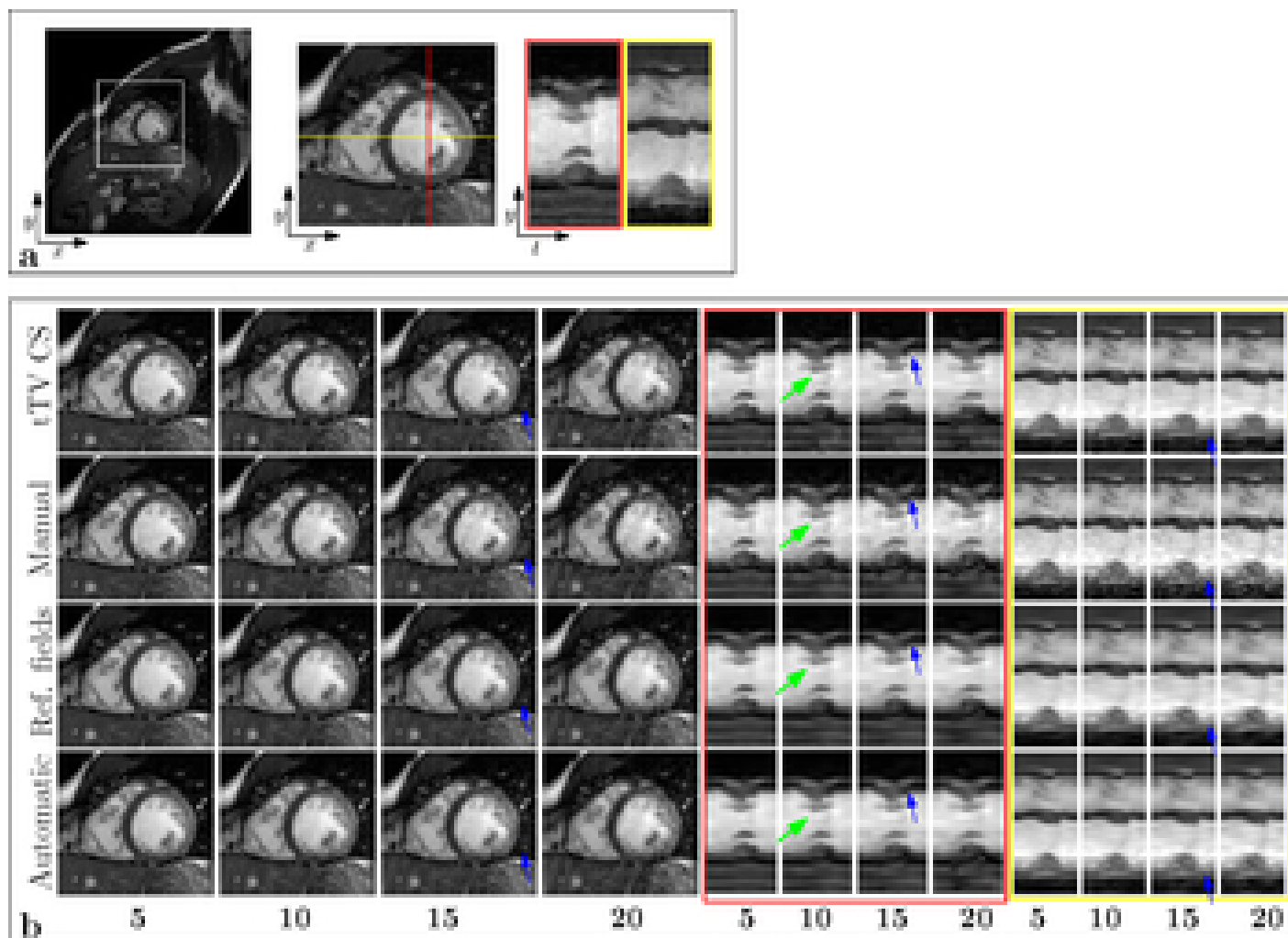

Figure 2 shows the mean square error of the reconstructed deformation fields within the myocardium as a function of the acceleration factor (AF). Results indicate that the usage of a unique λ is not optimum for high AFs. Results show the expected degradation of our method with respect to the ideal method in which deformation fields are known beforehand. This solution outperforms the tTV solution for the whole range of AF tested, which gives room to further improvements.
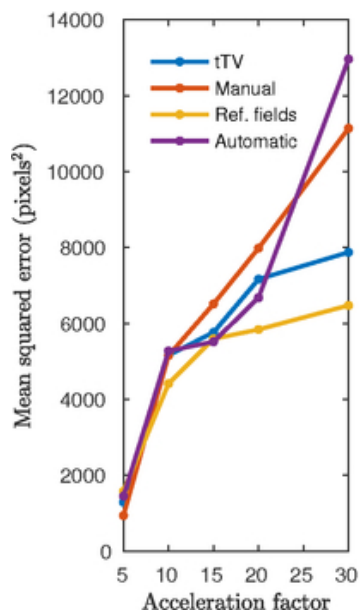
Discussion / Conclusion

Usage of a single regularization parameter reveals itself as not the best strategy for intermediate AFs, where a motion-weighted regularization parameter achieves better motion reconstruction. The interval (λ_{min}, λ_{max}) used can be further fine tuned if motion recovery is the priority, which would be the case if our method was used as an initialization of other involved methods that apply motion compensation to foster sparsity of the solution [3]. Additional research is needed to get closer to the ideal solution (orange line) by refining the motion estimation algorithm.

References

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