Evaluation of Different Strategies for Distortion Correction in Fetal Diffusion-Weighted Imaging

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Distortion correction

- Correction of distortions is a key element in the processing pipeline of D-MRI images.

- This is challenging for the fetus because of:
  1. Fetal motion
  2. Low signal-to-noise ratio (SNR)
  3. Low resolution (compared to the fetal brain size)
  4. Surrounding structures (uterus, placenta, fetal limbs, etc).
What does it look like?

- $T_2^{\text{epi}}$
- $D_{W_1}$
- FA-Orientation
- FA
Method

GROUPWISE REGISTRATION

RESAMPLING
Results (1)

original

corrected
## Results (2)

**Table 1**: Descriptors of FA distribution for the evaluated methods on the fetus. $H(FA)$ = Entropy, $D_{KL}$ = Kullback-Leibler divergence, $FA_{cfs}$ = mean FA in the CSF. For each column, the best value is shown in bold. Dashed entries for Fetus #3 mean omitted values because of complete misregistration.

<table>
<thead>
<tr>
<th>Method</th>
<th>Fetus #1</th>
<th>Fetus #2</th>
<th>Fetus #3</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$H(FA)$</td>
<td>$D_{KL}$</td>
<td>$FA_{cfs}$</td>
<td>$H(FA)$</td>
</tr>
<tr>
<td>Affine</td>
<td>2.07</td>
<td>0.37</td>
<td>0.09</td>
<td>1.97</td>
</tr>
<tr>
<td>NRR</td>
<td>2.05</td>
<td>0.58</td>
<td>0.09</td>
<td>1.82</td>
</tr>
<tr>
<td>Original</td>
<td>2.04</td>
<td>0.48</td>
<td>0.14</td>
<td>2.17</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>2.11</td>
<td>0.22</td>
<td>0.12</td>
<td>2.09</td>
</tr>
<tr>
<td>Our approach</td>
<td><strong>1.96</strong></td>
<td><strong>0.59</strong></td>
<td><strong>0.08</strong></td>
<td><strong>1.80</strong></td>
</tr>
</tbody>
</table>
Work in Progress
Evaluation (1)

- \( \text{mean}_{\text{csf}}(FA) \)
  - It should be zero ideally (isotropic diffusion properties of CSF)
  - Distortion introduces different diffusion values
  - Segmentation required, performed on \( T_2^{\text{se}} \)

- Change in FA introduced by distortion
- Brain and CSF in \( T_2^{\text{epi}} \)
**Evaluation (2)**

- $H(FA)$
  - Better registration results present more spiky FA distributions [1]
  - There is an increase in sharpness of FA images after distortion correction [2]


Evaluation (3)

- $D_{KL}(p(FA) \parallel p_{\text{ref}}(FA))$
  - Maximize the distance between $p(FA)$, and $p_{\text{ref}}(FA)$ for misaligned sequences