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INVERSION: a robust method for co-registration of T1 and diffusion weighted MRI images

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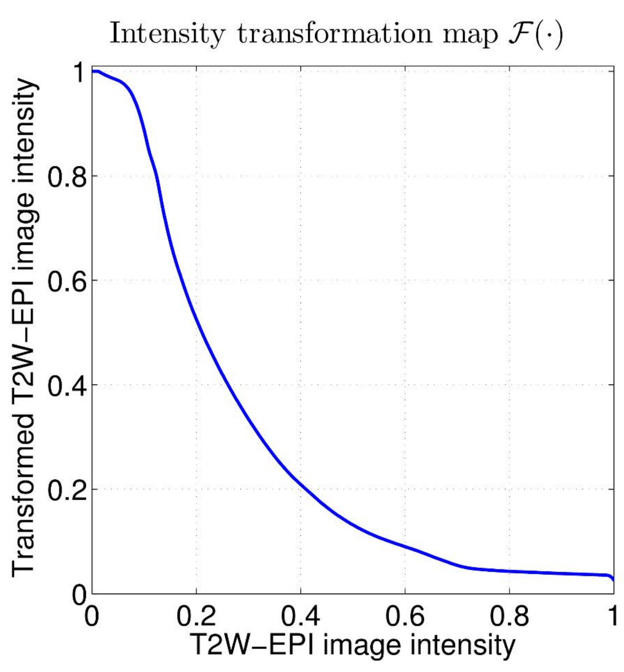
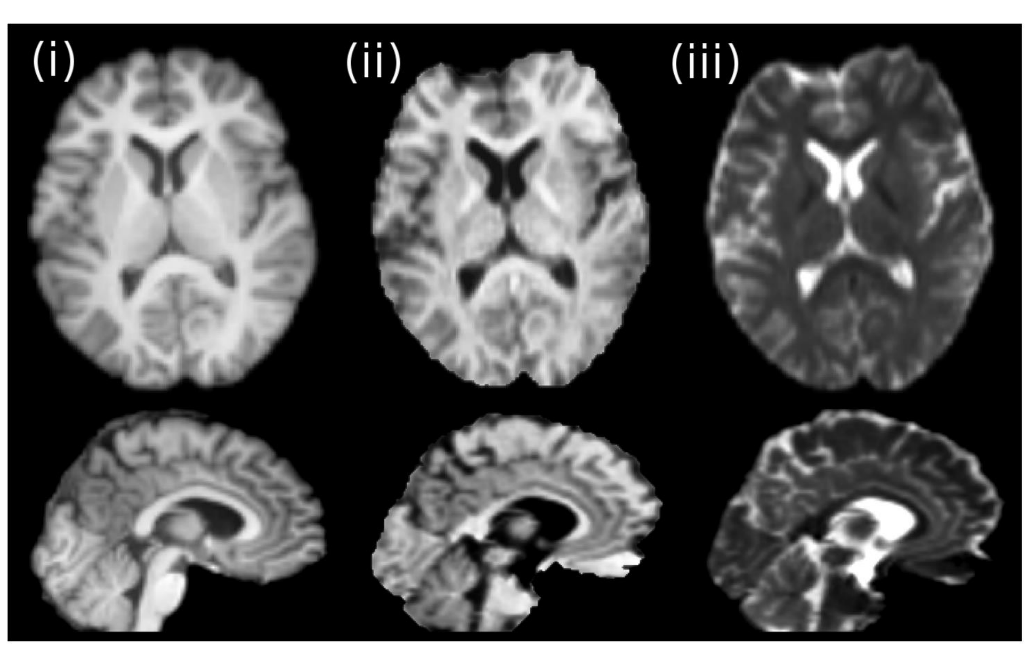
Motivation & Introduction

- Multi-contrast images registration is useful to fuse information from different modalities.
- Normalized Mutual Information (NMI)[1] & Correlation Ratio (CR)[2] have been commonly used for Inter-modal registration.
- CR & NMI are known to be non-convex and non-smooth, which can cause registration algorithms to converge to sub-optimal solutions[3].

INVERSION

- INVERSION – **I**nverse contrast **N**ormalization for **VER**y **S**imple registrat**ION**)
- Use prior information: Contrast in a T1w brain image is approximately the inverse of the contrast in a T2w image.
- Intensity order: white matter > gray matter > CSF in a T1 image, while CSF > gray matter > white matter in a T2W-EPI image.
- The transformation map between T1w image I_{T1} and T2W-EPI image I_{T2} is given by $F(I_{T2}, I_{T1}) = f_{I_{T1},I_{T2}}(1 - I_{T2})$, where $f_{I_{T1},I_{T2}}$ is the histogram matching function.
- Enables the use of simpler sum of squared differences (SSD) cost function for inter-modal image registration.

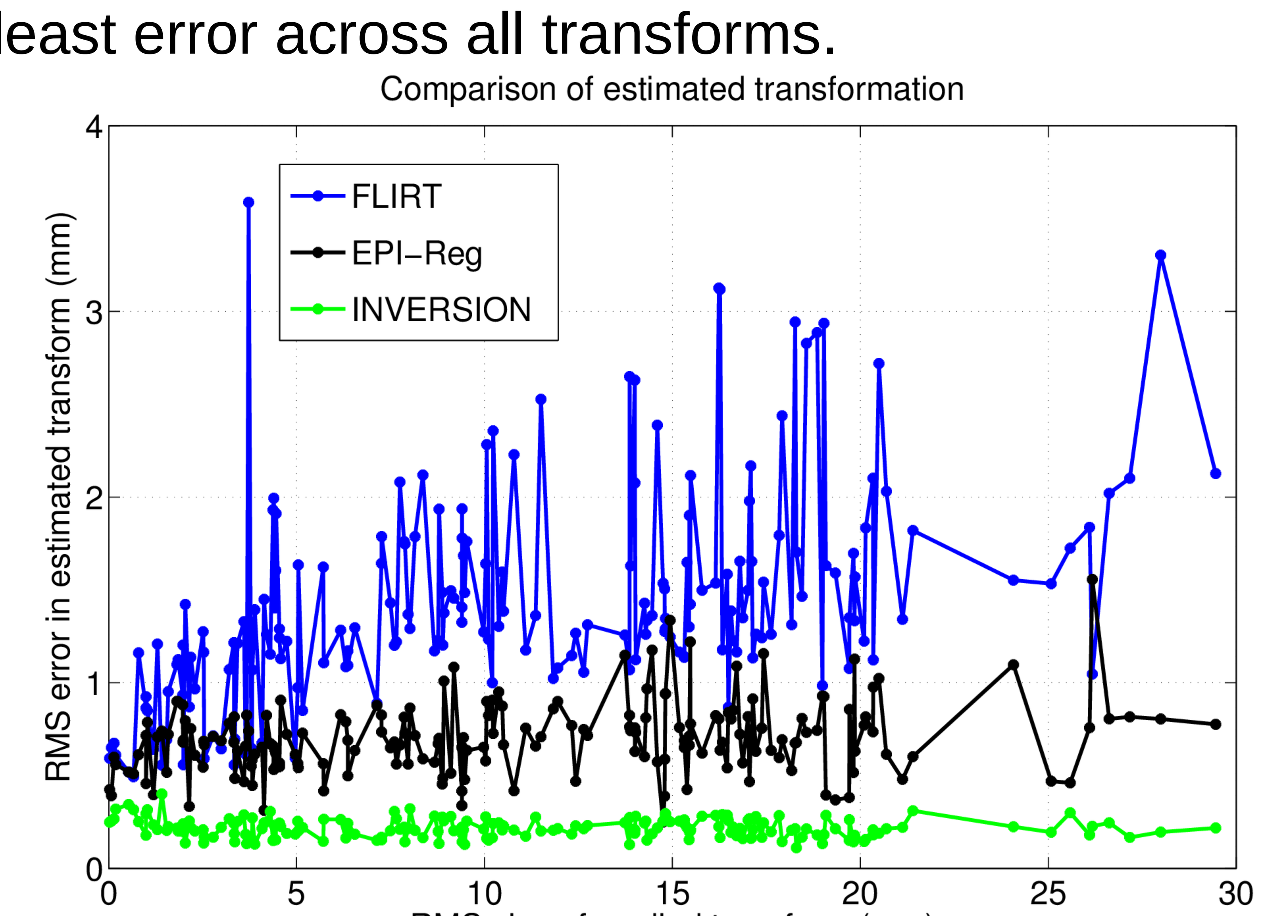




(Left) Intensity transformation map of a brain image. (Right) Slices from (i) the T1-weighted image, (ii) the inverted T2W-EPI image, and (iii) the original T2W-EPI image.

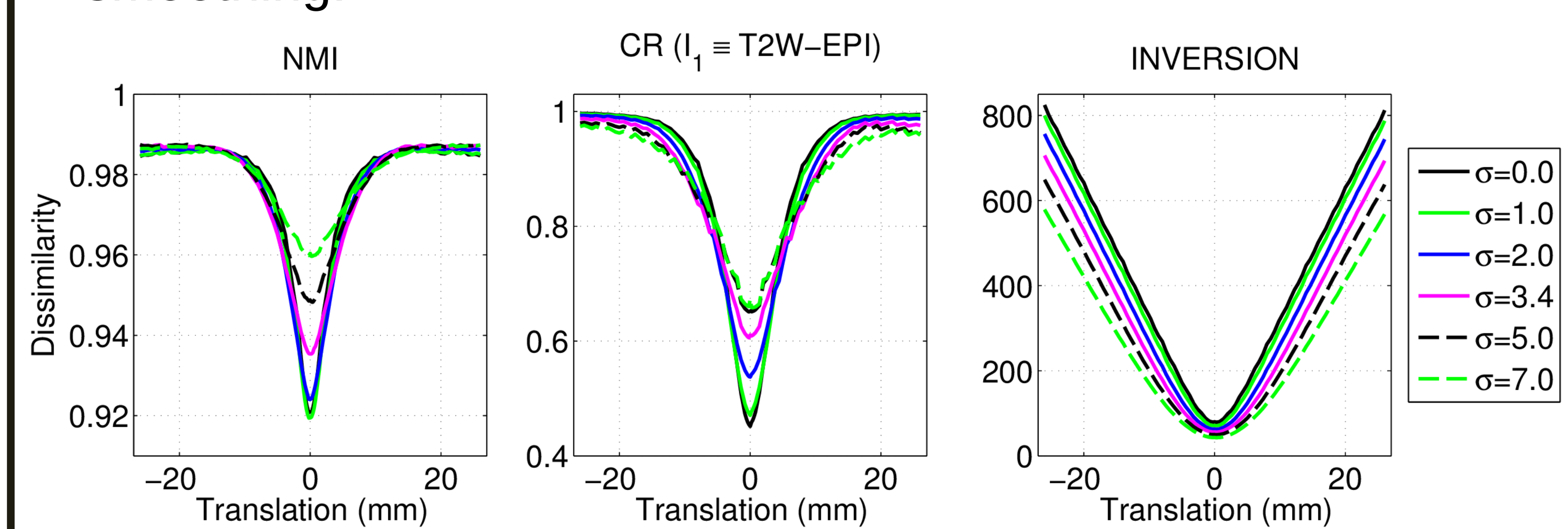
Comparison with other methods

- Applied 200 known rigid transformations to the aligned MPRAGE image and assessed the RMS error[3] of the registration achieved with each methods.
- All methods show good performance but INVERSION shows the least error across all transforms.



Cost function behavior

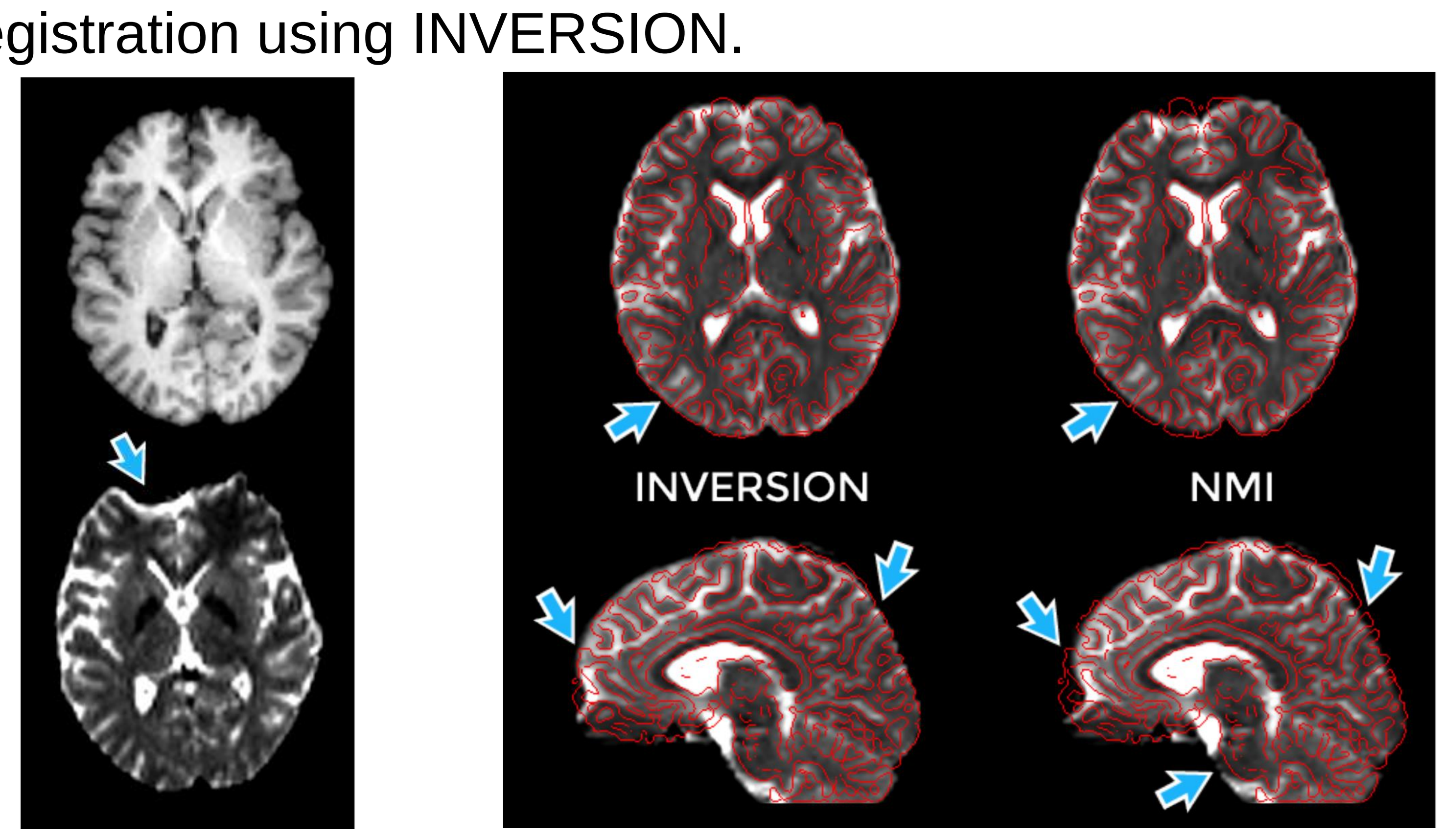
- Studied change in different cost functions as images were misaligned (translation along the x-axis) and smoothened using Gaussian kernel.
- NMI and CR showed good behavior for small translations but both had relatively flat & noisy regions of the cost function at large translations, which can make optimization difficult.
- INVERSION showed the smoothest cost function and was convex over the translation range at all levels of the smoothing.



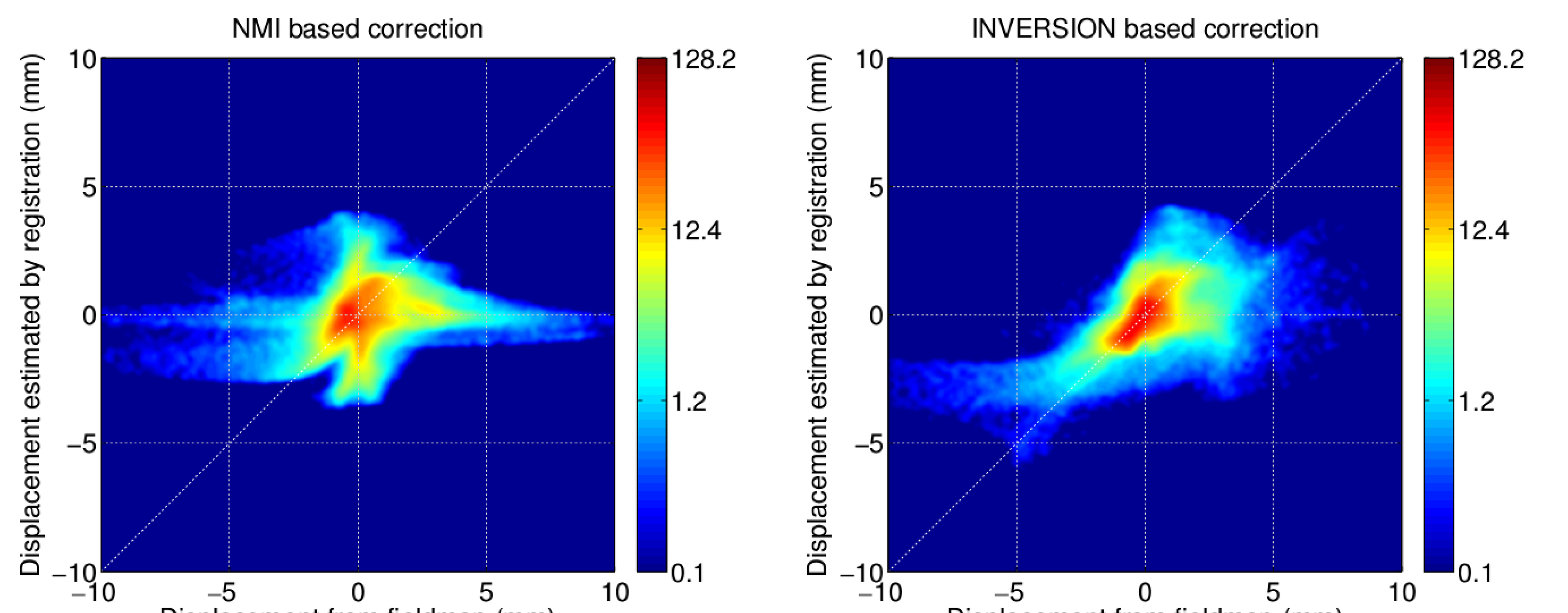
Behavior of different cost functions as a function of misalignment and smoothing.

Distortion correction

- Diffusion images are frequently distorted due to use of EPI sequence in inhomogeneous magnetic field.
- Use T1w anatomical image as template in non-rigid registration using INVERSION.



(Left) Example of distortion in diffusion images. (Right) Qualitative comparison of distortion correction using INVERSION and NMI.



Scatter plot comparing distortion estimates with ground truth displacement computed from fieldmap.

Grant Supports
NIH R01 EB009048
NIH P41 EB015922
NIH R01 NS074980
NSF CCF-1350563

References
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