

Olfactory bulb (OB) pipeline documentation

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In this document you will find all required information to start using the data generated from the Rhineland Study olfactory bulb (OB) MRI pipeline.

1 Methods

1.1 Segmentation pipeline

All OB MRI structural information is extracted from the predicted segmentation maps generated from the in-house pipeline developed by Estrada et al. (1). The in-house pipeline is a fully automated deep learning pipeline to accurately segment OB tissue on high-resolutional T2-weighted (T2w) whole-brain MRI. Overall, the deep learning pipeline consists of three stages:

1. **Localization** of a region of interest (ROI) containing the OBs of both hemispheres using a semantic segmentation approach by implementing *FastSurferCNN* (2); we use the centroid of the predicted region as a center point for cropping a localized volume.
2. **Segmentation** of OB tissue within the localized volume through four *AttFastSurferCNN* - a novel deep learning architecture with a self-attention mechanism (3) to improve modeling of contextual information - with different training condition (four data-splits and data initialization).
3. **Ensemble** stage where the previously generated label maps are averaged and view-aggregated to form a consensual final segmentation.

2 How to cite

If you use the OB MRI data please cite :

- Santiago Estrada, Ran Lu, Kersten Diers, Weiye Zeng, Philipp Ehses, Tony Stöcker, Monique M. B. Breteler, Martin Reuter,
Automated olfactory bulb segmentation on high resolutional T2-weighted MRI,
NeuroImage, Volume 242, 2021, 118464, ISSN 1053-8119, <https://doi.org/10.1016/j.neuroimage.2021.118464>.

Citation example: Olfactory bulb tissue features were obtained using the post-processing pipeline proposed by Estrada et al. (1) on T2-weighted whole-brain MRI.

3 Variables

The pipeline variables summary are presented on Table 1 .

References

- [1] S. Estrada, R. Lu, K. Diers, W. Zeng, P. Ehses, T. Stöcker, M. M. Breteler, M. Reuter, Automated olfactory bulb segmentation on high resolutional t2-weighted mri, NeuroImage (2021) 118464.
- [2] L. Henschel, S. Conjeti, S. Estrada, K. Diers, B. Fischl, M. Reuter, FastSurfer-a fast and accurate deep learning based neuroimaging pipeline, NeuroImage 219 (2020) 117012.
- [3] H. Zhang, I. Goodfellow, D. Metaxas, A. Odena, Self-attention generative adversarial networks, in: International conference on machine learning, PMLR, 2019, pp. 7354–7363.

Table 1: OB Variables Summary

Variable ID	Name	Description
*_OB.Volume.mm3	Olfactory bulb volume (Left, Right or Total)	Volume estimates of the olfactory bulb. UNIT: Cubic millimeters
*_OB.NVoxels	Olfactory bulb number of voxels (Left, Right or Total)	Number of segmentend voxels of the olfactory bulb.
*_OB.normMean	Olfactory bulb intensity normMean (Left, Right or Total)	Intensity normMean of the olfactory bulb region.
*_OB.normMin	Olfactory bulb intensity normMin (Left, Right or Total)	Intensity normMin of the olfactory bulb region.
*_OB.normMax	Olfactory bulb intensity normMax (Left, Right or Total)	Intensity normMax of the olfactory bulb region.
*_OB.Entropy	Olfactory bulb prediction entropy (Left, Right or Total)	Entropy of the olfactory bulb predictions between the 12 ensemble models.
*_OB.CV	Olfactory bulb volumes estimates coefficient of variation (Left, Right or Total)	Coefficient of variation of the olfactory bulb volume estimates between the 12 ensemble models.
*_OB.CM	Olfactory bulb center of mass (Left, Right or Total)	Center of mass of the olfactory bulb in array space from the generated segmentation map.
loc_cm	Localization network center of mass	Center of mass of the olfactory bulb predicted by the localization network in array space.
seg_cm	Segmentation center of mass	Center of mass of the olfactory bulb extracted by the generated segmentation in array space.
dist.mm	Distance between the loc_cm and seg_cm	Distance between the generated center of mass UNIT: millimeters .
mse.px	Mean square error between the loc_cm and seg_cm	Mean square error between the generated center of mass.
ROI.NVoxels	Number of voxels of the forebrain ROI	Number of voxels of a the forebrain region containing the OB from the localization network .
in_image	T2 input image	the T2-weighted MRI used as input to the pipeline.
Flags	Olfactory bulb pipeline flags	Pipeline warning flags.