Structural MRI Constrained Motion and Distortion Correction of Fetal Brain Diffusion Imaging

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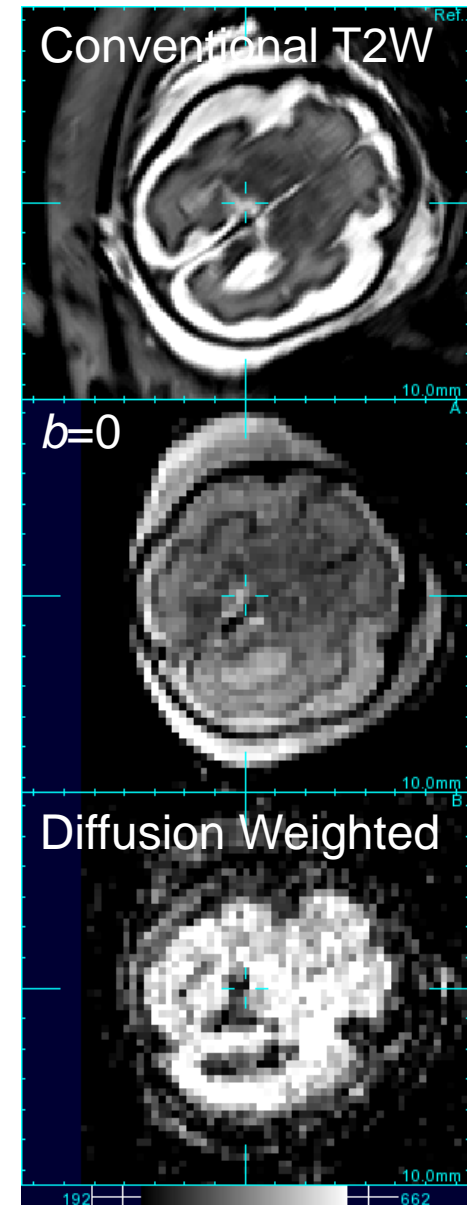[1]Department of Radiology and Biomedical Imaging, University of California San Francisco, USA.
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Introduction

- Diffusion Tensor Imaging:

  $$I = I_0 \exp\left(-b g^{\mathrm{T}} D g\right)$$

- The $b=0$ image (I_0) and multiple diffusion weighted images (I) need to be aligned.

Conventional T2W

$b=0$

Diffusion Weighted

Introduction

- Diffusion Tensor Imaging (DTI) of the fetal brain is a challenging problem;

  - Fetal motion distorts stacks and corrupts slices.

  - Eddy currents causes affine distortions in the phase encoding direction.

 - Inhomogeneous susceptibility of the maternal tissues causes local shape distortion in the phase encoding direction. Studholme et al, *TMI* (2000).

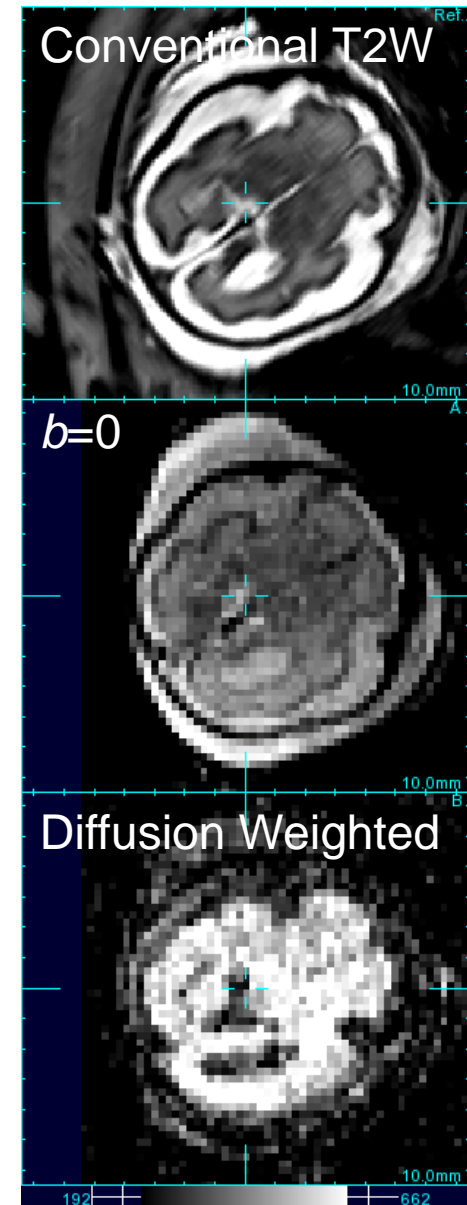Conventional T2W

$b=0$

Diffusion Weighted
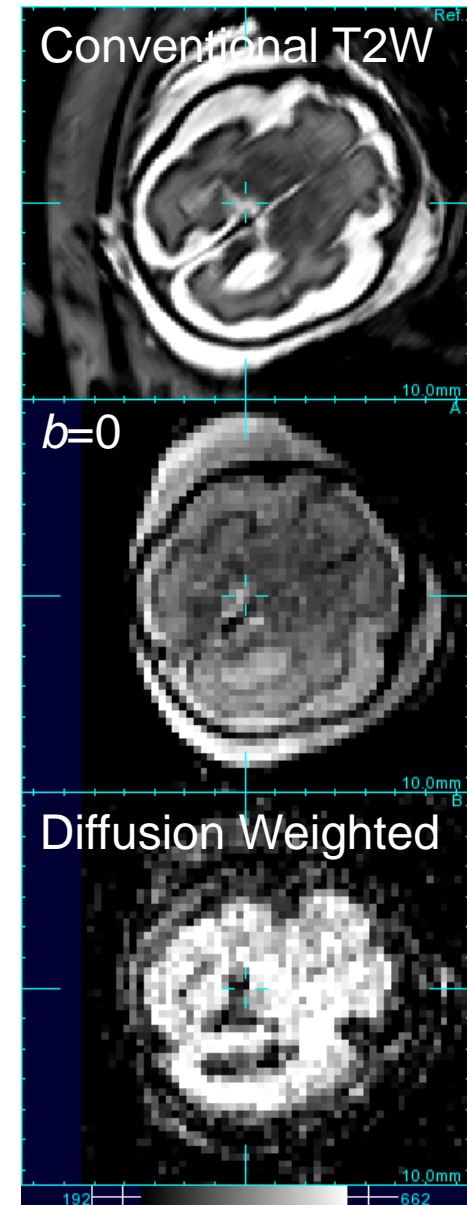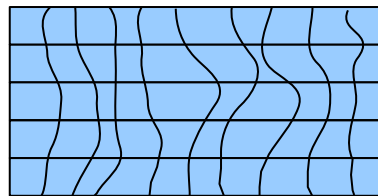
Related Work

- Slice-to-Volume Matching method for DTI

  - 3D b=0 image was constructed from multiple b=0 slice stacks, using SVM

  - Diffusion weighted images are rigidly registered to the 3D b=0 images by minimizing Normalized Mutual Information (NMI).

  Jiang et al, MICCAI 2007.

Conventional T2W

b=0

Diffusion Weighted
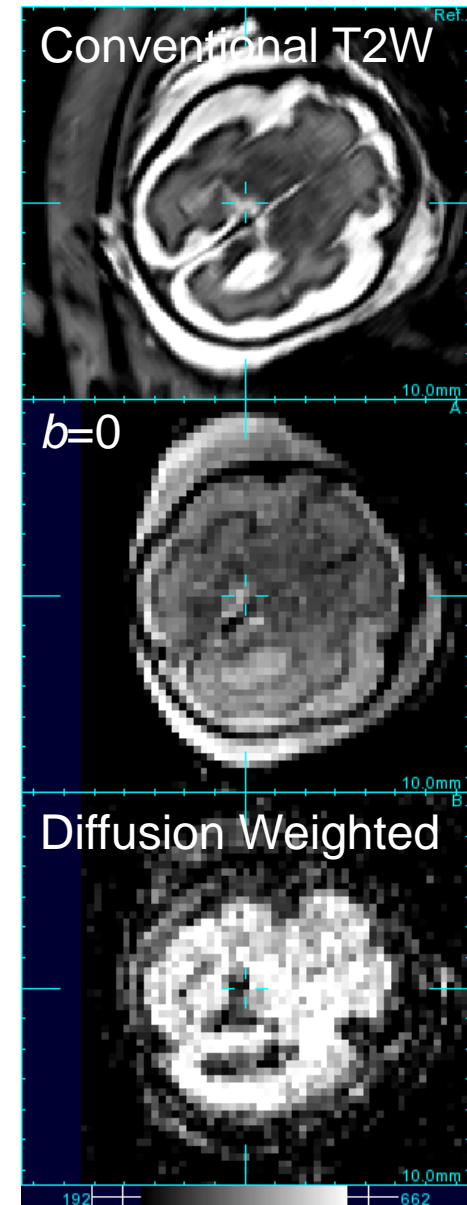
Project Goal

- To co-align a <u>conventional T2W</u> image, <u>$b=0$ image</u> and <u>diffusion weighted (DW)</u> images.

→Establish the correspondence between the fetal brain anatomy and a distortion-corrected diffusion tensor (DT) map.

Conventional T2W

$b=0$

Diffusion Weighted

Proposed Approach

- The conventional T2W image is used as the reference.

- DW images and the b=0 image are aligned with respect to the reference image.

- Diffusion tensors are estimated from motion and distortion corrected b=0 and DW images.

Conventional T2W

b=0

Diffusion Weighted
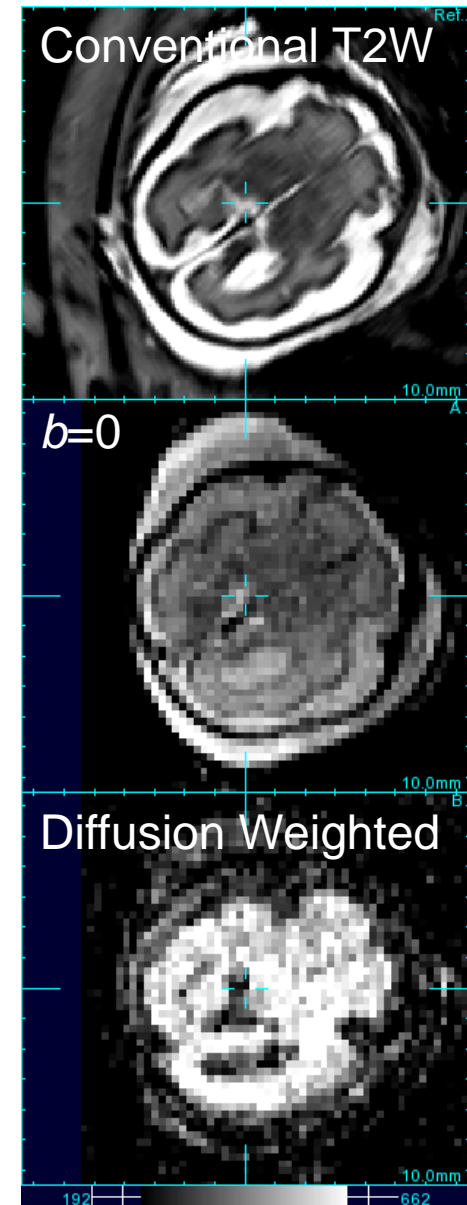
Procedures

Step 1. Conventional T2W Imaging
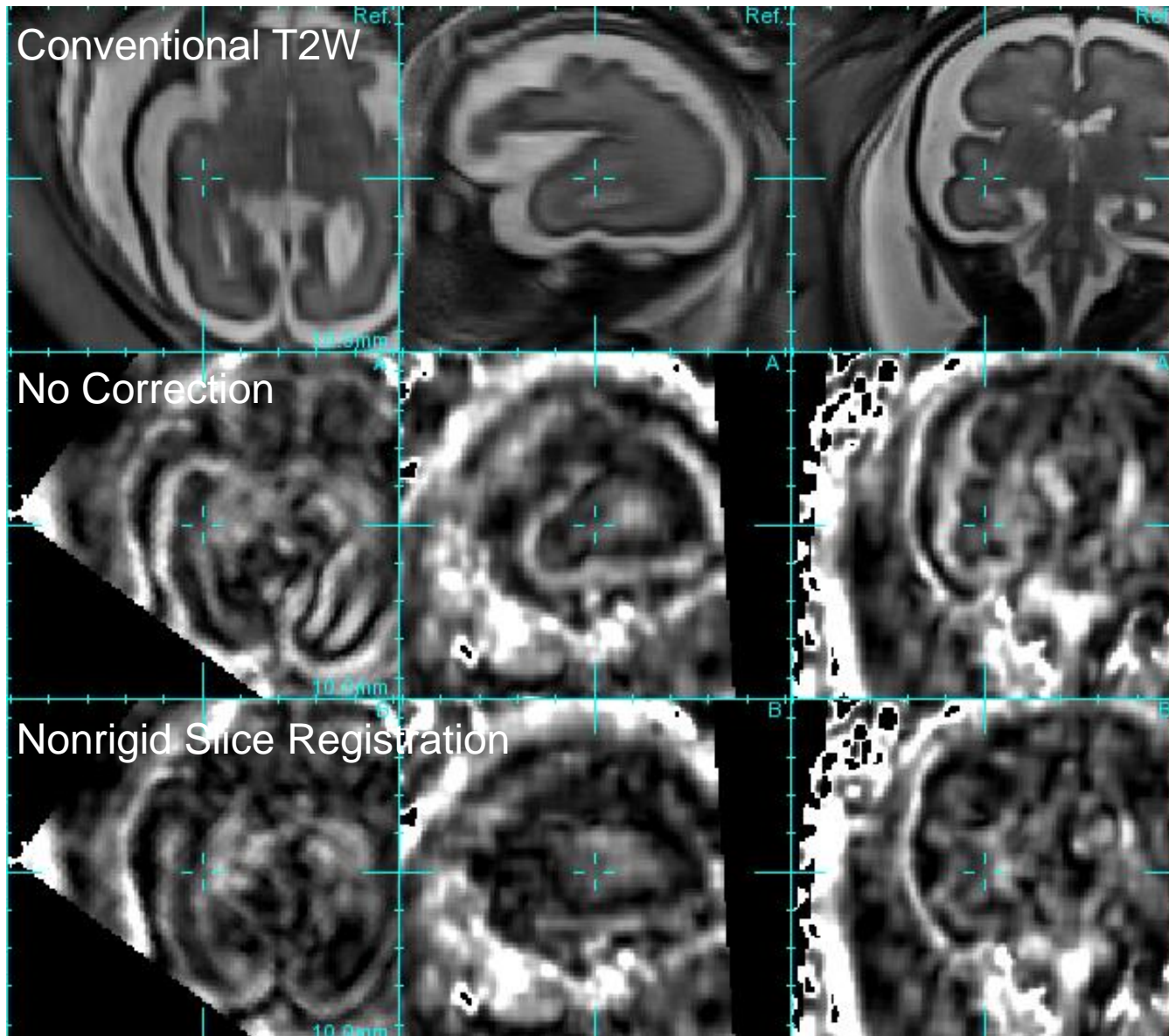
✗ Slice Intersection Motion Correction

Step 2. Registration of DW Images
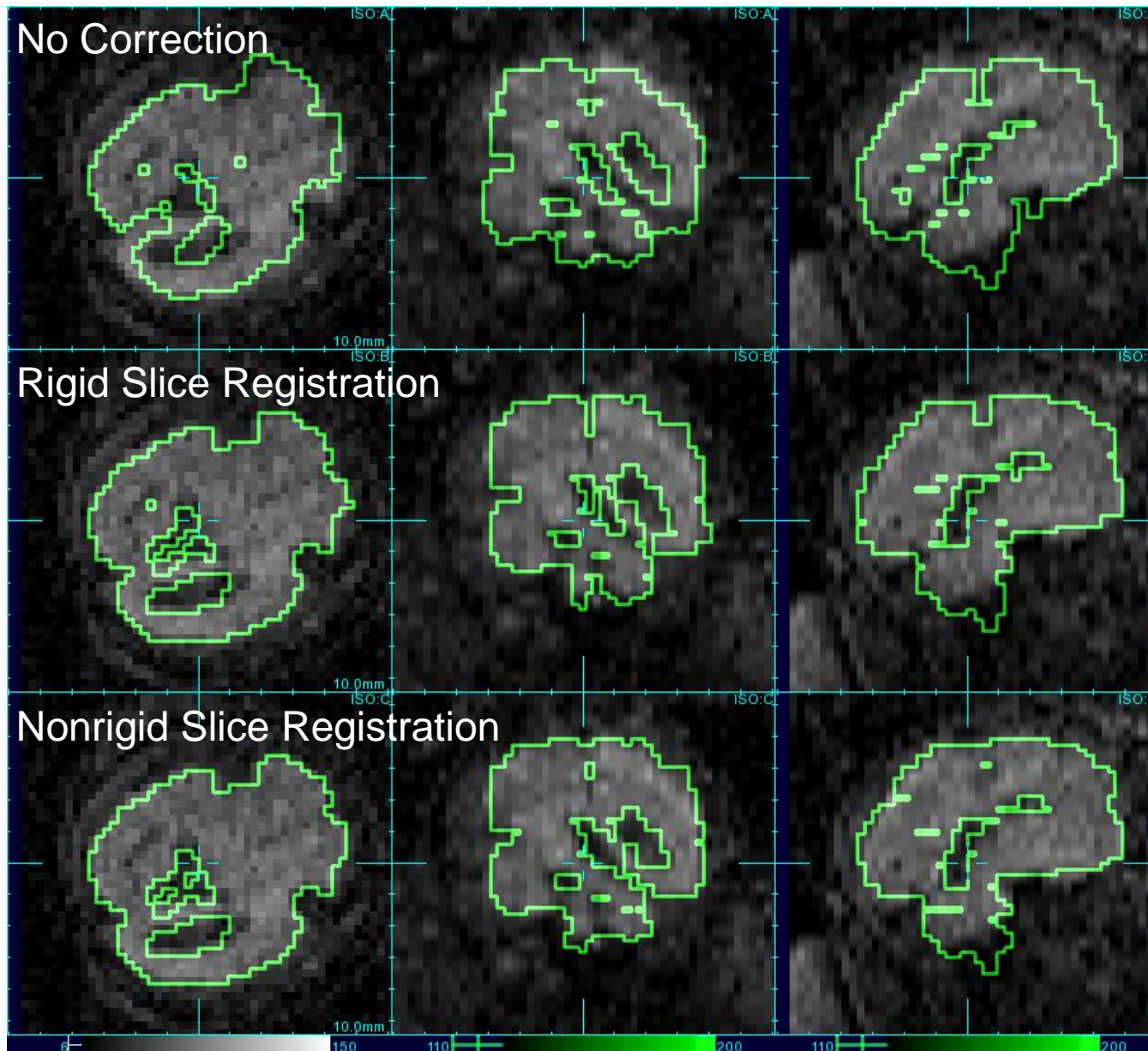
✗ Gradient ascent of NMI

Step 3. Diffusion Tensor Field Fitting

✗ Weighted linear least square fitting

Result: FA map

Conventional T2W

No Correction

Nonrigid Slice Registration

Validation

Validation

- Normalized standard deviation of DW voxel values within the CSF regions was computed.

Method	Ventricular CSF	Entire CSF
No reg.	0.4184	0.4159
Rigid slice	0.3569	0.3978
Nonrigid slice	**0.3506**	**0.3850**