Motion correction in MRI: MR-based navigation methods

Joint reconstruction of image and motion

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Highlights

- Generalized image reconstruction techniques can be used to correct for complex motion (non-rigid or non-affine), which is particularly useful in cardiovascular and body applications.
- When considering complex motion, estimating motion becomes as important as the motion-compensated image reconstruction itself, therefore a general formulation that can handle the joint reconstruction of image and motion is desirable

Problem Summary

Despite recent advances in accelerated MRI, high resolution 3D and dynamic MRI still often necessitate minutes of acquisitions. Patient motion (breathing, heart beating...) is therefore an issue especially in cardiovascular and body application. Such motion can be complex and needs to be modeled and integrated into the reconstruction process.

Joint Reconstruction of Image and Motion

The problem of image reconstruction from motion corrupted data can be formulated as a joint optimization problem whereby both the image and the motion are unknown [1] :

$$\min_{(\rho_0,u)} \; E\ u\ \rho_0 - s\ ^2 + \mu\, R(u), \tag{1}$$

with s the acquired data (i.e. the k-space samples), E the forward model describing the motion-corrupted MRI acquisition process, ρ_0 the motion-corrected image (in a reference motion state) and u the displacement fields at each k-space sample time; $R(u)$ is a regularizer that constrains the motion fields to be relatively smooth, e.g. $R\ u\ =\ \nabla u\ ^2$.

In this general form the problem is highly underdetermined. Strategies to make the problem more tractable will be described in this presentation, including: i) parameterization of the displacement fields u using motion sensor signals as a prior knowledge (separation of space and time variables in u) [1] ; ii) parameterization of the displacement fields using a spatially adaptive mesh (dimensionality reduction) [2]. A method called GRICS (generalized reconstruction by inversion of coupled systems) for solving problem (1) under such constraints will be described based on alternating optimization and using a multi-resolution implementation in order to allow large displacements to be estimated. Some applications and extensions of this framework to multi-contrast imaging will also be presented [3]–[5].

Summary

Joint reconstruction of image and motion can be implemented using prior knowledge about motion such as motion sensors.

References

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