3D LIVE SURFACES - A NEW APPROACH FOR SEMIAUTOMATIC VOLUMETRY OF BRAIN LESIONS

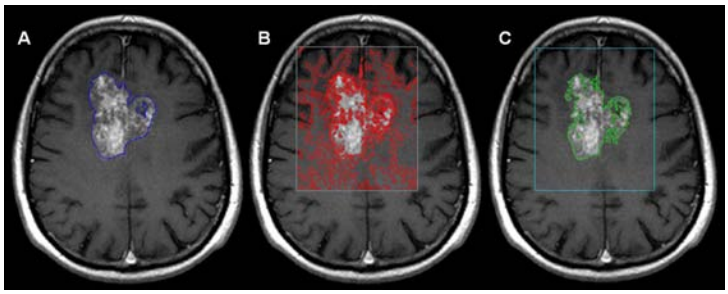
L. Gerigk[1], S. König[2], J. Keitel[1], J. Hesser[2], and C. Groden[1]

[1]Neuroradiology, University Hospital of Mannheim, University of Heidelberg, Mannheim, Germany, [2]Institute for Computational Medicine, University of Mannheim, Mannheim, Germany

Introduction

We developed a computer program for semiautomatic volumetry of brain lesions based on the livewire algorithm adapted to three-dimensional space. Evaluation was performed on clinical patients with glioblastoma multiforme.

Despite of the advent of new functional imaging techniques like perfusion imaging, spectroscopy and diffusion tensor imaging, evaluation of brain tumor response in clinical and research applications is still mainly based on measuring the size of the contrast-enhancing tissue using approximation methods based on diameters, following suggestions by Macdonald [1] or the RECIST criteria [2]. Recent studies have shown that volumetric measurement is superior to these methods [3, 4], but, because volumetry based on manual segmentation is time consuming, numerous research projects and almost all clinical settings still use diameters. Our aim was to overcome this situation by developing a semiautomatic method for fast and reliable volumetry.



Manual segmentation (A) compared to semiautomatic segmentation (C), based on an automatic, threshold-based presegmentation (B).

Methods

The livewire algorithm was extended for use in three-dimensional space [5] and integrated into a computer program (LiveSurface 3D) for segmentation and volume extraction from standard medical images. During development, problems in delineating lesions from physiological structures were analyzed and addressed.

For evaluation purposes, we compared semiautomatic segmentation with manual segmentation in 58 control studies of an unpublished therapy study including patients with glioblastoma multiforme. Volumetric measurements of the contrast-enhancing tissue were performed by two readers blinded to the clinical outcome. For manual segmentation, a simple contour drawing tool was integrated into our software.

Results

Different methods were tested to interactively support the delineation of lesions from structures being physiologically hyperintense on post-contrast, T1-weighted images. Manual splitting of pre-segmented regions was found to be the fastest and most reliable method. Automatic subsegmentation of the pre-processed regions using a lower threshold caused a marked increase in interaction steps and time, because it increased the number of subregions significantly, and could contribute to a successful segmentation in only 12 of 58 studies.

Whereas manual volumetry was successful in 57 of 58 cases (98%), semiautomatic volumetry could only be performed in 52 of 58 cases (90%). The main reason for failure of the semiautomatic method were lesions which could be only segmented based on anatomic knowledge, like lesions broadly adjacent to cerebral venous sinuses. Compared to the fully manual method, the time needed for a complete volumetric evaluation of one study could be reduced from 11.3 +/- 3.7 to 5.8 +/- 2.3 min. Intraclass correlation coefficients were 0.981 for the semiautomatic and 0.995 for the manual method at confidence interval of 95%.

Conclusions

Interactive segmentation of lesions based on a modified livewire algorithm can reduce the time needed for volumetric evaluation of brain tumors markedly without sacrificing reliability. This achievement is a prerequisite for replacing the widely used approximation methods based on diameters with volumetric measurements, allowing a more accurate evaluation of therapy response in clinical studies. The advantages of volumetry are also important in decision finding whether to escalate or discontinue a specific therapy. Our method is not applicable to lesions which can only be delineated based on anatomic knowledge. Until more advanced, knowledge-based methods for analysis are available, manual segmentation can be used as a fallback method in these cases. In our future projects, segmented volumes will be used as volumes of interest for the evaluation of functional datasets, mainly perfusion and diffusion studies.

References

1. Macdonald, D.R., T.L. Cascino, et al., J Clin Oncol, 1990. **8**(7): p. 1277-80.
2. Therasse, P., S.G. Arbuck, et al., J Natl Cancer Inst, 2000. **92**(3): p. 205-16.
3. Dempsey, M.F., B.R. Condon, and D.M. Hadley, AJNR Am J Neuroradiol, 2005. **26**(4): p. 770-6.
4. Marten, K., F. Auer, et al., Eur Radiol, 2006. **16**(4): p. 781-90.
5. Konig, S. and J. Hesser, Stud Health Technol Inform, 2006. **119**: p. 264-6.