

AUTOMATIC SEGMENTATION OF OPTIC PATHWAY GLIOMAS USING MULTIPARAMETRIC MRI METHODS

L. Ben Sira¹, L. Weizman², L. Joskowicz², R. Precel¹, S. Constantini^{3,4}, and D. Ben Bashat⁵

¹Department of Radiology, Tel Aviv Sourasky Medical Center, Tel-Aviv, Israel, ²School of Eng and Computer Science, The Hebrew University of Jerusalem, Jerusalem, Israel, ³The Paediatric Neurosurgery Department, Tel Aviv Sourasky Medical Center, Tel-Aviv, Israel, ⁴Sackler Faculty of Medicine, Tel Aviv University, Tel-Aviv, Israel, ⁵The Wohl institute for Advanced Imaging, Brain Imaging Center, Tel Aviv Sourasky Medical Center, Tel-Aviv, Israel

Background / Aims: Optic Pathway Gliomas (OPGs) are the most common brain tumors in patients with Neurofibromatosis (NF). OPGs are low-grade pilocytic astrocytomas arising in the optic nerve and chiasm. They may be asymptomatic, but may become very aggressive¹ and may cause severe complications depending on their localization and growth. To determine the proper treatment for NF patients with OPGs, it is crucial to accurately quantify the tumor volume and evaluate its evolution, in a repeatable manner. Currently, OPG volume is coarsely estimated manually by the physician in an inaccurate, time consuming, error prone, user-dependent method that may compromise disease progression. The aim of this study was to present an automatic segmentation method based on multi-spectral MRI datasets for tumors in a predetermined anatomical location.

Methods: Subjects: 15 data sets of 7 subjects diagnosed with OPG were included. Subjects were scanned on a 1.5T GE system. The protocol included T1 weighted images (WI), T2 WI and fluid attenuation inversion recovery (FLAIR).

Manual segmentation of the OPG was performed by an expert radiologist using Analyze 9.0. The automatic method was performed as follows (Figure 1): First, the suprasellar location was defined by an experienced radiologist on the John Hopkins Univ. Int. Consortium of Brain Mapping T2 atlas². All of the data sets were co registered and normalized using the SPM package. MRI intensity values were standardized using Dynamic Histogram Warping algorithm³ and probabilistic OPG intensity model was built by annotated training set. Following that, the core of the chiasm and the OPG region of interest (ROI) were defined by mapping back the suprasellar location from the atlas space to the MRI images space. As a result, the chiasm core and the OPG ROI are defined in the patient image space (Figure 1a). OPG boundaries with CSF that were clearly distinguishable using the FLAIR sequence were found by fixed-value threshold. Other boundaries were defined by Generalized Likelihood Ratio Test (GLRT)⁴. Volumes of the tumors obtained both manually and by the automatic method, were compared.

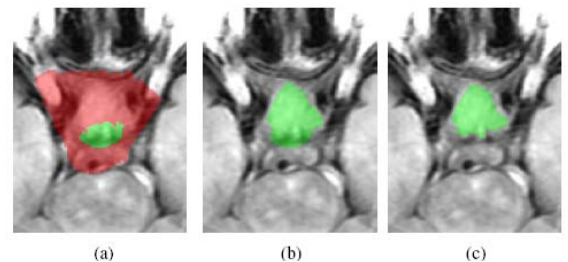


Figure 1: Illustration of the automatic segmentation method: detail of the chiasm core (green) and OPG ROI (red) overlaid on a clinical FLAIR image; (b) sharp boundaries detection, and; (c) final boundary completion.

Results and Discussion: The OPG was successfully defined in all cases both manually and using the automatic method. A significant correlation was obtained between the volume measured with both methods ($r=0.95$, $p<0.0001$) (Figure 2). Figure 3 demonstrates two patients with comparable OPG definitions using the two methods. Although a good correlation was obtained between manual and automatic segmentations, it can't assure a good overlap of the defined volumes. The trade-off between the missed and false detection errors of the automatic method can be controlled by a threshold, which is embedded in the GLRT. For our experiments, the selected threshold led to a mean volumetric overlap error of 28.6% and a false detection rate of 1.107ml/image. This is an expected error in fully automatic algorithms and has been obtained in other studies⁶.

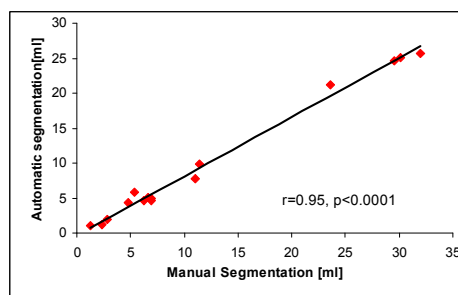


Figure 2: A correlation graph between volumes calculated using manual measurements and the automated segmentation method.

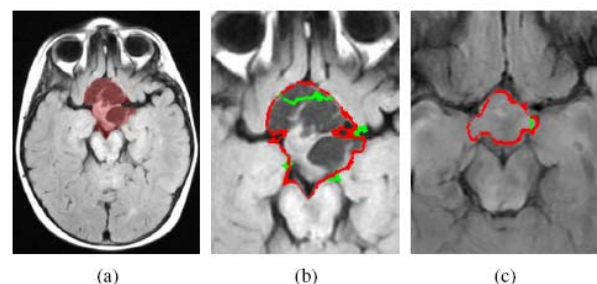


Figure 3: Two representative cases on axial FLAIR images: (a,b) - a cystic OPG; (c) small solid OPG. Red - delineated manually; Green - automated segmentation.

Conclusion: We have presented an automatic segmentation method for the measurement of OPGs, using multi-spectral MRI. The method effectively incorporates prior location, shape, and intensity and relies on the predicted anatomical location of this specific tumor. The potential clinical significance of the OPG segmentations provides an automatic tool for reliable tumor evolution, crucial for therapy decision making.

References:

¹J.S. Guillamo, et al., Brain 126:152-160, 2003; ² Laboratory of brain anatomical MRI, Johns Hopkins, Medical Institute, <http://cmrm.med.jhmi.edu/>; ³ I.J. Cox and S.L. Hingorani, Int. Conf. on Image Proc. Washington, D.C.,USA. IEEE, 1995; ⁴S. Kay, Fundamentals of statistical signal processing: detection theory. Prentice Hall, Englewood, NJ, 1998; ⁵ M.H. Zweig and G. Campbell, Clin. Chem. 39:561-577, 1993; ⁶Jason J. Corso. et al., Int. Conf. on Image Proc. Washington, D.C.,USA. IEEE, Vol 27;5, 2008.