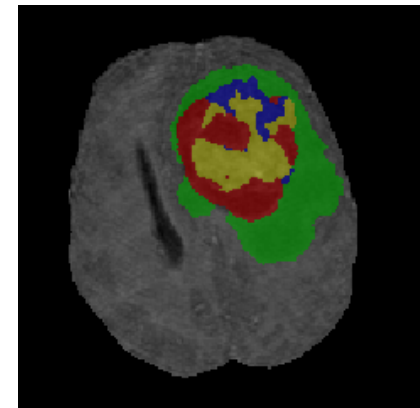
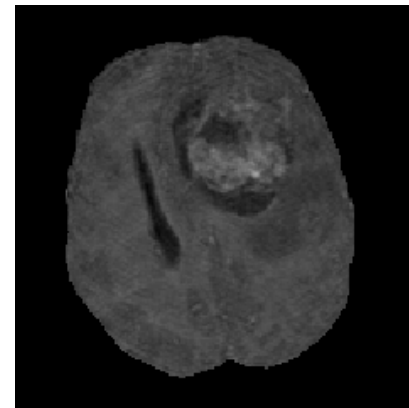


TCGA Glioma Research Group Weekly Meeting

Multimodal Brain Tumor Segmentation



Raphael Meier

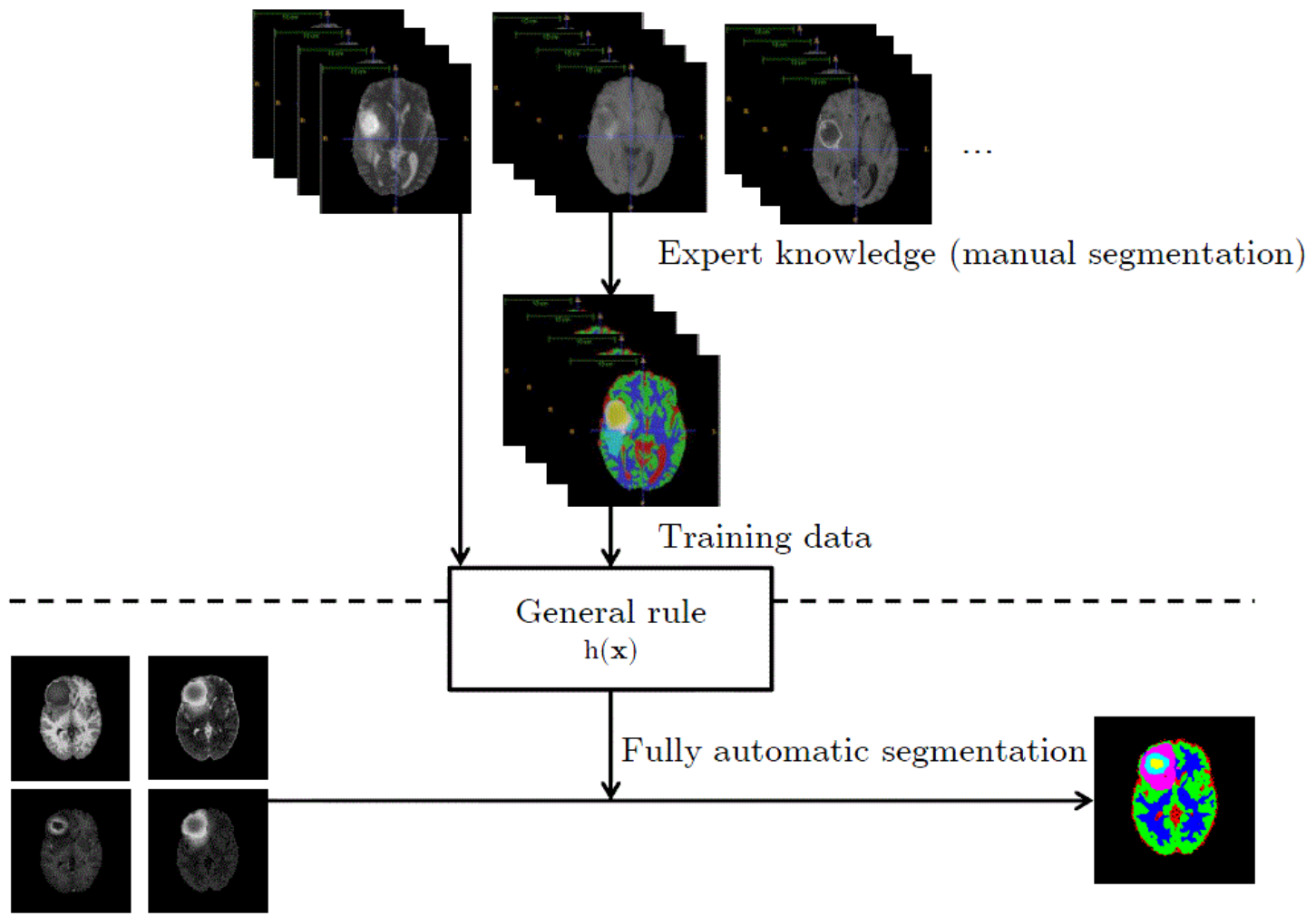
raphael.meier@istb.unibe.ch

University of Bern

Institute for Surgical Technologies and Biomechanics

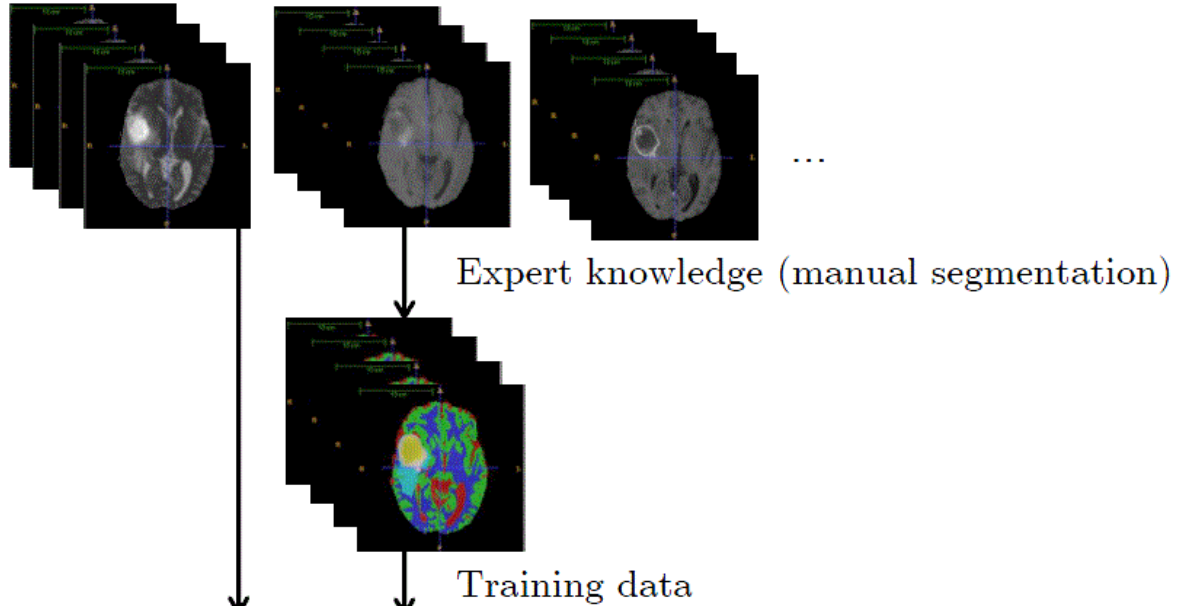
Medical Image Analysis Group

Methodology

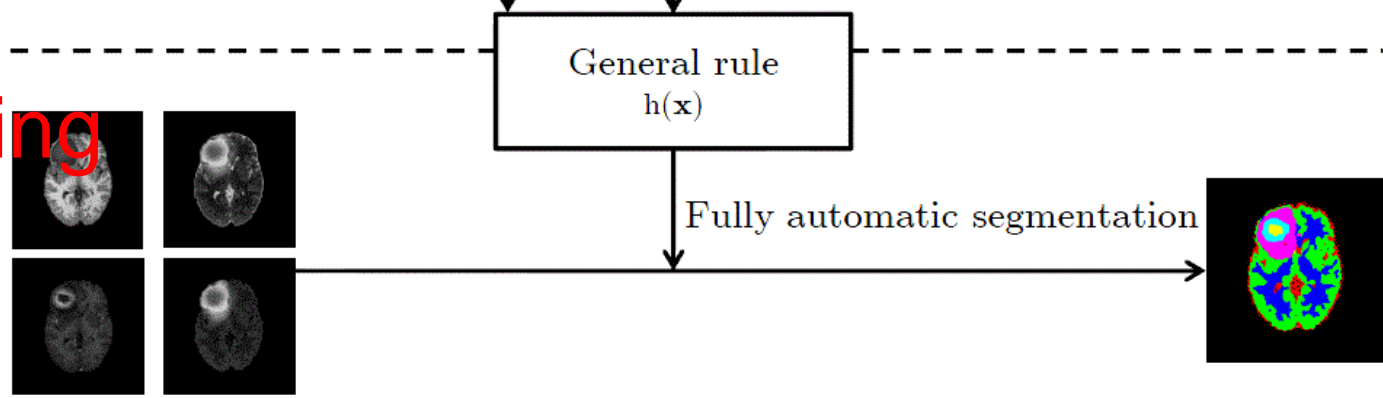


Methodology

Training

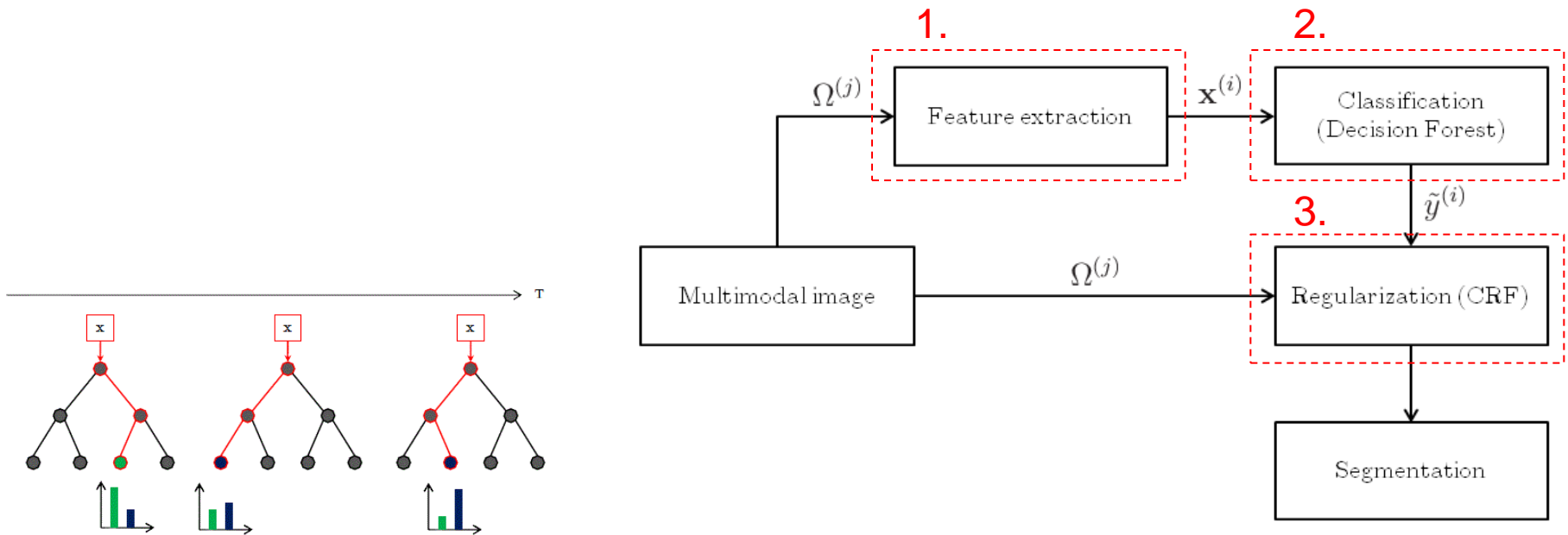


Testing



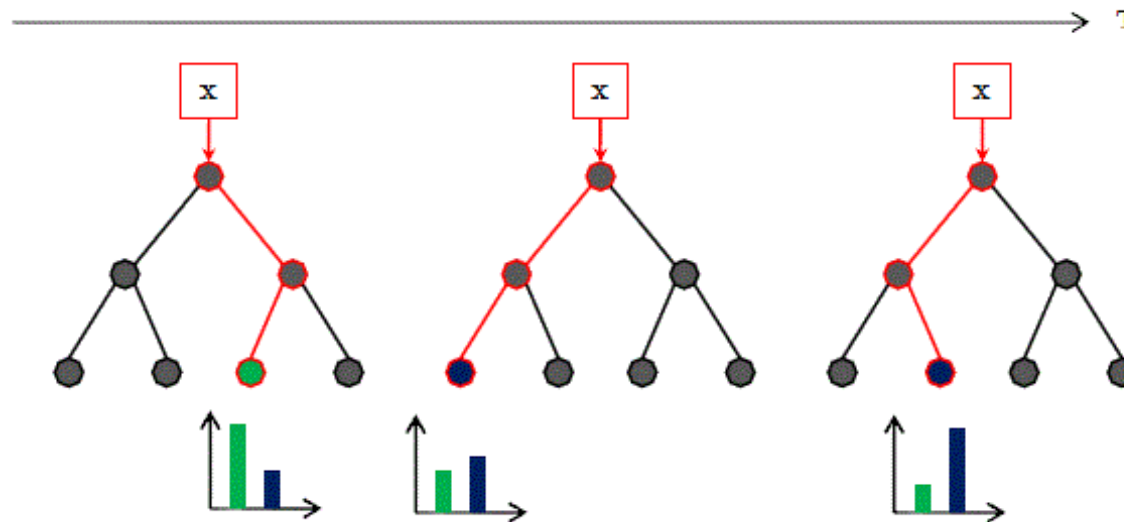
Methodology

- Machine-learning based approach
 - Classification (Decision Forest) with subsequent spatial regularization (CRF)



Methodology

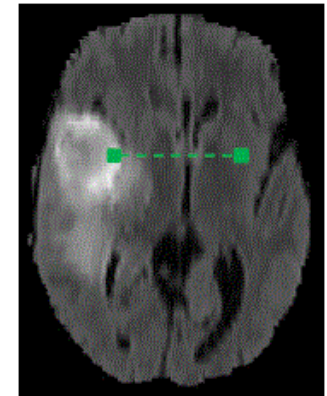
- Decision Forest
 - Idea: Aggregate decision trees to improve predictive performance
 - Output: Average posterior probability over all trees



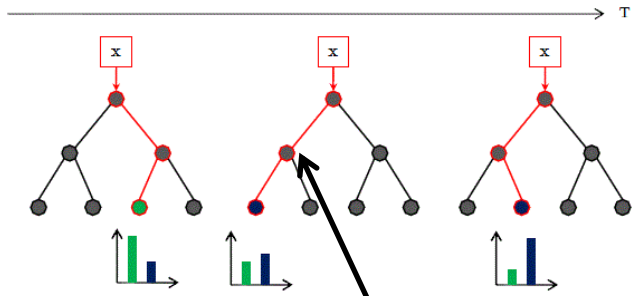
$$p(y|\mathbf{x}) = \frac{1}{T} \sum_{t=1}^T p_t(y|\mathbf{x})$$

Features

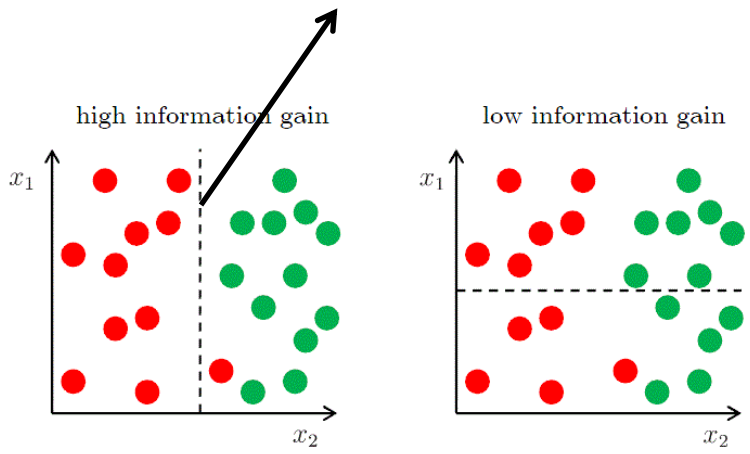
- Appearance-sensitive features
 - Multimodal intensity and intensity differences
 - First-order texture features
 - Gradient textures
 - Multiscale representation
- Context-sensitive features
 - Atlas-normalized coordinates
 - Multi- and monomodal ray features
 - Symmetry features
- 237-dim. feature vector



Feature Importance



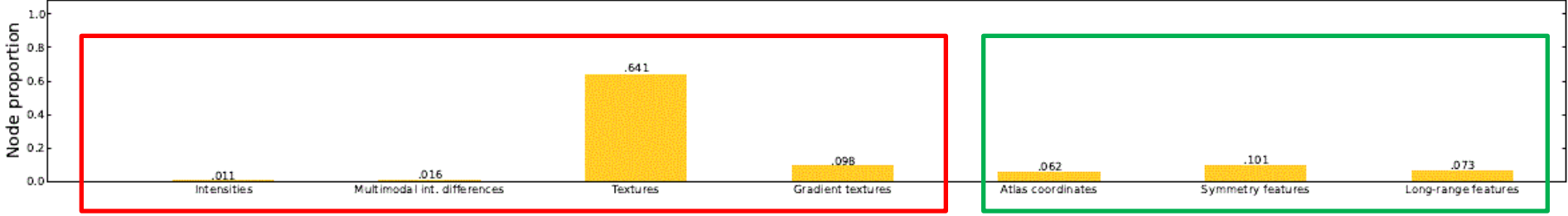
$x_i > \text{threshold}$



Depth	Tumor vs. healthy	Healthy tissues	Tumor core
1	I_{FLAIR}	I_{T1}	I_{T1c}
2	I_{T2}	I_{T1c}	$I_{T1} - I_{T2}$
3	$I_{T1} - I_{FLAIR}$	I_{T1c}	$I_{T1} - I_{T1c}$
4	I_{T2}	$I_{T1} - I_{T2}$	I_{T2}
5	I_{FLAIR}	I_{T1c}	I_{FLAIR}
6	I_{FLAIR}	I_{T1c}	I_{T1c}
7	I_{T1c}	I_{T1c}	I_{FLAIR}
8	I_{T2}	I_{T1c}	I_{T1c}
9	I_{T1c}	I_{T1c}	I_{FLAIR}
10	I_{T1c}	I_{T1c}	I_{T1c}
11	I_{T1c}	I_{T1c}	I_{FLAIR}
12	I_{T1c}	I_{T1c}	I_{T1c}
13	I_{T1c}	I_{T1c}	I_{T1c}
14	I_{T1c}	I_{T1c}	I_{T2}
15	I_{T2}	I_{T1c}	I_{T1c}
16	I_{T2}	I_{T1c}	I_{T2}
17	I_{T2}	I_{T1c}	I_{T1c}
18	I_{T2}	I_{T1c}	I_{T1c}

Feature Importance

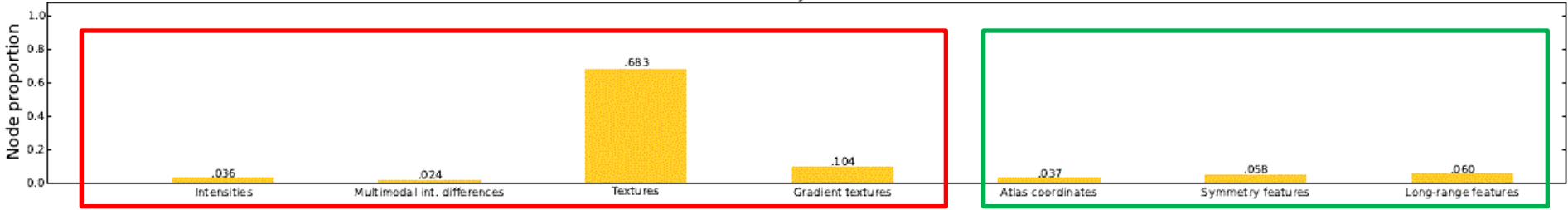
Tumor vs. healthy tissue



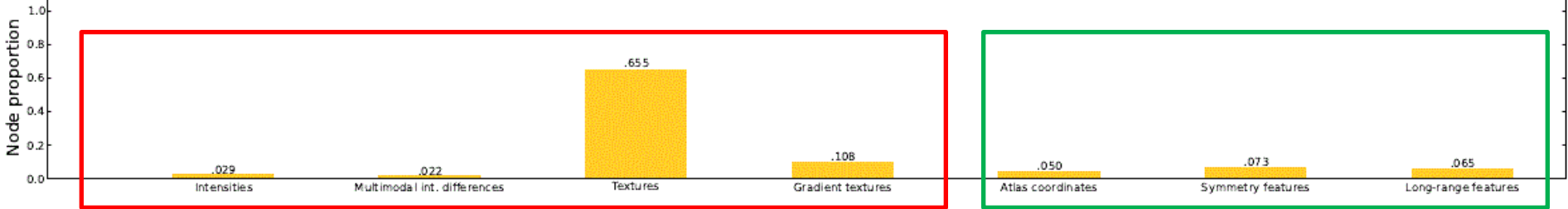
Appearance

Context

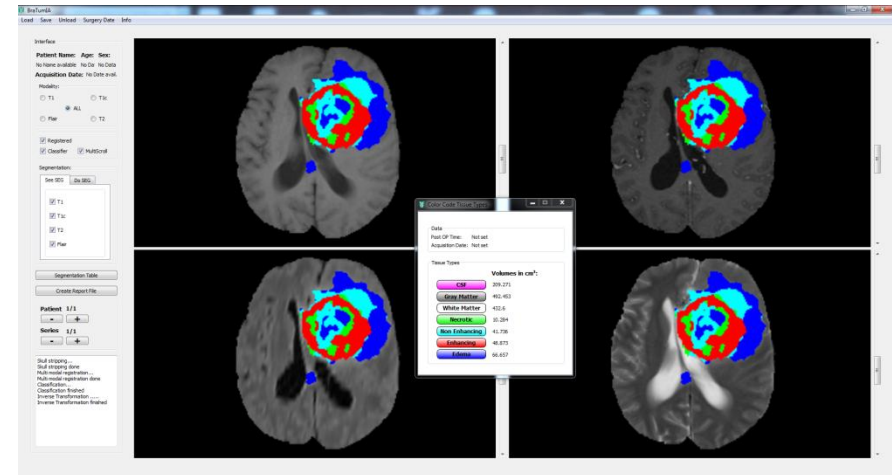
Healthy tissues



Tumor tissues



- Clinical tool with GUI for fully automatic brain tumor segmentation
- Pipeline
 - Skull-stripping
 - Multi-modal registration
 - Tumor tissue segmentation
 - VASARI
- Output: Segmentation label images and quantitative volumes



BraTumIA

The screenshot displays the BraTumIA software interface. On the left is a control panel with sections for 'Interface', 'Modality', 'Segmentation', and 'Patient'. The main area shows four axial brain MRI slices with a color-coded segmentation overlay. A 'Color Code Tissue Types' dialog box is open in the center, showing a table of tissue types and their volumes in cm³.

Tissue Types	Volumes in cm³:
CSF	209.271
Gray Matter	492.453
White Matter	432.6
Necrotic	10.284
Non Enhancing	41.736
Enhancing	48.873
Edema	66.657

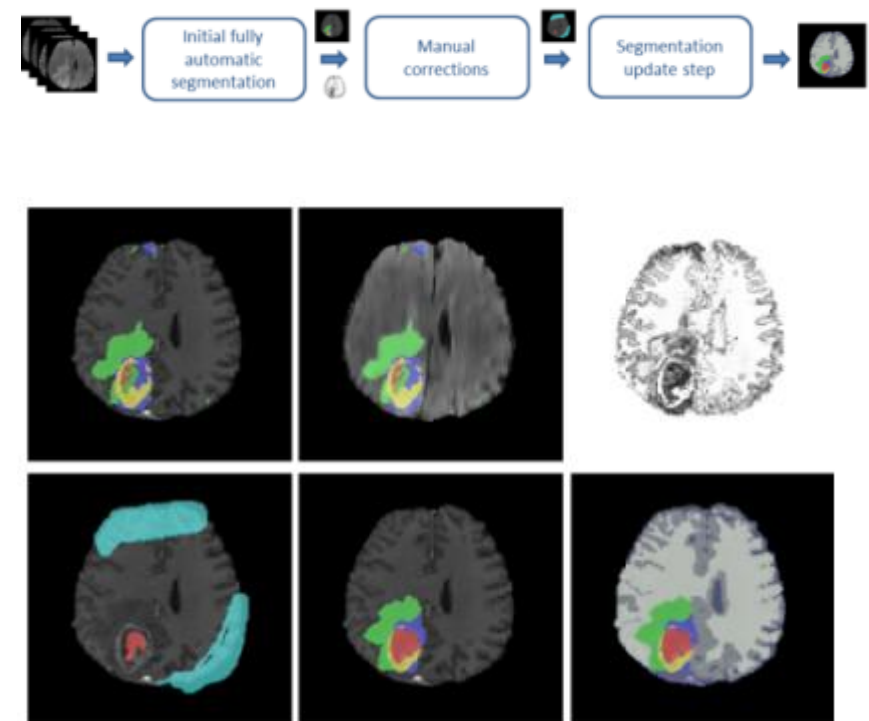
BraTumIA

~5 min. computation time

Tissue Types	Volumes in cm ³ :
CSF	209.271
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Future directions

- Interactive segmentation
- Postoperative image segmentation
 - Extend model to cope with postoperative images
- Segmentation of longitudinal MRI studies
 - Exploiting information from advanced MRI



Bauer et al., IEEE ISBI, 2014