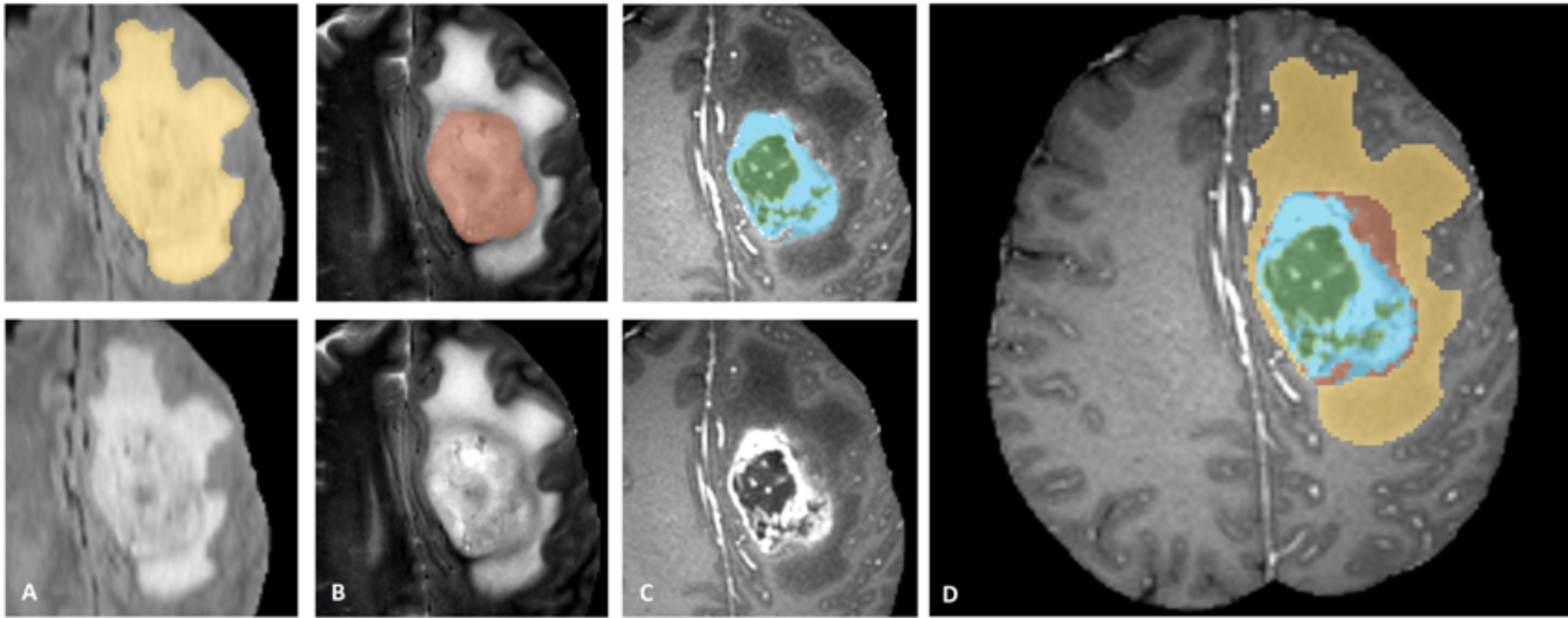


# **BRATS 2013**

## **Tumor Segmentation Challenge**

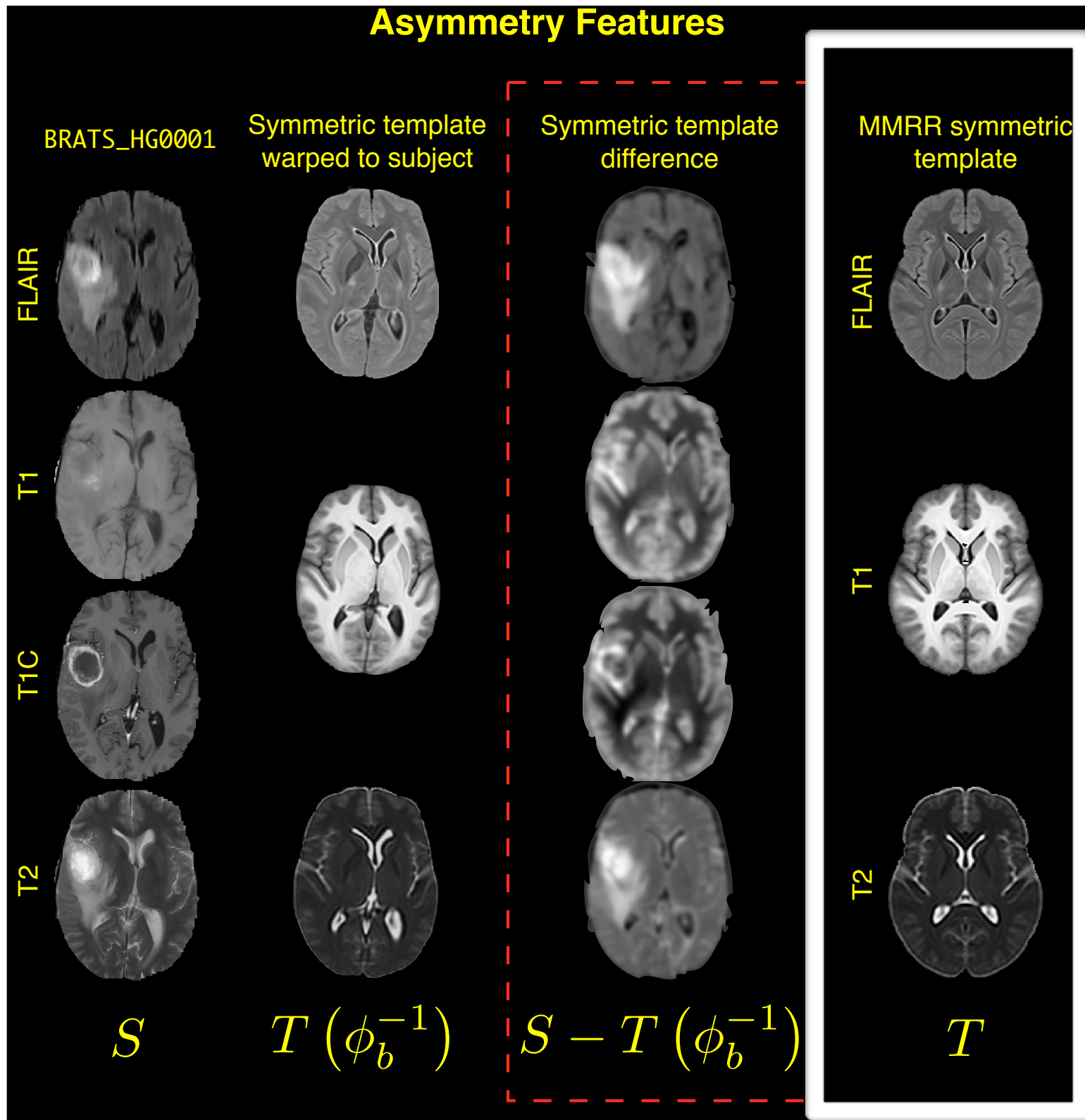
**Example 5**

# Multivariate Tumor Segmentation



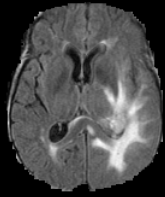
ual annotation through expert raters. Shown are image patches with the tumor structures that are annotated in the different modalities. The image patches show from left to right: the *whole* tumor visible in FLAIR (A), the tumor enhancing *active* tumor visible in T1c (blue), surrounding the cystic/necrotic components of the core (green) (C). The segmentation labels (D): edema (yellow), non-enhancing solid core (red), active core (blue), non-solid core (green).

# BRATS 2013 ANTsR Features

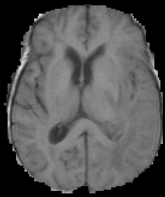


# BRATS 2013 *ANTsR* Pipeline

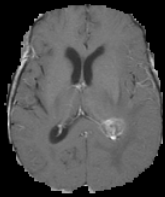
## Multi-modal input



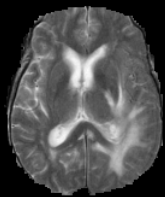
FLAIR



T1



T1C

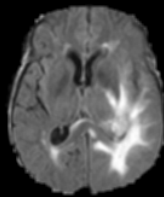


T2

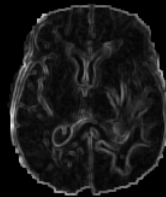
BRATS\_HG0301

## Neighborhood statistical images

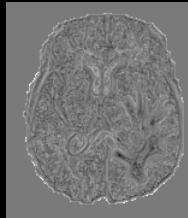
(Radius = 1)



Mean

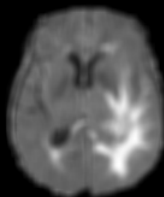


Standard deviation

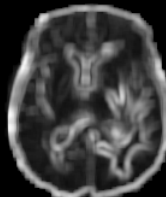


Skewness

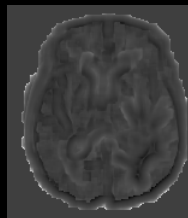
(Radius = 3)



Mean

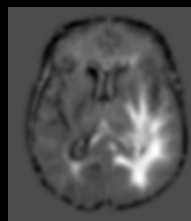


Standard deviation

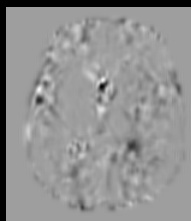


Skewness

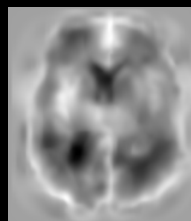
## Symmetric template-based



Template difference



Contralateral difference

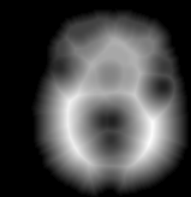


Log Jacobian

## Miscellaneous

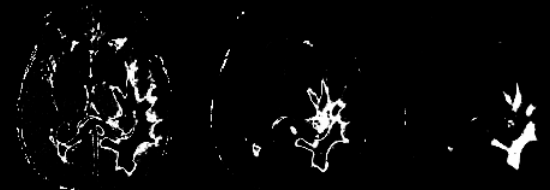


T1-T1C difference

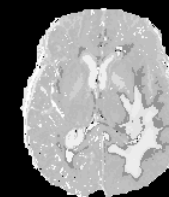


Normalized distance

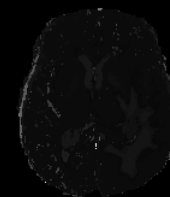
## GMM or MAP-MRF derived



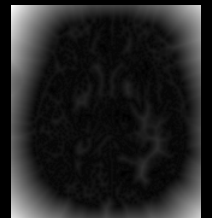
Atropos posteriors ( $n = 7$  classes)



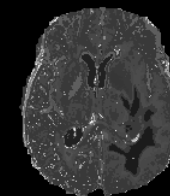
Eccentricity



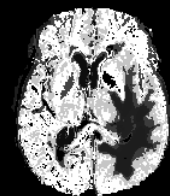
Elongation



Tumor core distance

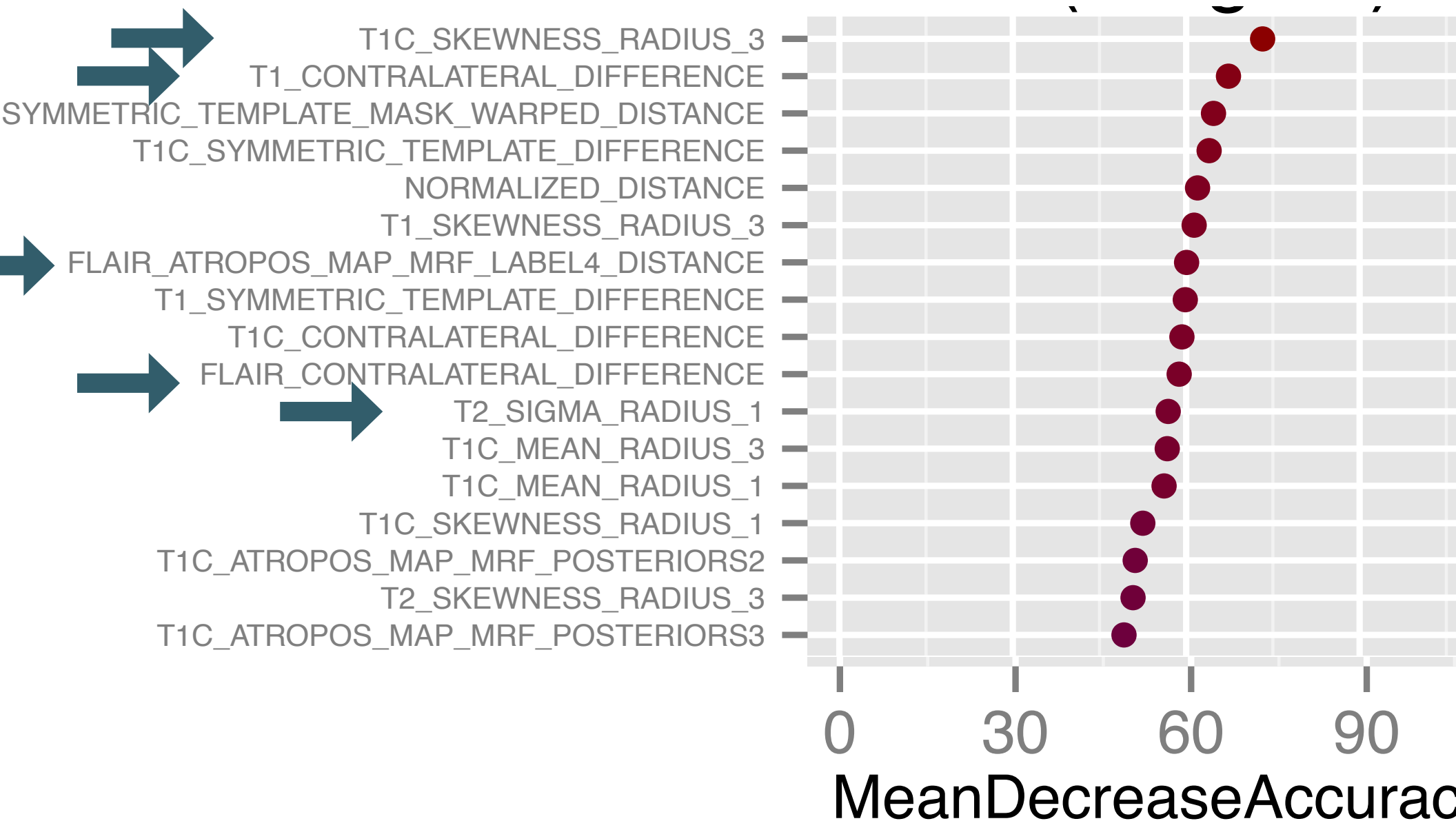


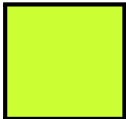
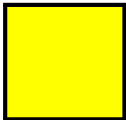





Volume/  
surface area



Physical volume

# Multiple Modality Feature Importance



BRATS 2013				
Real data		whole	core	active
Dice (in %)		<i>HG only</i>	<i>HG only</i>	
	Cordier	84	68	65
	Doyle	71	46	52
	Festa	72	66	67
	Meier	82	73	69
	Reza	83	72	72
	Tustison	<u>87</u>	<u>78</u>	<u>74</u>
	Zhao (II)	84	70	65





*MICCAI BRATS Workshop*  
*presents the 2013 “certificate of awesomeness”*

# 1<sup>st</sup> Place Award

*to*

*Nick Tustison*

*for*

the top-performing multi-modal brain tumor  
segmentation algorithm

*Presented on September 22, 2013*

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[Bruce Lee]

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[Barak H. Obama]

**Only competitors  
to release their solution:**

**[https://github.com/  
ntustison/BRATS2013](https://github.com/ntustison/BRATS2013)**