Lesion Segmentation in Brain MRI

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Challenge

http://iacl.ece.jhu.edu/index.php/MSChallenge

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THE 2015 LONGITUDINAL MS LESION SEGMENTATION CHALLENGE

2015 Longitudinal MS Lesion Segmentation Challenge

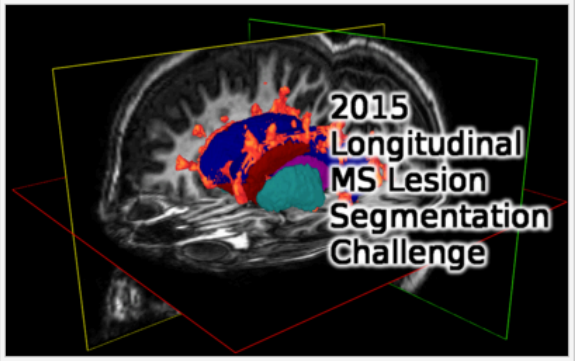
MS Challenge Overview | **MS Challenge Data** | **MS Challenge Evaluation**

I. INTRODUCTION

The Longitudinal MS Lesion Segmentation Challenge was conducted at the 2015 International Symposium on Biomedical Imaging in New York, NY, April 16-19. Competing teams applied their automatic lesion segmentation algorithms to MR neuroimaging data acquired at multiple time points from MS patients. Algorithms were evaluated against manual segmentations from two raters in terms of their segmentation accuracy and ability to track lesion evolution.

34 Teams initially registered for the Challenge coming from 15 different countries, representing 27 different institutions/universities. **Congratulations to Team IIT Madras (First Prize), Team PVG_1 (Second Prize), and Team IMI (Third Prize and Efficiency Prize)**!

Information about the data is available here, and the evaluation software from here.

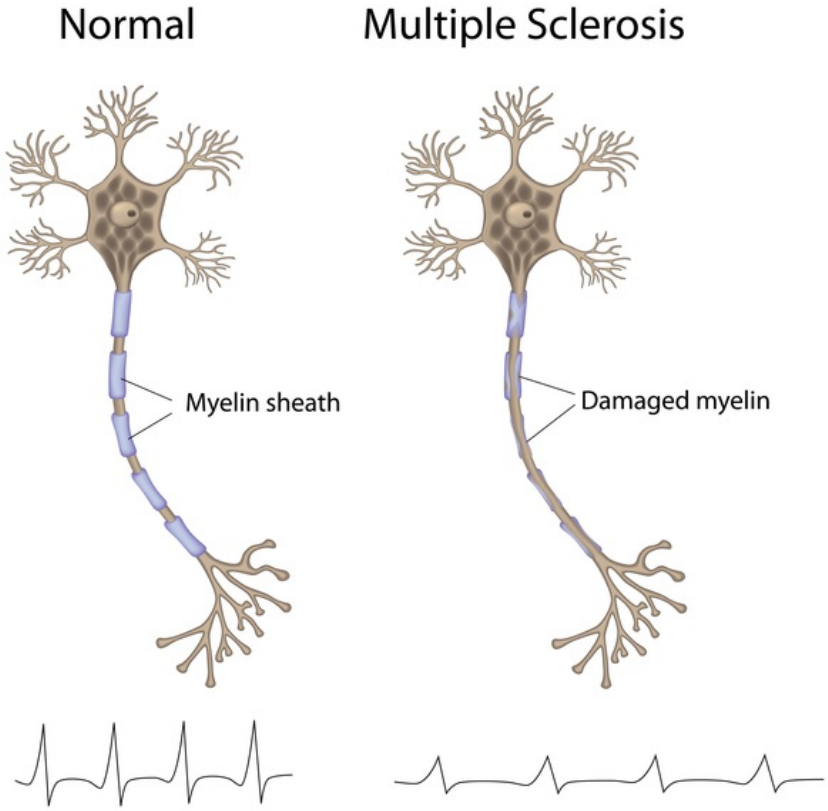


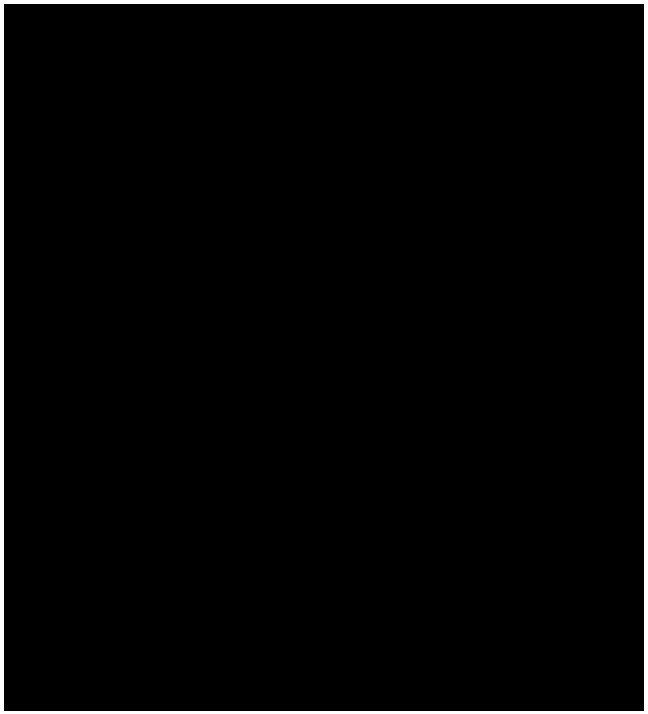
2015 Longitudinal Multiple Sclerosis Lesion Segmentation Challenge

CURRENT LEADERBOARD

A live leaderboard is maintained on the Smart Stats Website. This leaderboard is updated to include links to the associated papers; most currently point to the main Challenge Article: A. Carass, S. Roy, A. Jog, J.L. Cuzzocreo, E. Magrath, A. Gherman, J. Button, J. Nguyen, F. Prados, C.H. Sudre, M.J. Cardoso, N. Cawley, O. Ciccarelli, C.A.M. Wheeler-Kingshott, S. Ourselin, L. Catanese, H. Deshpande, P. Maurel, O. Commowick, C. Barillot, X. Tomas-Fernandez, S.K. Warfield, S. Vaidya, A. Chunduru, R. Muthuganapathy, G. Krishnamurthi, A. Jesson, T. Arbel, O. Maier, H. Handels, L.O. Iheme, D. Unay, S. Jain, D.M. Sima, D. Smeets, M. Ghafoorian, B. Platel, A. Birenbaum, H. Greenspan, P.-L. Bazin, P.A. Calabresi, C.M. Crainiceanu, L.M. Ellingsen, D.S. Reich, J.L. Prince, and D.L. Pham, **"Longitudinal Multiple Sclerosis Lesion Segmentation: Resource and Challenge"**, *NeuroImage*, 148(C):77-102, 2017. (doi) (PubMed).

Rational





Contribution

Contents lists available at ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/neuroimage

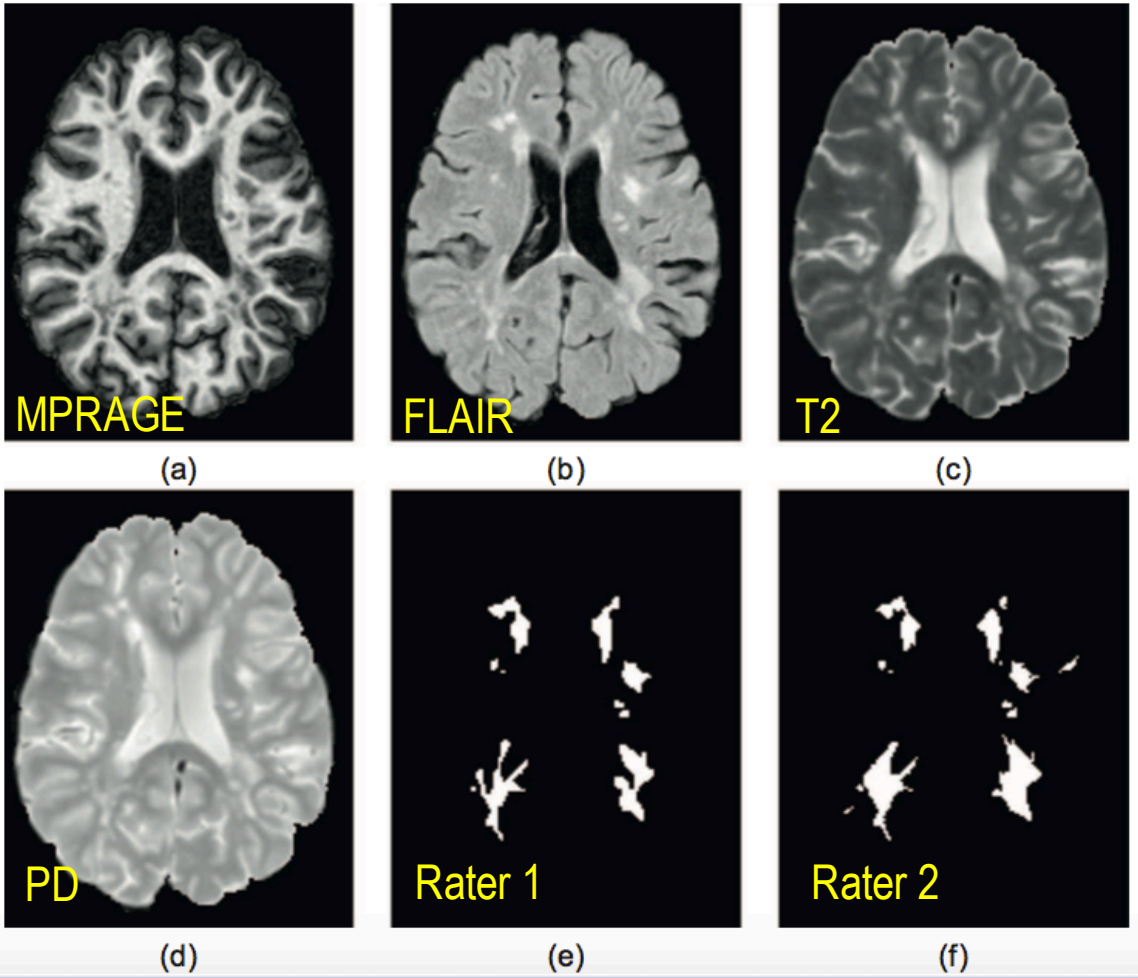
Longitudinal multiple sclerosis lesion segmentation: Resource and challenge

Aaron Carass[a,b,*,1], Snehashis Roy[c,1], Amod Jog[b,1], Jennifer L. Cuzzocreo[d,1], Elizabeth Magrath[c,1], Adrian Gherman[e,1], Julia Button[d,1], James Nguyen[d,1], Ferran Prados[f,g], Carole H. Sudre[f], Manuel Jorge Cardoso[f,h], Niamh Cawley[g], Olga Ciccarelli[g], Claudia A.M. Wheeler-Kingshott[g], Sébastien Ourselin[f,h], Laurence Catanese[i], Hrishikesh Deshpande[i], Pierre Maurel[i], Olivier Commowick[i], Christian Barillot[i], Xavier Tomas-Fernandez[j,k], Simon K. Warfield[j,k], Suthirth Vaidya[l], Abhijith Chunduru[l], Ramanathan Muthuganapathy[l], Ganapathy Krishnamurthi[l], Andrew Jesson[m], Tal Arbel[m], Oskar Maier[n], Heinz Handels[n], Leonardo O. Iheme[o], Devrim Unay[o], Saurabh Jain[p], Diana M. Sima[p], Dirk Smeets[p], Mohsen Ghafoorian[q], Bram Platel[r], Ariel Birenbaum[s], Hayit Greenspan[t], Pierre-Louis Bazin[u,1], Peter A. Calabresi[d,1], Ciprian M. Crainiceanu[e,1], Lotta M. Ellingsen[a,v,1], Daniel S. Reich[d,w,1], Jerry L. Prince[a,b,1], Dzung L. Pham[c,1]

Dataset

Data Set	N (M/F)	Time-Points	Age	Follow-Up
		Mean (SD)	Mean (SD)	Mean (SD)
Training	5 (1/4)	4.4 (± 0.55)	43.5 (± 10.3)	1.0 (± 0.13)
RR	4 (1/3)	4.5 (± 0.50)	40.0 (± 7.55)	1.0 (± 0.14)
PP	1 (0/1)	4.0	57.9	1.0 (± 0.04)
Test A	10 (2/8)	4.3 (± 0.68)	37.8 (± 9.18)	1.1 (± 0.28)
RR	9 (2/7)	4.3 (± 0.71)	37.4 (± 9.63)	1.1 (± 0.29)
SP	1 (0/1)	4.0	41.7	1.0 (± 0.05)
Test B	4 (1/3)	4.5 (± 0.58)	43.3 (± 7.64)	1.0 (± 0.05)
RR	3 (1/2)	4.7 (± 0.58)	44.8 (± 8.65)	1.0 (± 0.05)
PP	1 (0/1)	4.0	39.0	1.0 (± 0.04)

Dataset



Evaluation Metrics

$$\text{Dice}(\mathcal{M}_R, \mathcal{M}_A) = 2\frac{|\mathcal{M}_R \cap \mathcal{M}_A|}{|\mathcal{M}_R| + |\mathcal{M}_A|}, \qquad \text{ASSD}(\mathcal{M}_R, \mathcal{M}_A) = \frac{\sum_{r\in\mathcal{L}_R} d(r, \mathcal{L}_A) + \sum_{a\in\mathcal{L}_A} d(a, \mathcal{L}_R)}{2},$$

$$\text{PPV}(\mathcal{M}_R, \mathcal{M}_A) = \frac{|\mathcal{M}_R \cap \mathcal{M}_A|}{|\mathcal{M}_R \cap \mathcal{M}_A| + |\mathcal{M}_R^c \cap \mathcal{M}_A|}, \quad \text{TPR}(\mathcal{M}_R, \mathcal{M}_A) = \frac{|\mathcal{M}_R \cap \mathcal{M}_A|}{|\mathcal{M}_R \cap \mathcal{M}_A| + |\mathcal{M}_R \cap \mathcal{M}_A^c|}.$$

$$\text{LFPR}(\mathcal{M}_R, \mathcal{M}_A) = \frac{|\mathcal{L}_R^c \cap \mathcal{L}_A|}{|\mathcal{L}_R^c \cap \mathcal{L}_A| + |\mathcal{L}_R^c \cap \mathcal{L}_A^c|}, \qquad \text{LTPR}(\mathcal{M}_R, \mathcal{M}_A) = \frac{|\mathcal{L}_R \cap \mathcal{L}_A|}{|\mathcal{L}_R \cap \mathcal{L}_A| + |\mathcal{L}_R \cap \mathcal{L}_A^c|},$$

$$\text{AVD}(\mathcal{M}_R, \mathcal{M}_A) = \frac{\text{Max}(|\mathcal{M}_R|, |\mathcal{M}_A|) - \text{Min}(|\mathcal{M}_R|, |\mathcal{M}_A|)}{|\mathcal{M}_R|}.$$

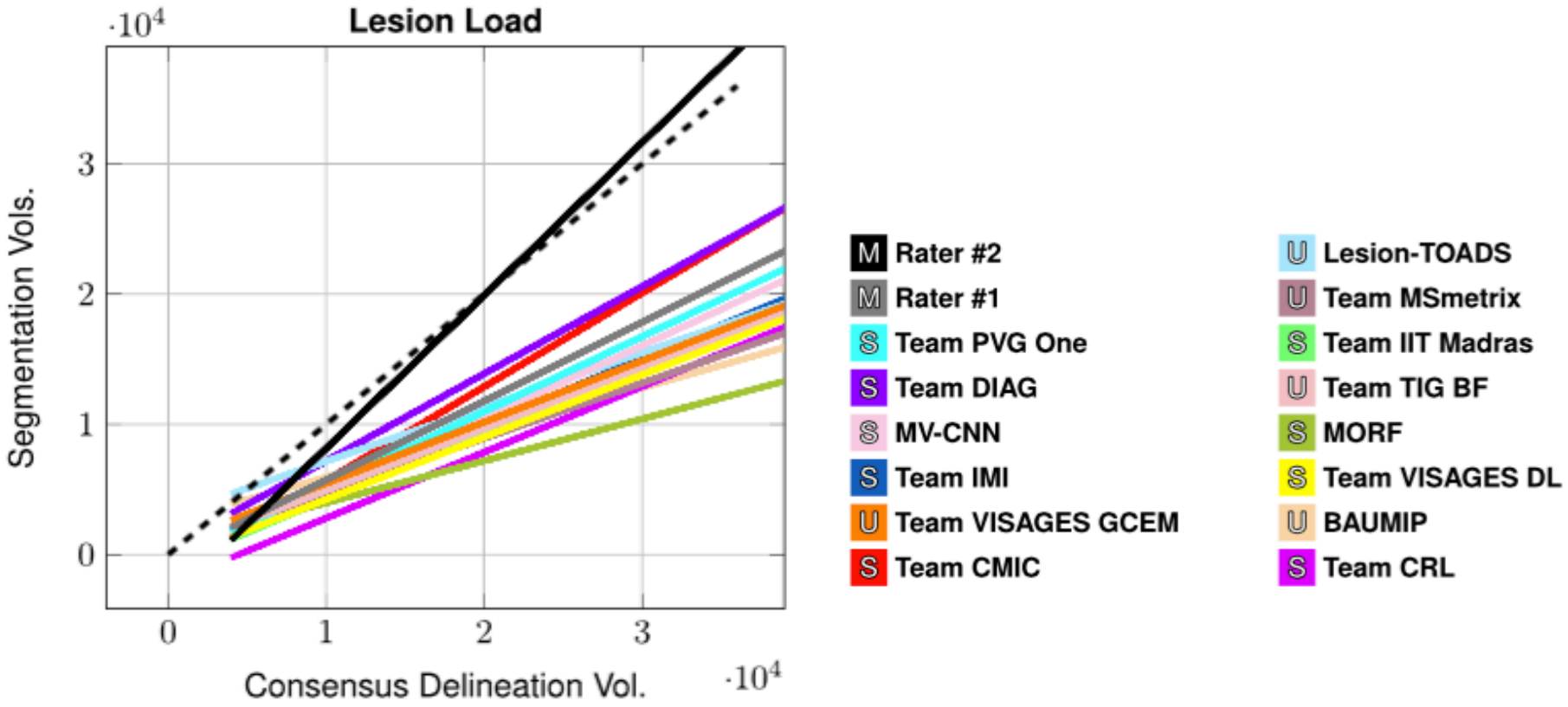
Human Rater Diversity

Symmetric metrics		
Dice		0.6340
ASSD		3.5290
Longitudinal correlation		−0.0053
Asymmetric metrics	**R1 vs. R2**	**R2 vs. R1**
PPV	0.7828	0.5688
TPR	0.5029	0.8224
Lesion FPR	0.1380	0.5630
Lesion TPR	0.4370	0.8620
AVD	0.3726	0.6117

Methods

Name	Approach	Sequences
S Team CMIC	Multimodal patch matching with an l_2-norm	T_1-w, T_2-w, PD-w, & FLAIR
U Team VISAGES GCEM	Robust EM initialized graph cut	T_1-w, T_2-w, & FLAIR
S Team VISAGES DL	Class specific sparse dictionaries	T_1-w, T_2-w, PD-w, & FLAIR
S Team CRL	Mixture of global & local intensity distributions from a reference population	T_1-w, T_2-w, & FLAIR
S Team IIT Madras	n^3 Convolutional Neural Networks	T_1-w, T_2-w, PD-w, & FLAIR
S Team PVG One	Hierarchical MRF & random forest refinement	T_1-w, T_2-w, & FLAIR
S Team IMI	Random forests	T_1-w, T_2-w, PD-w, & FLAIR
U Team MSmetrix	Hierarchical EM followed by temporal consistency check	T_1-w & FLAIR
S Team DIAG	n^2 Convolutional Neural Networks	T_1-w, T_2-w, PD-w, & FLAIR
U Team TIG	Hierarchical subject specific GMM	T_1-w, T_2-w, & FLAIR

Performance Comparison



Performance Comparison

Name	N-Dice	N-PPV	N-TPR	1−LFPR	N-LTPR	LongCorr	TotalCorr	Final Score	Ranking
S Team IIT Madras	0.9448	1.2465	0.7395	0.5873	0.6656	0.5540	0.8753	0.7179	1
S Team PVG One	1.0599	1.2664	0.8857	0.8479	0.5209	0.2503	0.8506	0.7041	2
S Team IMI	1.0149	1.3172	0.8404	0.7318	0.6037	0.2542	0.8611	0.6981	3
S Team CMIC	0.9390	1.0671	0.8194	0.6104	0.4666	0.3268	0.8543	0.6518	4
U Team MSmetrix	0.9417	1.2008	0.7544	0.6246	0.5340	0.3325	0.8583	0.6506	5
U Team VISAGES GCEM	1.0212	1.2238	0.8917	0.6944	0.6805	0.0576	0.7958	0.6435	6
S Team DIAG	0.8509	0.8688	0.8779	0.4202	0.7413	0.2123	0.8027	0.6102	7
S Team CRL	0.7062	1.1122	0.5140	0.5863	0.3495	0.3268	0.8543	0.5642	8
U Team TIG	0.5970	1.1083	0.3987	0.4281	0.6184	0.1770	0.8075	0.5487	9
S Team VISAGES DL	0.6830	1.0082	0.5554	0.5608	0.4603	0.1716	0.6459	0.5188	10

Take Home Messages

A. Carass et al., "Longitudinal multiple sclerosis lesion segmentation: Resource and challenge," *NeuroImage*, vol. 148, pp. 77–102, 2017.