Head and Neck Auto-segmentation Challenge: Segmentation of the Mandible

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1 Abstract

This paper presents a fully automatic method of the mandible segmentation for the Head and Neck Auto-segmentation Challenge. The aim is to segment the mandible and it is achieved by defining smaller Region of Interest (ROI) using prior anatomical knowledge and its registration with mandible models. To be more specific, the method consists the following three steps.

1.1 Initial mandible ROI

The first step, initially identifies the search area. Limiting the search area to the region that has high probability of containing a mandible not only greatly decreases the computational complexity, it also massively improves the segmentation precision. This region was determined by using consecutive detection of bone and soft tissue landmarks (obtained by thresholding) to update the volume.
The first updated volume contains only the head and neck which was cropped at the center of mass of the volume. Next, the nasal tip position (x, y, z) was identified in soft tissue thresholded volume and then the volume above the nasal in the z direction was ignored. By anatomy it is clear that the volume above the nasal tip is irrelevant to segmenting the mandible and therefore can be ignored, Fig1 (D).

1.2 Updated mandible ROI by registration

The second step further restricted the volume to contain only a mandible, because the identified ROI, Fig1 (D), contained structures other than mandibles. This was achieved by registration of a mandible models to the target volume. Mandible models were 3D point cloud constructed from the mandible labels of provided training data sets, Fig1 (E), red point cloud.

- The 3D bone point cloud of the target volume was obtained by thresholding the CT volume and using the foreground voxel positions, Fig1 (D), black point cloud.
- The initial alignment was performed by identifying the translation between the most anterior aspect of the point cloud both on models and the target, Fig1 (D), yellow and green stars.

- To get accurate alignment, the Iterative Closet Point matching was used [1]. In this method, the closed points between two point data sets are matched. Then the matched points are used to construct a transformation, which is then used to better align the point clouds.

After registration, the mandible model was transformed to the target space to estimate the mandible by converting the point could to binary mask. Since the models and target 3D point clouds were constructed from the smallest possible bone volume, the registration process was fast and multiple models can be used for better result.

1.3 Mandible 2D refinement and final segmentation

The third step further improved the segmentation precision for the cases, 1) where part of the binary mask overlap with the target which was not mandible or 2) where part of the binary mask does not overlap with the mandible in target volume. These cases can be adjusted, by considering the anatomy of the mandible in axial direction which may contain only one or multiple pieces. For the slices where the binary mask was only a connected piece, usually initial slices, the overlapped region of the target image with binary mask and along with all connected pixels to this region is labeled as mandible. For the slices where the binary mask was more than a connected piece, we used the first slice where mandible was two separate pieces as our new mask. This mask was used to segment the mandible pieces for upper slices. Defining a mask for each specific target volume improves the segmentation accuracy for small joint regions of the mandible.

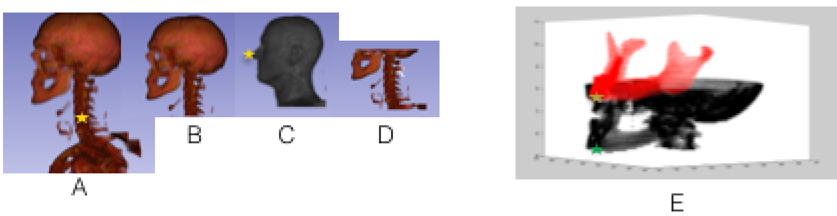

Fig. 1. Different ROIs in the process optic nerve segmentation. A) Original bone volume, B) cropped volume. C) Nasal landmark. D) Mandible ROI. E) Mandible model point cloud (red), Target mandible ROI point cloud (black), Model landmark (yellow star), and Target data landmark (green star).

References

1. Dirk J. Kroon: Segmentation of the mandibular canal in cone-beam CT data. Thesis. University of Twente, 71–74 (2011)