Capability of the Medical Image Computing Platform 3D Slicer for Glioblastoma Multiforme Segmentation in Magnetic Resonance Imaging (MRI) Data

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Purpose

Gliomas are the most common primary brain tumors, evolving from the cerebral supportive cells. The World Health Organization (WHO) grading system for gliomas defines grades I-IV, where grade I tumors are the least aggressive and IV are the most aggressive [1]. 70% belong to the group of malignant gliomas (anaplastic astrocytoma grade III, glioblastoma multiforme grade IV). The glioblastoma multiforme, named for its histopathological appearance, is the most frequent malignant primary tumor and is one of the most highly malignant human neoplasms. Volumetric change in grade IV tumors (glioblastoma multiforme (GBM)) over time is a critical factor in treatment decisions by physicians. Typically, the tumor volume is computed on a slice-by-slice basis using MRI patient scans obtained at regular intervals. In this contribution we investigated the capability of the medical image computing platform 3D Slicer for the segmentation of GBMs.

Methods

For this study, we used the GrowCut [2] software module in 3D Slicer [3], which is freely downloadable from the website http://www.slicer.org. The lower figure shows the 3D Slicer interface with the Editor on the left side and a loaded GBM data set on the right side: axial slice (upper left window), sagittal slice (lower left window), coronal slice (lower right window) and the three slices shown in a 3D visualization (upper right window). A typical user initialization of GrowCut under Slicer for the segmentation of a GBM is presented in Figure 2: axial (left image), sagittal (middle image) and coronal (right image). Note: the tumor has been initialized in green and the background has been initialized in yellow.

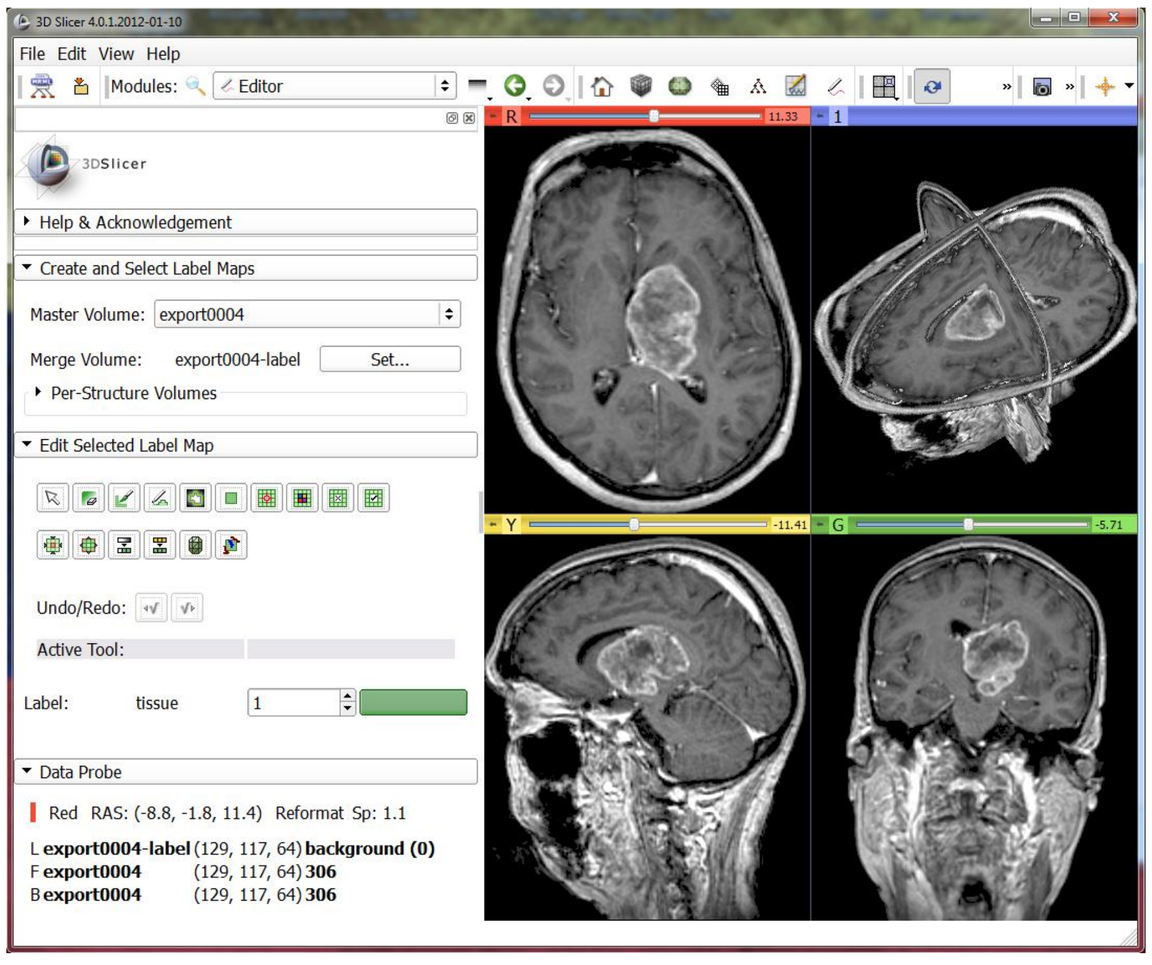
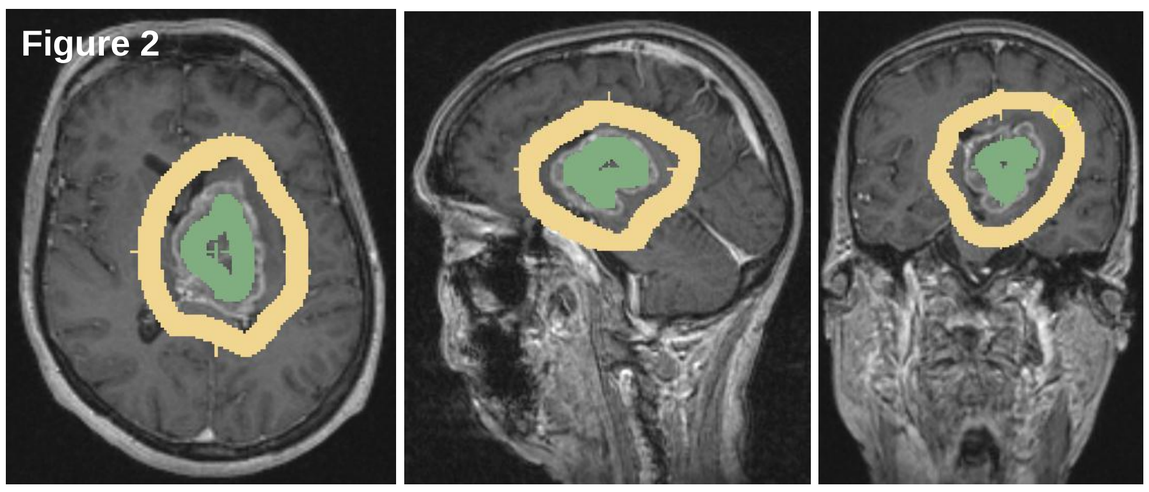


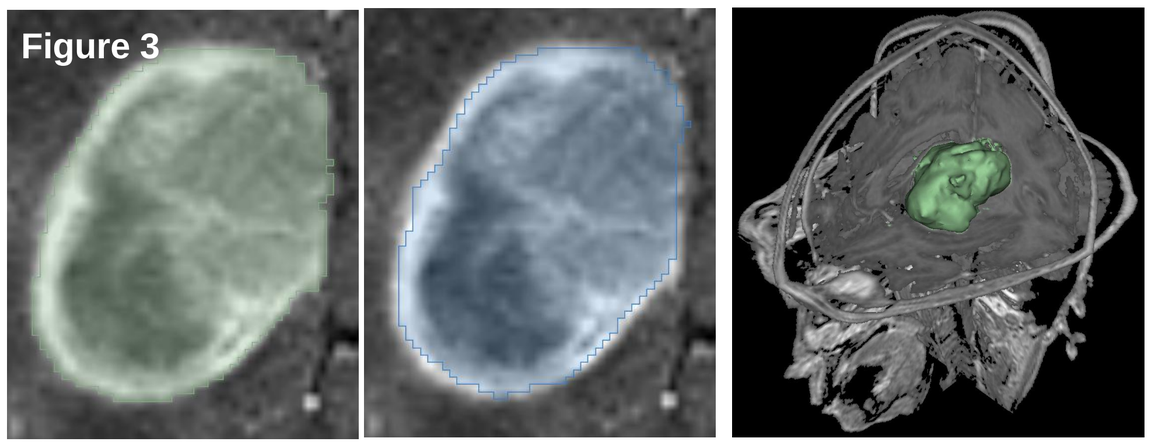
Figure 2



Results

In this study, four physicians segmented GBMs in ten patients, once using the competitive region-growing based GrowCut segmentation module of 3D Slicer, and once purely by drawing boundaries completely manually on a slice-by-slice basis. The time and user effort required for GrowCut segmentation was on an average 25% compared to pure manual segmentation. A comparison of Slicer based segmentation with manual slice-by-slice segmentation resulting in a Dice Similarity Coefficient [4] of 88.43±5.23% and a Hausdorff Distance of 2.32±5.23mm shows that the two are comparable. Figure 3 shows a comparison of GBM segmentation results on an axial slice: semi-automatic segmentation under Slicer (green, left image) and pure manual segmentation (blue, middle image). The right image presents a 3D segmentation result of GrowCut (green). After the initialization of the GrowCut algorithm under Slicer it took about ten seconds to get the segmentation result on an Intel Core i7-990 CPU, 12x3.47 GHz, 12 GB RAM, Windows 7 Home Premium x64 Version, Service Pack 1.

Figure 3



Conclusion

In this study we evaluated the capability of 3D Slicer for segmentation of GBMs compared to manual slice-by-slice segmentation. As a metric for our evaluation we used the agreement between slice-by-slice and Slicer segmentations to show that Slicer can be used to produce GBM segmentations that are statistically equivalent to what the physicians achieve manually in fraction of the time (0.25). Areas of future work include a direct comparison of the Slicer-based segmentation with a graph-based algorithm [5], and extension to multi-modal images.

References

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