A Software Application for Interactive Medical Image Segmentation with Active User Guidance

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Related Software

- Medical image data
- Focus on segmentation
- Many basic tools
- Classification from annotated pixels for pre-segmentation

P.A. Yushkevich et al. *„User-guided 3D active contour segmentation of anatomical structures: Significantly improved efficiency and reliability",* NeuroImage 31(3), 2006

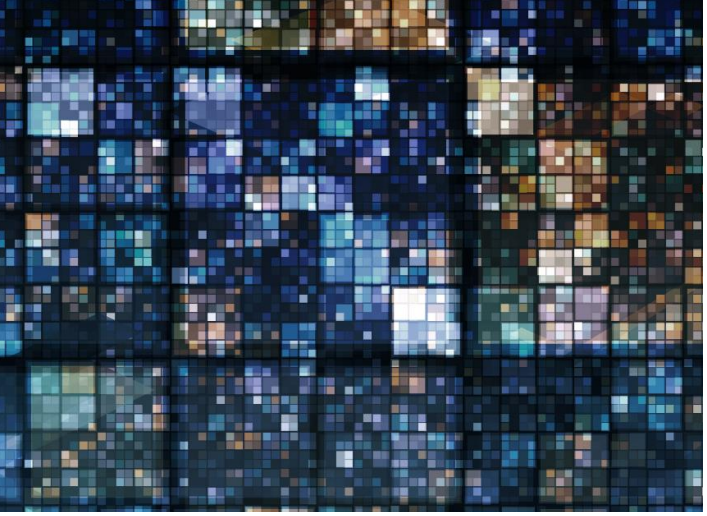
- Generic
  (Not designed for medical images)
- Classification from pixel annotations
  (scribbles)
- Little interoperability between workflows

C. Sommer et al. *„ilastik: Interactive Learning and Segmentation Toolkit“,* 8th IEEE ISBI, 2011

- Not Open Source
- Contour-based segmentation
- Plane suggestion feature

A. Top et al. *„Spotlight: Automated Confidence-Based User Guidance for Increasing Efficiency in Interactive 3D Image Segmentation“,* MICCAI MCV, 2010

A. Top et al. *„Active Learning for Interactive 3D Image Segmentation“,* MICCAI, 2011



MITK

- Designed for medical images
- Plugin system, wide range of interoperable applications
- Basic segmentation capabilities
- Add plugin for interactive pixel classification with active guidance

I. Wolf et al. *„The Medical Imaging Interaction Toolkit“,* Med Image Anal 9(6), 2005

M. Nolden et al. *„The Medical Imaging Interaction Toolkit: challenges and advances“,* Int J Comput Assist Radiol Surg 8(4), 2013


Active Learning

$$\mathcal{T}_i \begin{cases} \text{Unknown Data} & \mathcal{U}_i \\ \text{Query} & Q_i \subseteq \mathcal{U}_i \\ \text{Known Data} & \mathcal{K}_i = \mathcal{K}_{i-1} \cup Q_{i-1} \end{cases}$$

$$\underset{\mathcal{K},\{Q_i\}_{i=0}^{N-1}}{\operatorname{argmin}} \; \mathcal{L}\left(||f_{\mathcal{K}} - \hat{f}||, |\mathcal{K}|, N\right)$$

B. Settles *„Active Learning Literature Survey“,* CS Technical Report 1648, University of Wisconsin-Madison, 2010


Proposed Method

- Random Forest
  - 50 trees
  - 10 split maximum depth
  - Gini splits
- Features (0.7 & 1.6 σ)
  - Gaussian Smoothing
  - Laplacian of Gaussian
  - Gaussian Gradient Magnitude
  - Structure Tensor Eigenvalues
  - Hessian of Gaussian Eigenvalues
- Evaluation with BraTS 2013
  HG patients

Algorithm

- Pre-Training
  - 5-class Gaussian Mixture Model
  - Estimate probability distribution

$$D(\vec{x})$$

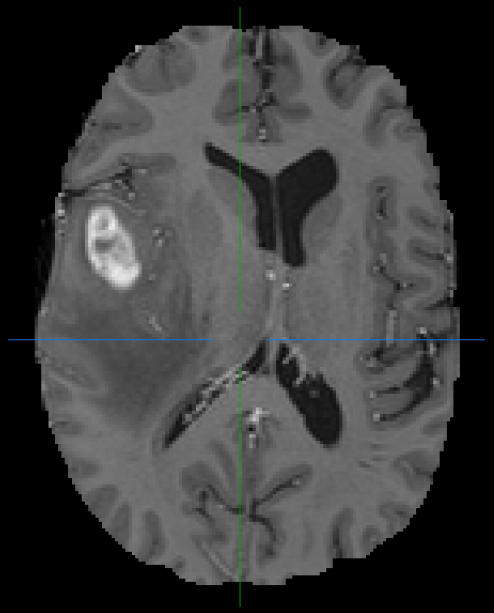
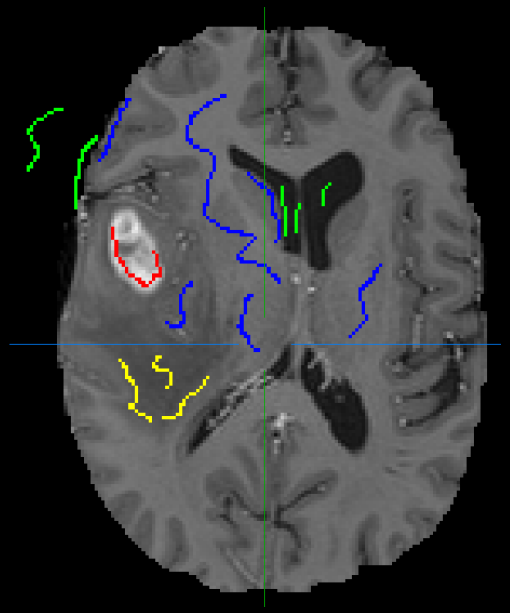
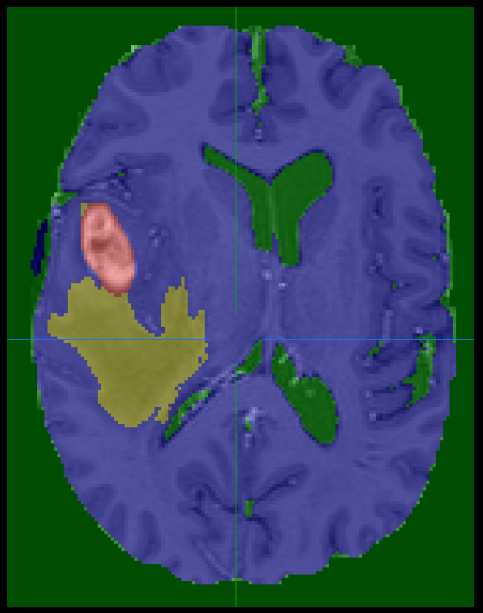
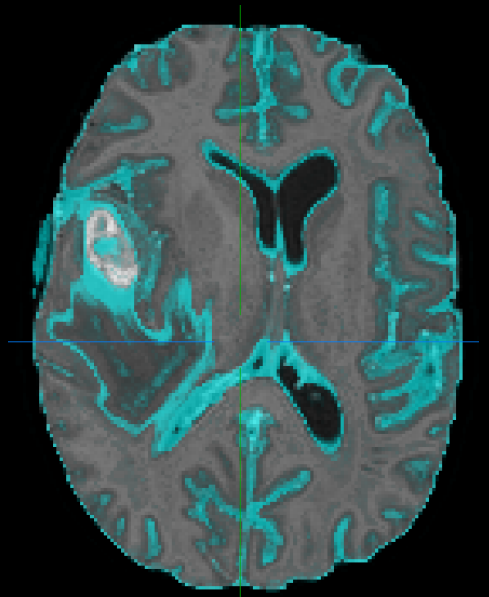
- Repeat
  - Annotate 10 pixels
  - Train classifier and predict
  - Calculate probability entropy

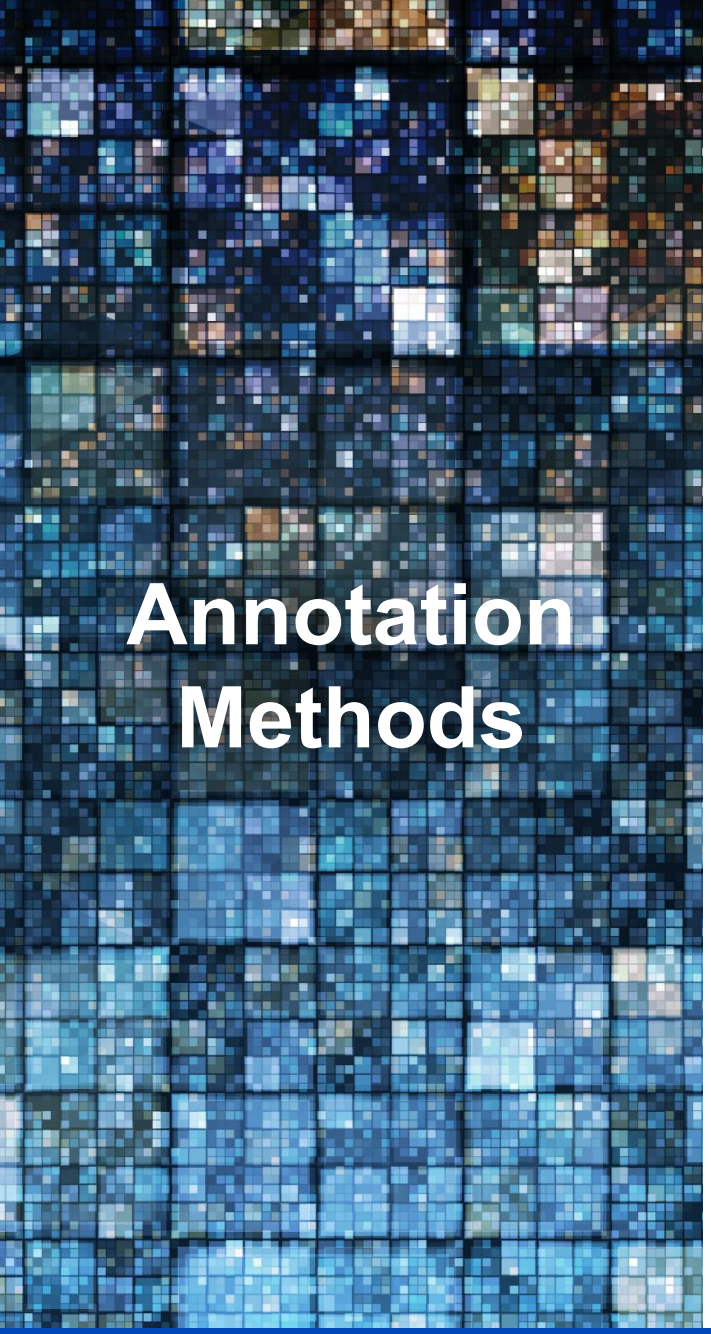
$$H(\vec{x}, t)$$

  - Threshold at 80%
  - Compute

$$G(\vec{x}, t) = H(\vec{x}, t) \cdot \left(1 - \frac{D(\vec{x})}{2}\right)$$

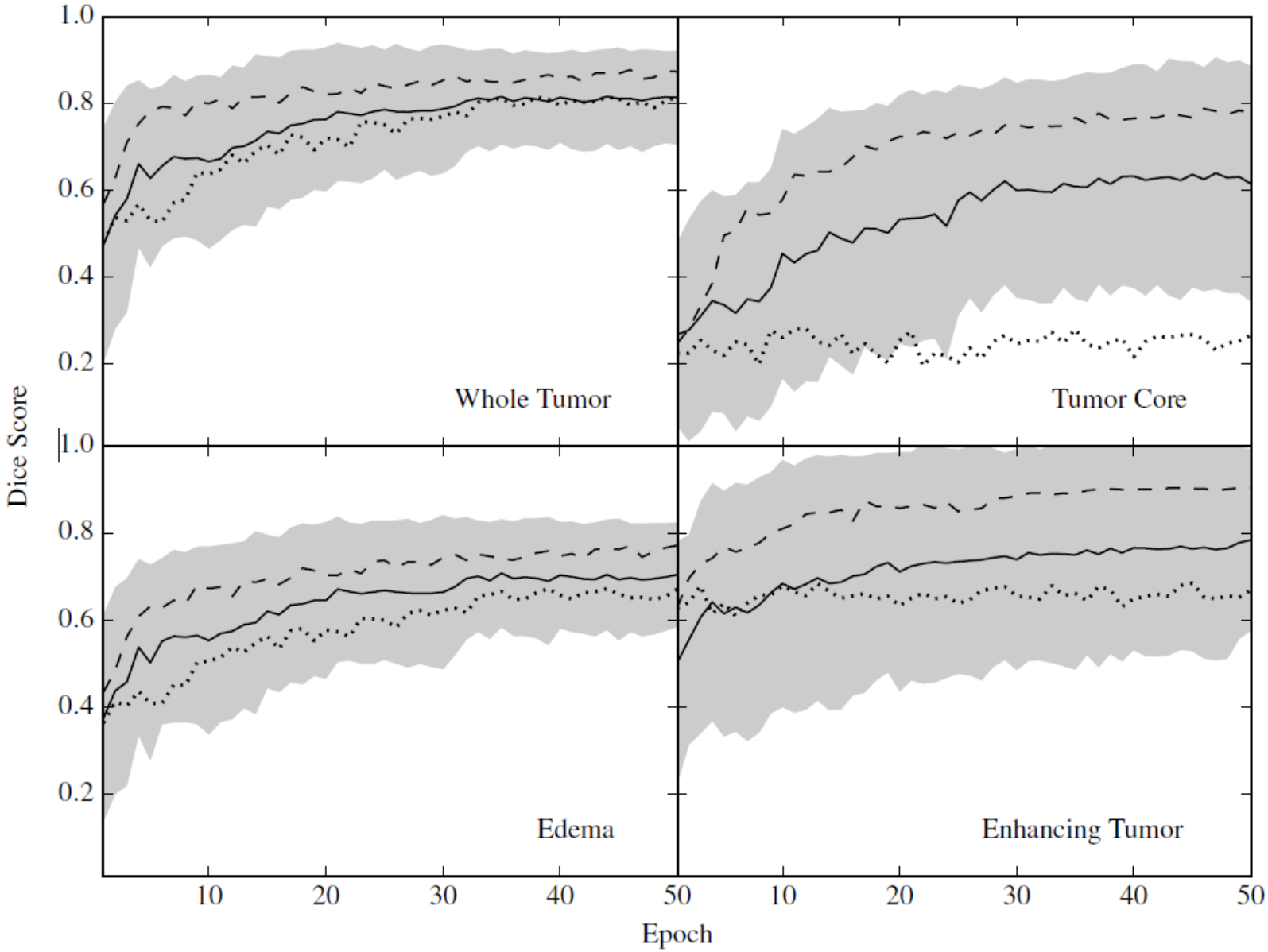
  - Find connected region with highest mean $G(\vec{x}, t)$

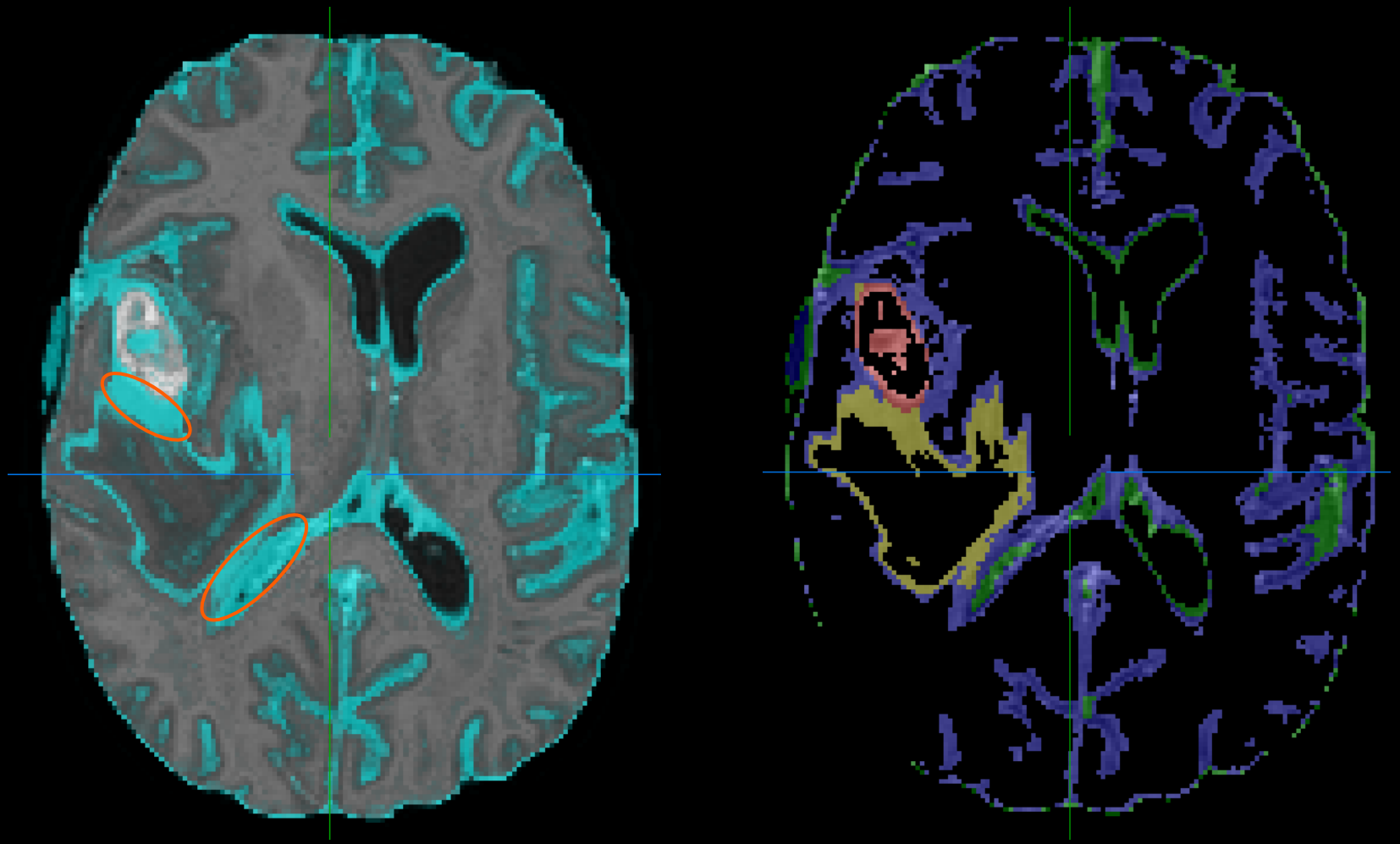





Annotation Methods

- Random stroke
- Stroke in high uncertainty region
- 10 single most uncertain pixels


Dice Score
1.0
0.8
0.6
0.4
0.2
Whole Tumor
Tumor Core
Edema
Enhancing Tumor
10
20
30
40
50
Epoch




Summary

Easy-to-use and generic tool for
interactive pixel classification of medical images

Active-Learning based user guidance to minimize
annotation effort

Thank you for your attention!

Further information on www.dkfz.de

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