volBrain: An online MRI brain volumetry system

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Introduction

Automated quantitative MR analysis has huge potential to better understand and detect many brain diseases where brain anatomy is altered. In the last years, this field has been subject to many advances. Techniques based on multi-atlas label fusion are currently the most successful ones. In this work we present a novel framework for automated brain volumetry analysis based on the non-local patch-based label fusion technique. To make this pipeline fully accessible to the scientific community we have developed a web-based interface that enables to process T1w MR brain images remotely without any user's interaction in a very easy manner.

Methods

The proposed system, called "volBrain", is an advanced pipeline that provides automatically volumetric information of the brain MR images at different scales.

volBrain Pipeline description

volBrain pipeline is based on the following steps: 1) non-local means denoising [1], 2) rough N4 inhomogeneity correction [2], 3) affine registration to MNI space [3], 4) SPM based fine inhomogeneity correction [4], 5) intensity standardization [5], 6) non-local Intracranial Cavity Extraction (NICE) [5], 7) tissue classification [6], 8) patch-based hemisphere segmentation and 9) patch-based multi-atlas subcortical structures segmentation [7].

Library construction

volBrain system is based on the use of a library of manually labeled brains (atlases). To construct that library we used 50 T1 MRI subjects from several public databases (30 normal adults from IXI (http://brain-development.org), 10 Alzheimer cases from OASIS (http://www.oasis-brains.org) and 10 pediatric cases from ICL (http://brain-development.org) covering a large lifespan. All the images were preprocessed using the volbrain pipeline (steps from 1 to 5). The 50 images were manually labeled in the MNI space at different scales obtaining masks for 1) intracranial cavity mask, 2) hemisphere cerebellum and brainstem areas and 3) subcortical structures (see figure

1). To increase the size of the library the mirrored versions of the images (left-right) are used, giving a total number of 100 atlases.

Online volBrain service

In order to make volBrain fully available to all the potential users, we decided to provide a web-based service that can remotely process the MRI data without any users interaction. The process is very simple: 1) upload your compressed T1w file and 2) receive the results by email.. The resulting images can be downloaded in the user's area of the web-based service. The volbrain system can be accessed at: http://volbrain.upv.es.

Results

The system provides the volumes/segmentations and structure asymmetries at different scales: 1) intracranial cavity, 2) tissue volumes: WM, GM and CSF volumes, 3) cerebrum, cerebellum and brainstem volumes (Separating left from right cerebrum and cerebellum) and 4) Lateral ventricles and subcortical GM structures (putamen, caudate, pallidus, thalamus, hippocampus, amygdala and accumbens) (see figure 2).

The volBrain system takes around 15 minutes to perform the full analysis. When it finishes it sends an email to the user with a pdf summarizing the results of the analysis (the user can also download all the Nifti result files). To highlight the quality of the volBrain pipeline we performed a leave-one-out segmentation experiment using the volBrain library of the subcortical structures (see results at table 1).

Conclusion

In this work we present a new online system to provide volumetric information in fully automatic manner that we hope can help researchers around the world to make their volumetric brain analysis much easier without requiring any computing infrastructure.

References

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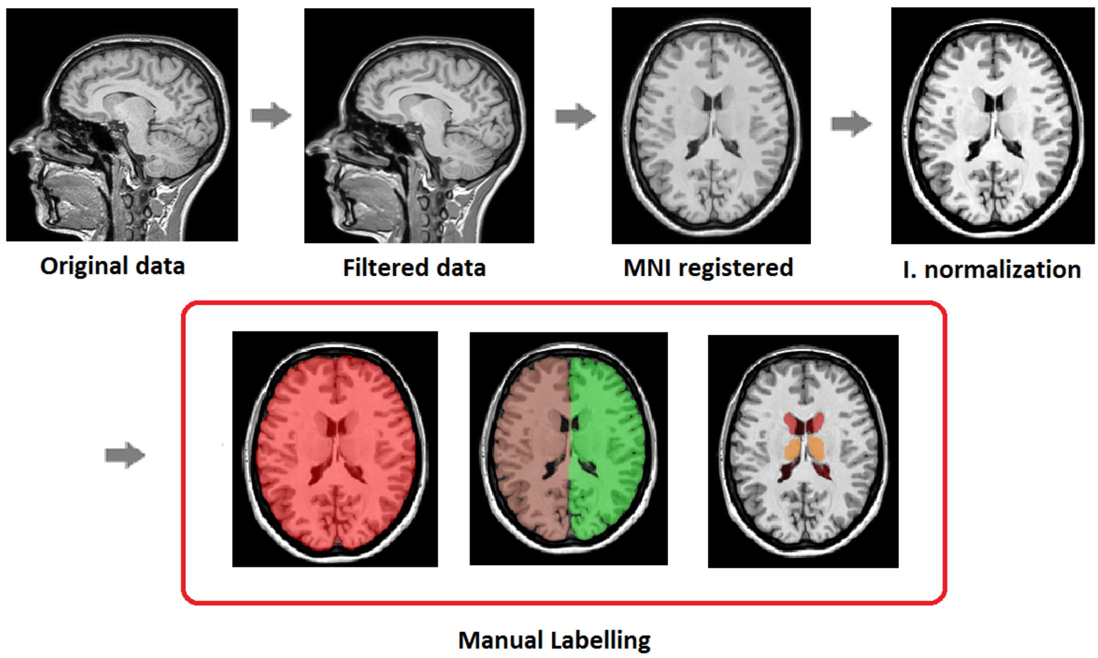

***Figure 1**. Atlas library construction pipeline. Upper row shows the MRI preprocessing steps aimed to locate each case in a common geometric-intensity space. Lower row show the manual labels used at different scales (ICV, macrostructures and subcortical).*

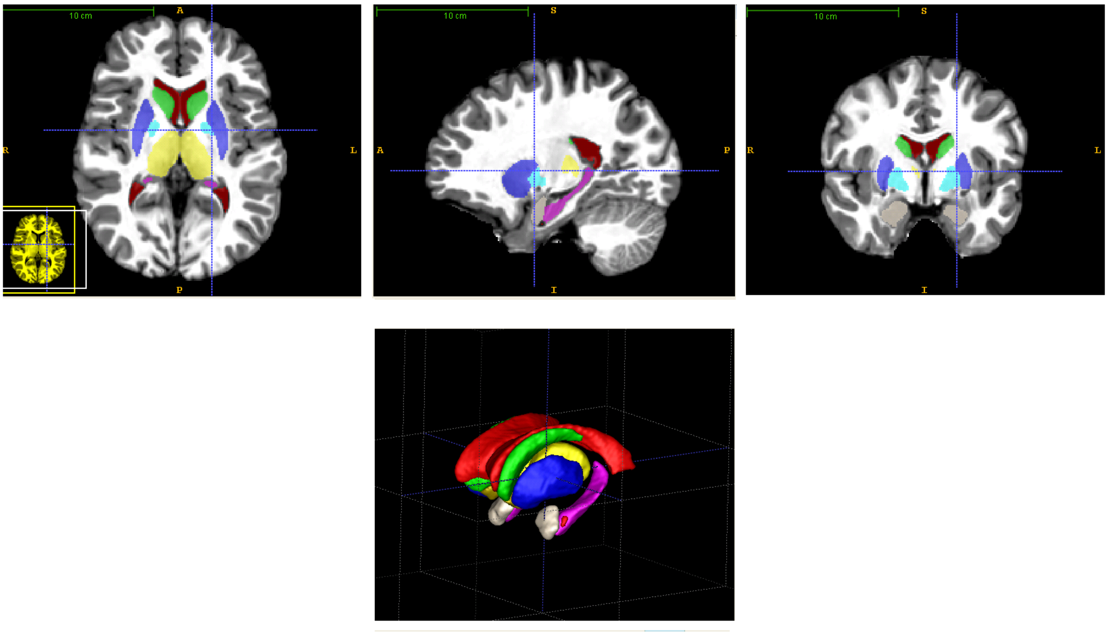

Figure 2. *Results of volBrain subcortical segmentation.*

Table 1. *Average Dice results for all the subcortical structures obtained using LOOCV (N=50)*

Average DICE								
L. Ventricles	**Caudate**	**Putamen**	**Thalamus**	**Pallidus**	**Hippocampus**	**Amygdala**	**Acumbens**	**All**
0.9836	0.9427	0.9442	0.9476	0.8914	0.9533	0.8795	0.8362	**0.9292**