Landmark driven atlas-based segmentation of neuro-anatomical structures from 3T MR images.

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Purpose

In the study of numerous neurological pathologies, the accurate quantification of neuro-anatomical structures of the brain is essential. Regional measurements have been demonstrated as being useful diagnostic markers. Manual delineation of the brain is a difficult and time-consuming task. Recent efforts in the field of segmentation algorithms have shown that this process can be automated to a limited extent. Atlas-based approaches are a field of active research [1,2,3]. The purpose of this study is to automatically segment the neuro-anatomical regions by the registration of the patient MR images to an atlas image. The novelty of the approach lies in how the deformable registration is guided to improve the segmentation by incorporating *a priori* anatomical knowledge derived from other segmented regions of the brain.

Method

Taking a lead from MAP based methods and with a requirement to build robust segmentation algorithms, the concept of including a *priori* information has been extended in a novel manner for this method. In this work, we study the use of an atlas registration technique to segment the brain structures. The process consists in finding the transformation that deforms one image called *deformable model* where the structures of interest have already been defined (i.e. an electronic atlas of the brain) toward another image called *reference image* where structures of interest will be projected (i.e. the patient images). A multi-resolution demons-based method [4,5] is being used for the registration process. In the demons approach, the registration is based on the histogram of the images where spatial information is missing. We are modifying the algorithm by incorporating the spatial information of some structures, which are already manually segmented, located near the structure to be segmented. In the present study, we leverage mask information of 7 other pre-segmented regions (neighboring or in the vicinity of the target structure). Figure 1 shows a flow diagram of the proposed algorithm.

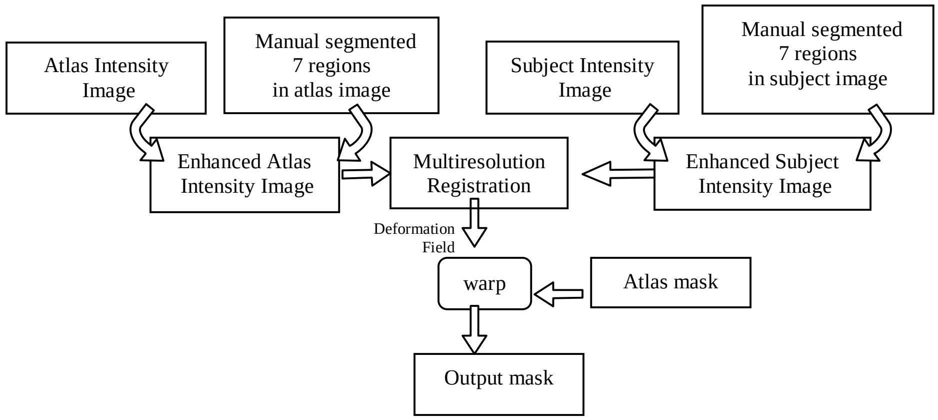

Figure 1. Flow chart of the proposed algorithm

Results

The algorithm was tested successfully on 6 T1 weighted images (TR, 12.1ms; TE, 5ms; FOV 21.9x21.9cm; matrix, 256x256; resolution .0.789x0.789 mm; 54 coronal slices with slice thickness 2mm acquired on a 3T General Electric MR scanner) to segment the putamen. The Dice Similarity Coefficient (DSC) [6] was used to evaluate the goodness of the method. The overlap measured between the segmented data and ground-truth using manual methods was comparable to inter-rater variability of the same region. Figure 2 shows the result of the segmentation on coronal slices of one of the datasets; Figure 3 is the 3D rendering of the segmented Putamen. Table 1 gives the comparison of overlap measure (DSC) of the automatically segmented volume with manual segmented data and the inter-rater variability. The proposed algorithm was also tested on 9 IBSR 1.5 T images to segment the hippocampus. The overlap with manual segmentation obtained was 70.9 $\pm$ 4 %.

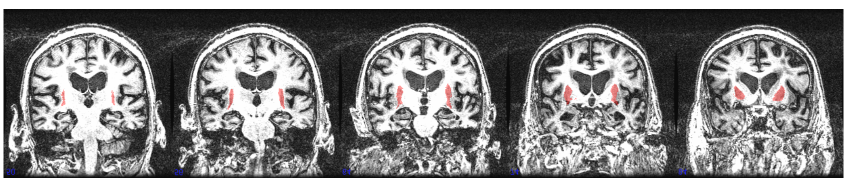

Figure 2 coronal views of segmented result

Figure 3. 3D rendered image of segmented putamen.

Case ID	Atlas – manual overlap	Inter-rater variability
1	73.6	87.97
2	74.128	86.18
3	78.75	77.1
4	82.26	84.13
5	76.71	80.06
6	78.67	87.7
7	76.75	87.04

Table 1 Comparison of atlas-manual overlap with inter-rater variability.

Conclusions

We proposed a new approach for the atlas-based segmentation utilizing the information of the spatial location of nearby segmented regions. It was found that the proposed method works better than the conventional atlas-based segmentation. The algorithm was tested successfully on 7 3T data sets for segmenting putamen and on 9 1.5 T IBSR data for segmenting hippocampus.

References

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