Robust and Accurate Contralateral Registration for Pose Normalization and Tumor Segmentation

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1. Introduction

Radiotherapy or surgery of brain tumors require prior tumor segmentation. Automatic tumor segmentation and quantitative analysis poses challenging computational problems (see [1] for a recent method and good overview).

- We aim to provide sophisticated **registration procedures**, expected to improve segmentation results in existing segmentation approaches
- We show that **joint probabilities** in cross-modal registration and **outlier regions in robust contralateral registration** can be used to guide automatic tumor segmentation.
- Moreover our inverse consistent contralateral registration into a half-way space results in an upright and straight head position (**pose normalization**).

2. Methods

1.Contralateral Registration

Within-modality contralateral robust registration can detect outlier regions and accurately align images by iteratively reducing outlier influence [2]. Thus, normal tissue will be accurately aligned, while tumor regions are automatically detected as outlier.

2.Accurate Cross-Modal Registration

Extending the symmetric registration procedure described in [2] and using normalized mutual information as cost function, we construct accurate registrations of e.g. T2 and enhancing T1-weighted images by matching at a mid-space.

3.Detecting Enhancing Tumor Regions

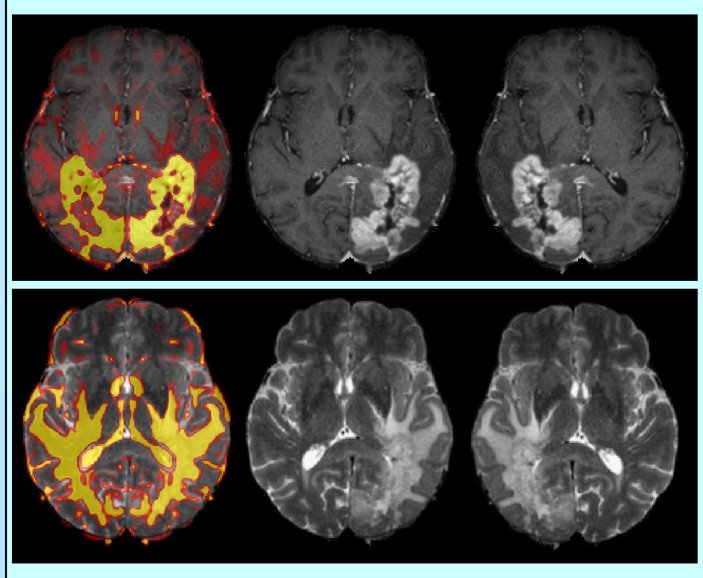
Based on accurate correspondence, enhancing regions can be detected as voxels with low probabilities in the joint 2D histogram. This allows the localization of the tumor, e.g. to detect the affected hemisphere.

4.Segmentation

Enhancing tumor segmentation can then be established using the product of the contralateral outlier mask, the cross-modal mask and the normalized T1 intensities.

3. Results

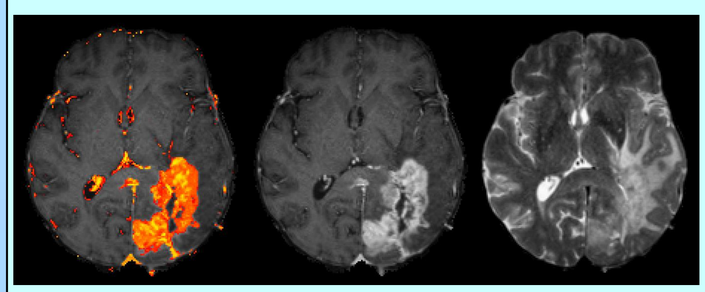
Contralateral Outlier Weights



Within modality contralateral registration: T1 (top) and T2 (bottom) weighted MRI.

- Robust contralateral registration reveals outlier (yellow/red) **highlighting asymmetries** such as the enhancing tumor or edema.
- Inverse consistent registration into a mid-space removes left/right rotational offsets automatically **normalizing the pose** (straight and upright).

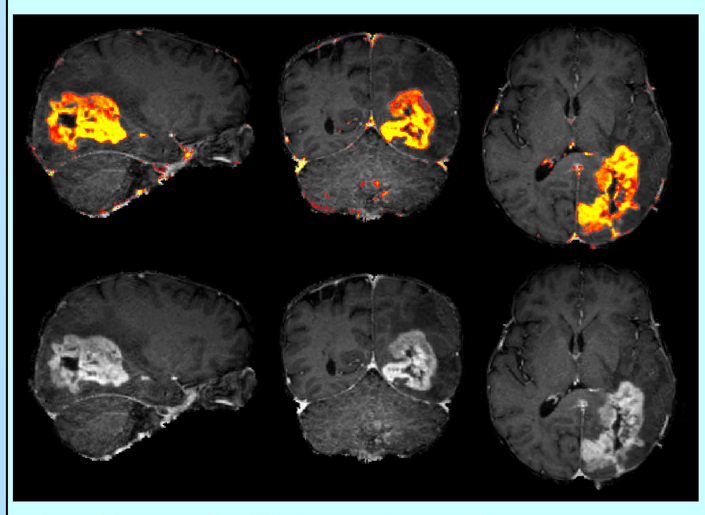
Rare Cross-Modal Joint Intensities



Important for segmentation accuracy: **inverse consistent cross-modal** registration improves registration accuracy.

- Voxels with low joint intensity profiles indicate abnormal (i.e. rare) tissue types.
- These rare intensity combinations highlight enhancing tissue and allow for better tumor localization.

Segmentation of Enhancing Region



Combining the T1 intensities, the cross-modal weights and the T1 contralateral outlier weights removes most false positives and produces the segmentation.

4. Conclusion

- The presented method constructs **accurate cross-modal and contralateral registrations** in the presence of large abnormalities, expected to guide and improve state-of-the-art segmentation procedures.
- Our method, furthermore, is fast and yields **initial enhancing tumor masks** by detecting outlier regions.
- As a byproduct it **normalizes head position**, useful for 'auto-align' or to easily mirror the healthy hemisphere for automatic processing.
- For further validation we will compare with manual labels and quantify the improvement when initializing prior based segmentation with our method.

5. References

[1] *Popuri, K., Cobaz, D., Murtha, A., Jägersand, M., 2011. 3D variational brain tumor segmentation using Dirichlet priors on a clustered feature set. International Journal of Computer Assisted Radiology and Surgery, online.*

[2] *Reuter, M., Rosas, H.D., Fischl. B., 2010. Highly Accurate Inverse Consistent Registration: A Robust Approach. NeuroImage 53 (4), 1181–1196.*

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