PERFORMANCE EVALUATION FOR AUTOMATED LESION SEGMENTATION TOOL: LESIONQUANT

Weidong Luo[1], Kelly M. Leyden[1], Aziz M. Ulug[1,2], Sebastian Magda[1], Julia Albright[1], Robert Haxton[1], Chris Airriess[1]

[1]*CorTechs Labs Inc., San Diego, CA, USA* [2]*Institute of Biomedical Engineering, Bogazici University, Istanbul, Turkey*

INTRODUCTION

- Quantitative measures such as lesion volume and distribution have significant value for clinicians evaluating disease progression.
- Clinical standards for lesion evaluation include visual inspection of MRI images, or expert manual segmentation of lesions.
- These subjective measurements are often vulnerable to inter- and intra-rater variability, resulting in low reproducibility.
- CorTechs Labs' LesionQuant is a fully-automated lesion segmentation tool for clinical use designed to provide accurate and reproducible lesion segmentations.
- This study objectively evaluates the segmentation results of LesionQuant compared to expert manual segmentation.

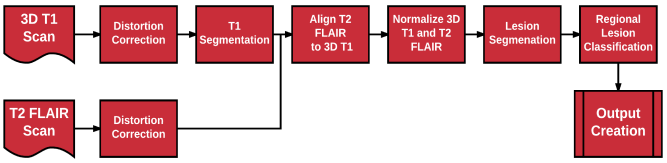
OBJECTIVE

To objectively evaluate the accuracy and reproducibility of an automated lesion segmentation tool, LesionQuant.

MATERIALS and METHODS

LesionQuant Processing

The figure below shows the LesionQuant process workflow. To avoid system bias, only participants with lesion volumes greater than 5 cc and at least 5 lesions outside the periventricular region were included in the study. Subjects were scanned using a 3D T2 FLAIR and 3D T1-weighted protocols (slice thickness= 1.2mm, in plane voxel size = 1.0mm x 1.0mm).



Accuracy

- 31 patients with Multiple Sclerosis (MS) were scanned on 3T and 1.5T scanners for this study.
- 3D T1 and 3D T2 FLAIR images were processed through LesionQuant to obtain lesion volumes.
- Manual segmentation of lesion volumes was performed separately by an expert neuroanatomist.
- Accuracy evaluation was performed on a voxel by voxel basis after LesionQuant outputs and expert manual segmentation were spatially registered.
- Pearson's correlation coefficient, and DICE Coefficient (Percentage Volume Overlap) were used as objective evaluation metrics.

Reproducibility

- Eight sets of repeated scans were acquired for this study using four different scanner manufacturers (Toshiba 3T and 1.5, GE 1.5T, Philips 1.5T, Hitachi 1.2T,1.5T, and 3T).
- Agreement of the total lesion volume between repeated scan segmentations for each subject was evaluated utilizing Pearson's Correlation Coefficient, Absolute Volume Difference, and Percentage Volume Difference.

STATISTICS

Pearson's Correlation Coefficient (PCC)

- *Accuracy*: The correlation between the LesionQuant labeled lesion volume and expert labeled lesion volume.
- *Reproducibility*: The correlation between the initial scan and repeat scan lesion volumes across all test cases.

$$PCC = \frac{cov(x,y)}{\sigma(x)\sigma(y)}$$

Volumetric Difference (Diff)

- Mean percentage volume difference between first scan and repeat scan.

V_{scan} Lesion volumes classified by LesionQuant for the first scan.
V_{rescan} Lesion volumes classified by LesionQuant for the repeat scan.

$$Diff = \mu\left(\frac{2 * (|V_{scan} - V_{rescan}|)}{V_{scan} + V_{rescan}}\right)$$

DICE Coefficient

- Mean percentage volume overlap of labeled volumes between LesionQuant lesion class volume and expert labeled lesion class volume across all test cases.

$$DICE = \mu\left(\frac{2V_{ovl}}{V_{ctx} + V_{exp}}\right) * 100$$

RESULTS

ACCURACY: The accuracy results showed a high correlation between LesionQuant and expert manual segmentation, as shown in Table 1.

Structure Class	Pearson's Coefficient	DICE Coefficient (mean (STD)) [%]
Lesion Volume	**0.9776**	**83.4 (7.5)**

Table 1: Accuracy results of automated lesion segmentation of 31 subjects using LesionQuant compared to expert manual segmentation.

REPRODUCIBILITY: Results demonstrated a high correlation between initial scan and repeat scan data, as shown in Table 2.

Structure Class	Pearson's Coefficient	Absolute Volume Difference (mean) [cc]	Percentage Volume Difference (mean (STD)) [%]
Lesion Volume	**0.999**	**0.24**	**2.4 (±2.5)**

Table 2: Reproducibility results comparing eight subjects scanned on different scanners.

DISCUSSION

The results of the study demonstrate that LesionQuant provides accurate and reliable segmentation when compared to expert manual segmentation.

- In the future, further evaluations should increase the number of participants as well as include patients with other white matter diseases.
- Further studies should also include the full spectrum of lesion distribution and disease severity present in MS.
- Finally, a future analysis should compare LesionQuant to other automatic tools that are available on the market.

REFERENCES

1. Pustian D, etc., Automated Segmentation of Chronic Stroke Lesions Using LINDA: Lesion identification with neighborhood data analysis, Hum Brain Mapp. Apr;37(4):1405-21, 2016
2. Sahraian, A.S et al, MS Lesions in Fluid Attenuated Inversion Recovery Images. *MRI Atlas of MS Lesions.* pg. 35-44, 2008, Springer, Berlin, Heidelberg
3. Surya Probha D. Satheesh Kumar J. Performance Evaluation of image Segmentation Using Objective Methods, Indian J. of Science and Technology, Vol 9(8), 2016
4. Zhang YJ., Evaluation and comparison of different segmentation algorithms, Pattern Recognition, 1996; 29(8):1335-46
5. Zhang H., Fritts, JE, Goldman SA, Image segmentation evaluation: A Survey of Unsupervised methods. Computer Vision and Image Understanding, Vol 110(2), 2008

ACKNOWLEDGMENTS

- This study was supported by CorTechs Labs Inc. The authors are employed by CorTechs Labs. Thank you to all research participants who provided valuable patient data, and to our clinical collaborators.

- **Corresponding Author:** Kelly Leyden kleyden@cortechslabs.com

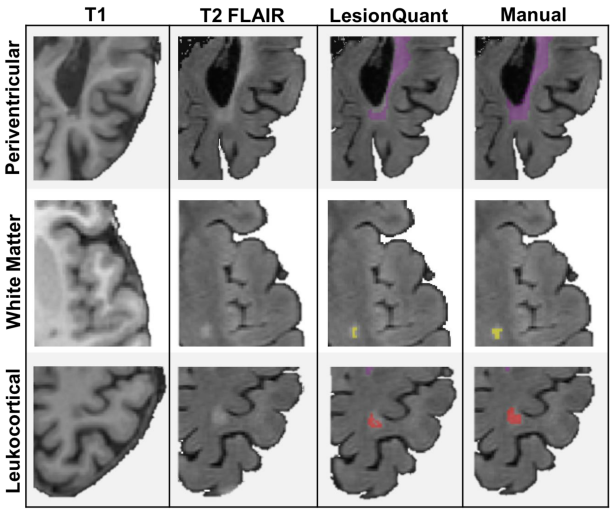


Figure 1. Enlarged view of lesions from 3 different regional classifications as they appear on a 3D T1, a 3D T2 FLAIR, after LesionQuant processing, and after expert manual segmentation.