GrowCut-Based Vertebral Body Segmentation with 3D Slicer

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Introduction – Diseases of the spine are quite common, especially due to degenerative changes of the ligamentary and osseous structures. With increasing incidence of vertebral bone disease and resulting limitation of mobility and quality of life of older patients has led to increased number of spinal surgical procedure in this age group. When making the decision for adequate procedure neuro-imaging plays a main role for estimating the dimension of surgical treatment [1]. Accurate and objective evaluation of vertebral deformations is of significant importance in clinical diagnostics and therapy of pathological conditions affecting the spine [2]. A Computer assisted diagnosis system aims to facilitate characterization and quantification of abnormalities as well as minimize interpretation errors caused by tedious tasks of image screening and radiologic diagnosis. Our aim is to perform semi-automated segmentation of vertebral bodies derived from T2-weighted MRI acquisitions to speed-up a pure manually slice-by-slice analysis which aids therapy planning and image guided surgery of spinal injuries [3].

Material and Methods – We used the GrowCut segmentation method of the 3D Slicer platform [4] to delineate vertebral bodies of 13 cases. GrowCut Segmentation is a competitive region growing algorithm using cellular automata [5]. The algorithm starts with a random number of seed points and automatically converges to a natural segmentation. This is useful when deriving classes from large image datasets for applications such as region-based image retrieval. The algorithm achieves reliable and fast segmentation of moderately difficult objects in 2D and 3D using an iterative labeling procedure resembling competitive region growing. After trial of the various segmentation facilities available in Slicer, we determined that the use of GrowCut by initializing it on sagittal, axial, and coronal cross-sections [6-9] provides the most efficient segmentations of vertebral bodies (Figure 1).

Results – For an evaluation of our study, the GrowCut results have been compared with manually slice-by-slice segmentations using the Dice Similarity Coefficient (DSC) [6]. The DSC measures the relative volume overlap between M and S, where M and S are the binary masks from the manual slice-by-slice (M) and the Slicer (S) segmentation. The average DSC for all data sets was 82.99±%±5.03% and shows that the two are comparable. We also found an average segmentation time for a GrowCut-based segmentation of less than 6 minutes (5.77±0.73). For visual inspection, Figure 2 presents a direct comparison of a manual (blue) and a GrowCut (yellow) segmentation on a sagittal slice, and a 3D visualization (Figure 3) of the GrowCut segmentation result (green).

Discussion – In this initial study, we present segmentation results for vertebral bodies in T2-weighted MRI data using the 3D Slicer platform. We showed that a Slicer-based segmentation can be more efficient and thus a less time-consuming process compared to manually volumetric assessment. The time and user effort required for GrowCut segmentation was on an average about 50% compared to a manual segmentation. There are several areas of future work including the evaluation of a larger set of data and comparison with other segmentation methods, like [11].

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Figures

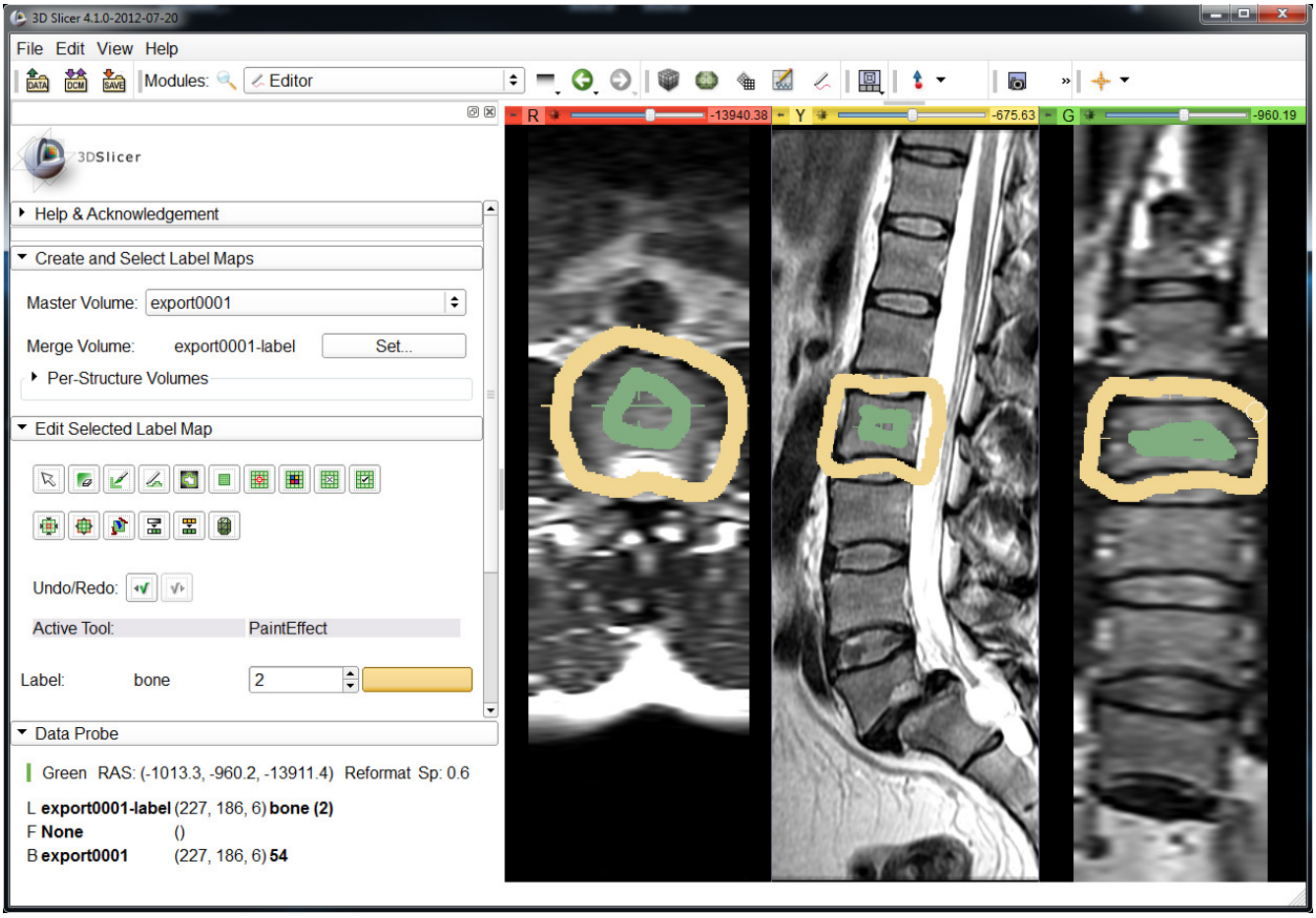

Figure 1

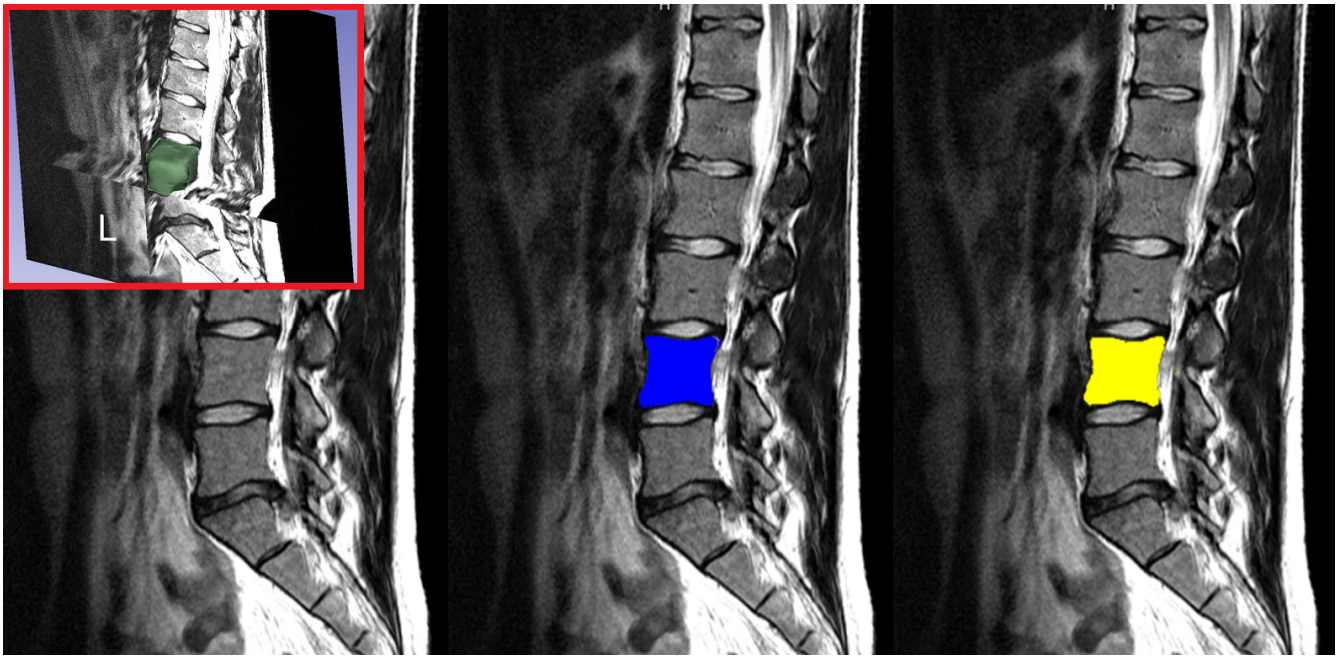

Figure 2

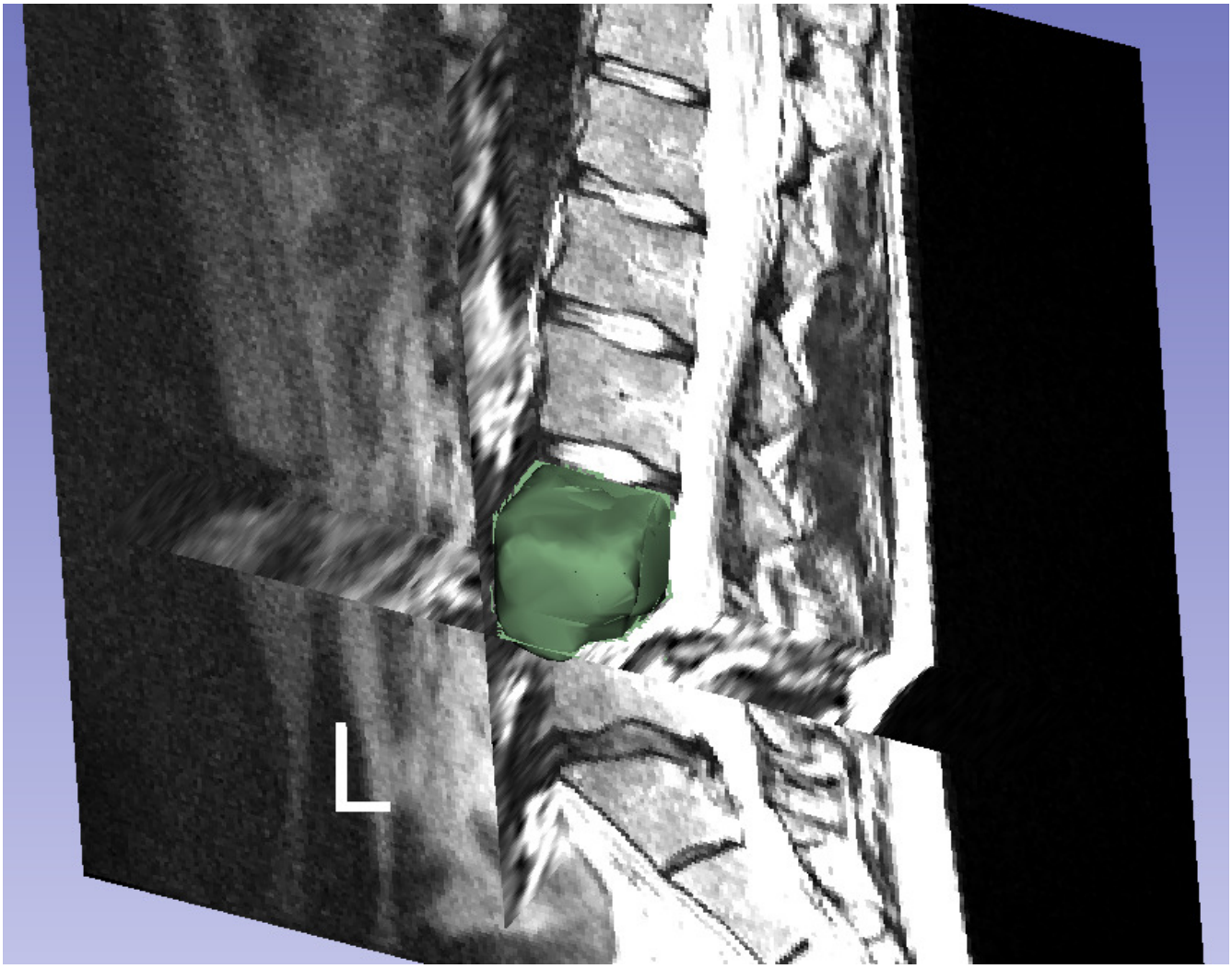

Figure 3