Synthetic and estimated tissue displacement in high-grade glioma

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Goal

- Present the current state of my second publication
- Plans for the next publication

Suggestions are welcome!
Background

Tissue displacement in glioblastoma from non-rigid registration
Displacement maps in glioblastoma

Fig. 2. Longitudinal evolution of Patient 1 from day 18 after starting radiochemotherapy treatment to day 372. According to RANO criteria tumor progression started on day 208, however displacement maps (DM) show significant deformations already at day 28.
<table>
<thead>
<tr>
<th>Day</th>
<th>0</th>
<th>18</th>
<th>28</th>
<th>41</th>
<th>57</th>
<th>123</th>
<th>208</th>
<th>271</th>
<th>299</th>
<th>372</th>
</tr>
</thead>
</table>

Day progression from 0 to 372 with corresponding images of brain scans.
### Days, interval

| 18 | 10 | 13 | 16 | 66 | 85 | 63 | 28 | 73 |

**Image Description**

- The table above lists various days and intervals.
- The images below correspond to these days, illustrating changes or patterns over time.

**Diagram**

- Arrows indicate the progression from day 1 to day 10, suggesting a timeline or sequence of events.
- The brain images show variations across different days, highlighting changes in a specific context.
Challenges

• How accurate are estimated displacements in (traditionally) clinically important regions?
  • Contrast-enhancement
  • Necrosis
  • Edema

• Can coregistration estimate displacement better under specific conditions?
  • Amount of true displacement in mm
  • Amount of growth infiltration
  • Irregularity of tumoral growth displacements
2nd publication

Evaluating non-rigid registration for tumor growth characterization by creating synthetic displacements
Outline

• Created a simple radial growth model for generating synthetic displacements with input parameters for (maximum) tissue displacement, tumor infiltration and growth irregularity.

• Tested five non-rigid registration methods by estimating model generated displacements (ANTs SyN with MI and CC *, Farneback, ILK, TV-L1).

• Hypothesis: We expect the five methods to perform equally good in contrast enhanced, necrotic and edematous regions for the following different simulated conditions:
  • Low (3-) and high (8-mm) maximum tissue displacement.
  • Low and high infiltration parameter setting.
  • No, intermediate and high growth irregularity.

(*) MI=Mutual Information
CC=Cross Correlation
Radial growth model

Synthetic deformation

Non-rigid registration
Model of displacements from one examination to the next

1D

Tumor cross section

2D

Displacement

3D

Infiltration

Tumor cross section

- Tissue displacement from non-rigid registration of magnetic resonance images, may constitute as a valuable biomarker in characterizing cancer progression and detecting early tumor recurrence in high-grade Glioma.
- Voxel-wise accuracies of five state-of-the-art non-rigid registration methods were evaluated within necrotic (blue), contrast-enhanced (red) and edematous (green) lesions for 27 patients under different simulated conditions of maximum tissue displacement, tumor infiltration and growth irregularity, as described by a radial growth model.
- Significant lower displacement estimation errors for all registration methods for low (3 mm) maximum tissue displacement and high tumor infiltration, compared to the alternatives 8 mm and low tumor infiltration.
Feedback from JMRI -

• R1: Lack of novelty and significant limitations (…)
• R2: «The authors evaluate the performance of registration methods to synthesize predicted displacements of brain in n=27 patients with high grade glioma. Results generated using data at one time-point are compared with images generated two weeks later. The authors use various parameters in the prediction and evaluate results using five methods. Two of the five show superior results.»
1. Many of the methods are ad hoc, not justified, and seem to have negligible physical or biological basis. For example, why the seemingly arbitrary selection of 3mm and 8mm radial tissue displacement?

2. The overall significance of the work seems questionable. If one wishes to determine the possible growth of a glioma after a time of no treatment or the possible reduction in mass after treatment, then one can simply perform a followup MRI exam.

3. There is no testable hypothesis presented. Presumably the authors wish to compare their synthetic prediction with ground truth as represented in the scans performed two weeks later. However, there is no clear description of such a comparison, and there is no clear presentation in the Results showing such a comparison.

4. As presented, the information in the figures has negligible value. There are no figure legends. There is no clear comparison of synthetic vs. actual images.

5. Although the authors state that two methods (Syn ANTS with cross correlation and Farneback optical flow) had better performance than the other three, it is not clear if the performance of these two methods is adequate for some possible imaging task.
3rd publication

Distinguishing between «good» and «bad» treatment response by quantifying overall shrinkage or growth
<table>
<thead>
<tr>
<th>Days, interval</th>
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<tbody>
<tr>
<td>18</td>
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1  2  3  4  5  6  7  8  9  10
Radiation dose distribution

| 1 | 6 | 7 |

123 days  
Shrinkage

85 days  
Recurrence
growth pathlines from contrast-enhanced lesion according to best fit radial deformation model. Compare with true MRI.
• (Treatment related) aspects that can be interesting to relate to shrink and growth patterns?