Approach and Execution

Introduction

Magnetic Resonance Imaging (MRI) is a widely used medical imaging technique which uses nuclear magnetic resonance to acquire images in Fourier domain k-space. The major challenge to MRI currently is the long scan times required to produce high resolution or large FOV images. This is limited due to the physical and physiological constraints which causes longer scan times.

To speed up the process Compressed Sensing can be applied to MRI as it allows for the under-sampling of the k-space to faithfully reconstruct images. As outlined in section it does this through satisfying three requirements: sparsity, incoherent under sampling and non-linear reconstruction methods. Wavelet, tv and l1 minization.

Currently, the conventional method (Sparse MRI) does not use prior information from a previous image to speed-up acquisition or improve image reconstruction. However, in many types of MRI scans this information is available and may potentially be used. Such applications include Dynamic MRI, Diffusion MRI, Cardiac Imaging and Multi-contrast MRI. Referenced based Compressed sensing has be explored a lot over the past few years in various applications of MRI.

Current methods which use a reference based approach are listed in the table below.

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| **Author** | **Description** | **Imaging application tested** |
| Liang and Lauterbur (Ref. 44) | Exploiting temporal similarity in dynamic MRI using generalized scheme imaging | Dynamic MRI (dynamic T1-weighted and diffusion MRI) |
| Hanson et al. (Ref. 11) | Exploiting two high resolution reference images to improve dynamic imaging in a generalized scheme | Dynamic MRI (DCE MRI) |
| Hess et al. (Ref. 12) | Exploiting reference image for generation of basis functions, used to improve dynamic MRI | Dynamic MRI (MR angiography) |
| Tsao et al. (Ref. 32) | Incorporating reference image and prior on changed regions for improved reconstruction | Longitudinal MRI |
| Tsao et al. (Ref. 45) | Exploiting spatiotemporal correlations for dynamic MRI (training-based approach) | Dynamic MRI (cardiac imaging) |
| Lustig et al. (Ref. 16) | Random sampling in *k*-*t* space, reconstruction based on wavelet-Fourier sparsity | Dynamic MRI (cardiac imaging) |
| Haldar et al. (Ref. 46) | Using anatomical priors to improve SNR via penalized ML | Single-contrast MRI |
| Lang and Ji (Ref. 17) | Exploiting similarity to a reference image in a CS framework | Dynamic MRI (brain DCE) |
| Gamper et al. (Ref. 18) | Exploiting sparsity in the *x*-*f* space for dynamic MRI | Dynamic MRI (cardiac imaging) |
| Jung et al. (Ref. 19) | Exploiting sparsity of residuals in dynamic MRI | Dynamic MRI (cardiac imaging) |
| Yun et al. (Ref. 13) | Exploiting a reference image for basis functions generation used to improve dynamic MRI | Dynamic MRI (brain fMRI) |
| Samsonov et al. (Ref. 33) | Exploiting sparsity of gradient of difference between baseline and follow-up scans | Longitudinal MRI |
| Chen et al. (Ref. 20) | Exploring the exploitation of a reference frame in x-t and x-f domains in dynamic MRI | Dynamic MRI (cardiac imaging) |
| Wu et al. (Ref. 24) | Using noisy reconstruction as a reference for sorting in parallel imaging | Single-contrast MRI |
| Peng et al. (Ref. 25) | Exploiting reference image for sparsifying transform generation | Single-contrast MRI |
| Bilgic et al. (Ref. 28) | Exploit similarity of spatial derivatives in multicontrast MRI | Multicontrast MRI |
| Du and Lam (Ref. **26**) and Lam *et al.* (Ref. **27**) | Exploiting similarity to a reference image in a CS-based hybrid reconstruction and registration scheme | Single-contrast MRI |
| Nguyen and Glover (Ref. 14) | Exploiting a reference image for generation of basis functions used for generalized series reconstruction of dynamic MRI | Dynamic MRI (brain fMRI) |
| Haldar et al. (Ref. 15) | Using structural MRI for SNR improvement of DWI in an ML scheme | Diffusion MRI |
| Qu *et al.* (Refs. **29** and **30**) | Exploiting similarity of image patches within and between multicontrast MRI in CS framework | Multicontrast MRI |
| Huang et al. (Ref. 31) | Joint TV and group wavelet based reconstruction for multicontrast MRI | Multicontrast MRI |
| Chiew et al. (Ref. 21) | Low-rank based reconstruction | Dynamic MRI (brain fMRI) |
| Li et al. (Ref. 34) | Using nonreference-based reconstruction as a prior for reference-based reconstruction | Longitudinal MRI |
| Adluru et al. (Ref. 22) | Exploiting TV-based reconstruction for improved low-rank based reconstruction | Dynamic MRI (cardiac imaging) |
| Otazo et al. (Ref. 23) | Low-rank based reconstruction | Dynamic MRI (cardiac imaging, MR angiography) |
| Our method (FASTMER) | Exploiting reference image in an adaptive-weighted CS scheme | Single- and Multicontrast MRI, Longitudinal MRI |

**Multi-contrast MRI**

**Dynamic MRI**

**Structural MRI**

Methodology.

As mentioned in section 1.1.1. currently the conventional method of compressed sensing in MRI does not use prior information or a reference image in its algorithm. In many instances such dynamic MRI, angiography and (t1 and t2 images) these

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