Quantitative analysis of time series of MR images of TBI patients

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Motivation and challenges of TBI imaging
- Traumatic brain injury (TBI) is a major cause of death and disability and affects 1.5 million Americans annually.
- Images present severe brain changes such as edema, bleeding, tissue deformation, and skull fractures.
- Clinicians do not yet have tools for quantitative analysis to evaluate best treatment options and predict outcome.
- Novel analysis of images taken over time (4D) provides quantitative parameters related to treatment efficacy.

Multicontrast longitudinal images of TBI patients

<table>
<thead>
<tr>
<th>T1</th>
<th>T2</th>
<th>FLAIR</th>
<th>GRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow-up</td>
<td>Baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline Lesions</td>
<td>- Swelling (edema)</td>
<td>- Bleeding</td>
<td>- Extracerebral lesion</td>
</tr>
<tr>
<td>Follow-up Lesions</td>
<td>- Chronic lesion</td>
<td>- Bleeding</td>
<td></td>
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</tbody>
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Quantitative parameters and visualization

- Illustration of cortical thickness.
- Temporal change of cortical thickness (color) shown with tissue deformation (arrows).
- Cortical thickness distribution of whole brain (unit: mm) from acute to chronic.
- Anatomical subdivision of brain WM to assess local volume changes.

Quantitative analysis of longitudinal images (4D)

We develop a joint registration/segmentation method for image time series which provides tissue labels and deformations.

Result of tissue segmentation: Labels of healthy and pathological classes for volume and shape characterization.

<table>
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<tr>
<th>Label of WM</th>
<th>Label of GM</th>
<th>Label of lesions</th>
</tr>
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<td>Baseline</td>
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Conclusion
- Our novel methodology combines 4D image information through the creation of a personalized atlas that explicitly handles complex changes of pathology.
- Processing of longitudinal image data provides patient-specific profiles of tissue and lesion changes.
- First time that clinicians get tools for quantitative assessment of brain changes related to therapeutic intervention and recovery → Leads to improved decision making on optimal intervention strategy.