NVM SegMentor: An Open Source Tool for Documentation and Facilitation of MRI Brain Measurement Methods

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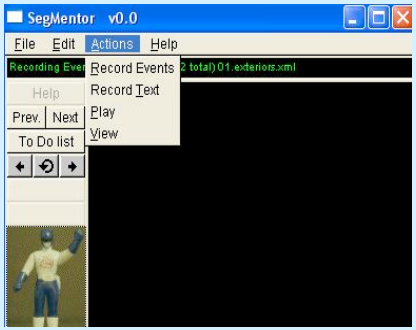
ABSTRACT

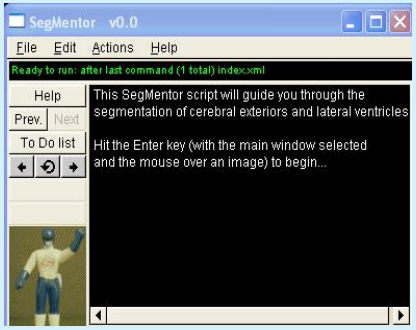
"NVM" is an open source software tool for making precise neuroanatomical measurements in MRI. "SegMentor" is a feature of this software that explicitly defines and embeds measurement methods into the tool by providing on-line, context-sensitive instructions and definitions, and also by assisting in making the measurements. SegMentor records, plays, and allows viewing and editing of scripts that provide information to the user and also control the rest of the program. We present the results of a study to analyze the effectiveness of SegMentor for increasing the reliability and decreasing time necessary for making precise neuroanatomical measurements. By analyzing the same brain scans with and without using SegMentor, we show improvements in both accuracy and efficiency: using SegMentor increases the repeatability and decreases the cost to obtain quantitative MRI brain measurements.

INTRODUCTION

Neuromorphometrics Inc. was conceived as a quantitative MRI service to serve as an alternative to the time consuming and often inconsistent manual segmentation of MR brain images. Unlike other research tools that don't allow for user input in automatic segmentation of brain structures, Neuromorphometrics has created a program that allows for segmentation of brain structures on MR brain images in a semi-automatic method called SegMentor. SegMentor is a scripted alternative to manual segmentation procedures that allows for time savings over manual segmentation. SegMentor also allows for consistency of segmentation procedures between brains because all steps are scripted for the segmentation method of each brain structure. In addition, the SegMentor scripts can be modified to the needs of the specific research project or preferences of the investigator.

Neuromorphometrics Inc.'s scripted semi-automated product SegMentor is a new tool for the novice and experienced neuroscience researcher. NVM is an open source tool for MRI segmentation and can be downloaded from our website at www.neuromorphometrics.com.





SegMentor

SegMentor not only provides on-line, context-sensitive instructions and definitions, but also assists with segmentation. SegMentor records, plays, and allows viewing and editing of scripts that provide information to the user and also control the rest of the program. It also allows images and text to be captured as web pages to help document segmentation procedures as part of SegMentor scripts. It even Includes a to-do list for associated meta-scripts.

With SegMentor, a neuroanatomical measurement method is represented by a collection of XML and HTML documents. XML documents consist of two main types of information: 1) short text descriptions designed to remind the operator what to do next, and 2) macro language instructions. Each step in the script has a link to specific HTML document location that provides help on that step in the script. The interpreted macro language has a C language-like structure. Most commands are simply calls to NVM subroutines so that a script can control everything the user can control through the NVM user interface. Scripts can call system commands and can set the text displayed in two buttons in the SegMentor window that allow the operator to jump to different locations within that script.

The goal is to save time and effort for the user. A SegMentor script automates segmentation as much as possible except for difficult steps that need to be done using the operator's experience and anatomical knowledge. In this sense, the SegMentor script performs bottom-up low-level automation. Furthermore, since SegMentor can control all operations of NVM, scripts can be written to test the features of NVM and thereby improve software validation.

METHODS

Three MRI brain images were used for this experiment to assess whether SEgMentor scripts were faster or more consistent than manual segmentation methods. Using NVM, outlines were created around the exterior of the cerebrum and the lateral ventricles for all slices containing these structures (see [1] and [2] for detailed method descriptions). The hypothesis was that the SegMentor semi-automated scripts would prove to be more time efficient and consistent compared with the manual segmentation method.

All three brains were segmented first without using SegMentor (manual method) and then by using SegMentor (scripted) semi-automated scripts.

ANALYSIS

A Paired t-test was used to compare total time to completion for manual segmentation vs. scripted segmentation using SegMentor.

Volumetric comparisons were also performed to assess the reliability of manual vs. scripted segmentation of the same three brains. Structure volumes were calculated from outlines by including all voxels within outlines and half of the voxels on the outlines. The percent change in volume was calculated as the difference between the manual and scripted volumes divided by the average of the manual and scripted volumes.

RESULTS

Segmentation Results: Manual vs. Scripted with SegMentor

Total Time to completion on three brains segmented with and without SegMentor scripts

Brain #	Manual Total time (hour/min)	Scripted Total time (hour/min)	Difference Total time (hour/min)
Brain 1	9:00	8:55	0:05
Brain 2	11:12	8:05	3:07
Brain 3	10:18	9:39	0:39

Segmentation Results: Manual vs. Scripted with SegMentor

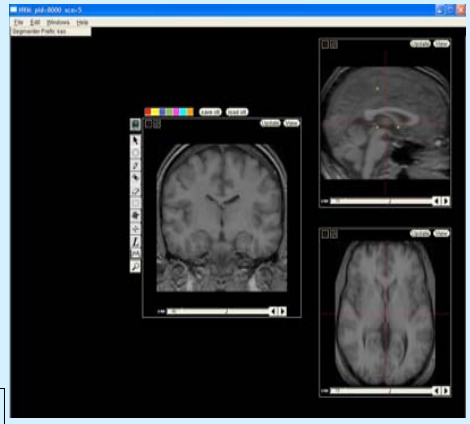
Total Time to completion on three brains segmented with and without SegMentor scripts

Manual Mean Time (hour/min)	Scripted Mean Time (hour/min)	Change Mean Time (hour/min)	test Statistic	*p* value
10:10 (38.3)	9:03 (18.9)	1:07 (46.1)	1.46	.28

Volumetric Results: Manual vs. Scripted with SegMentor

Percent Change in Volume on three brains segmented both with and without SegMentor

Brain #	Cerebral Exterior Left	Cerebral Exterior Right	Lateral Ventricle Left	Lateral Ventricle Right
1	0.07%	0.12%	-1.71%	-2.00%
2	2.52%	1.99%	2.71%	2.01%
3	-0.83%	-1.08%	-2.02%	-0.93%



CONCLUSIONS

Although not statistically significant given the small number of cases, SegMentor semi-automated scripts allowed for an average of one-hour time savings on brain segmentations without sacrificing accuracy when compared with manual segmentations of the same brains. Unlike fully automated segmentation programs, SegMentor scripts can be modified depending on the research study and Investigator preferences.

FUTURE DIRECTIONS

SegMentor scripts will soon be available for most commonly segmented brain structures. The NVM program including SegMentor is available for free download at www.neuromorphometrics.com.

LITERATURE CITED

[1] Filipek, P. A., C. Richelme, et al. (1994). "The young adult human brain: an MRI-based morphometric analysis." Cereb Cortex. 4(4): 344-60.

[2] Worth, A. J., N. Makris, et al. (2001). Accountability in Methodology and Analysis for Clinical Trials Involving Quantitative Measurements of MR Brain Images, Technical Report TR20011117, Neuromorphometrics,Inc.

Conflict of Interest: All Authors are Employees of Neuromorphometrics, Inc.