Interactive Multi-Label Liver Tumor Segmentation Approach

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Outline

- Motivation
- Challenges
- Segmentation Approaches: Overview
- GrowCut Algorithm
- Summary

Transarterial Chemoembolization (TACE)

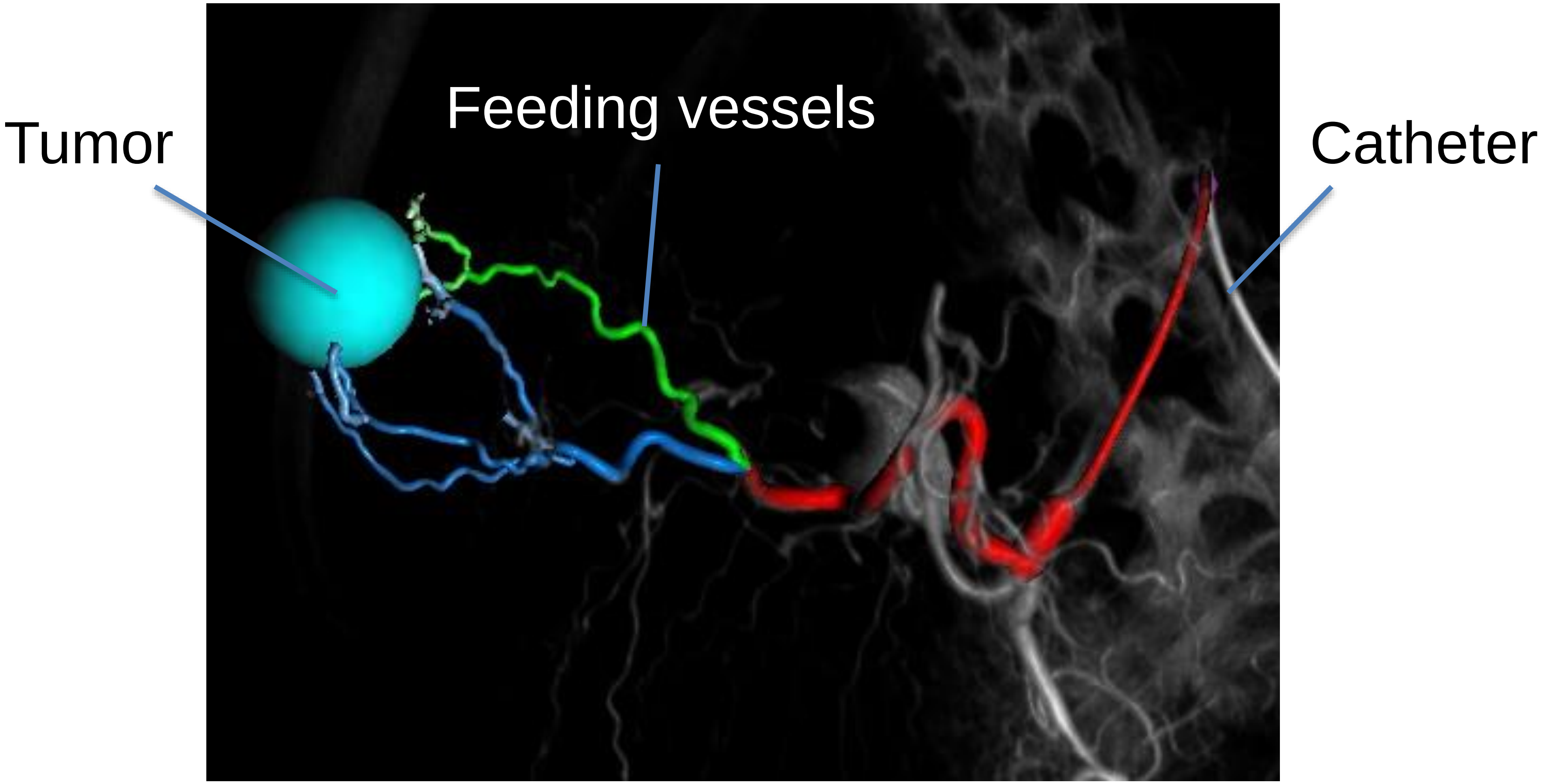

Figure 1: Vessel tree and corresponding ROI (blue sphere).

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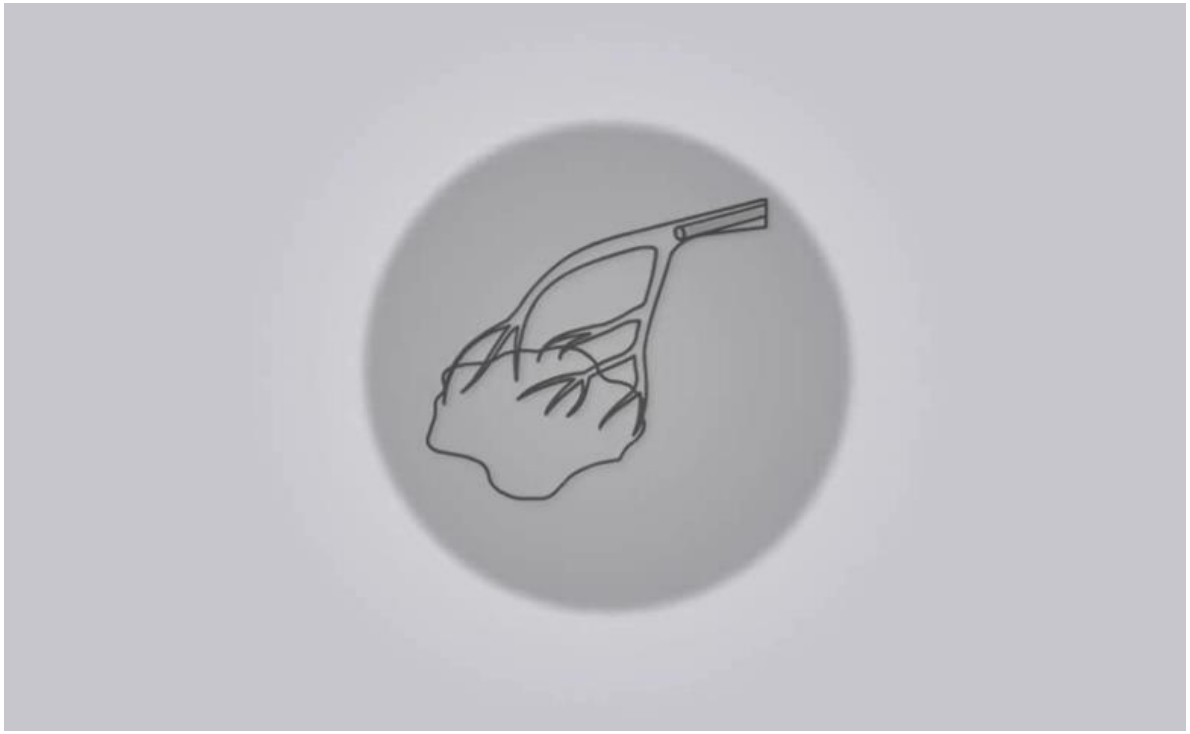

Goal: fast and reliable segmentation for various types of tumors

Challenges of Tumor Segmentation

- High diversity
  - No typical appearance due to abnormal/uncontrolled cell divisions

- Strong similarity between tumor and healthy tissue
  - No strong intensity boundaries

- Tumors vary greatly in
  - size, position and shape

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- High diversity
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- Tumors vary greatly in
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- Solution: Semi-automatic approach guided by user interaction
  - Humans usually outperform computers in recognition [3]
  - Provides rough information about size and location of the lesion

Image Segmentation Methods

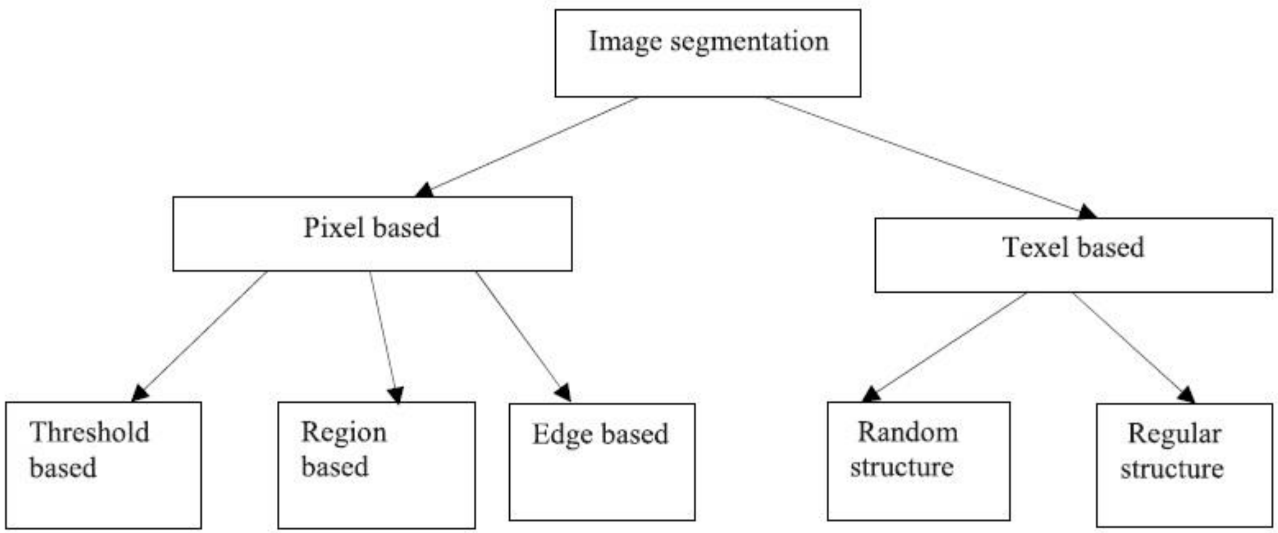

Figure 2: Image segmentation methods [2]

Image Segmentation Methods

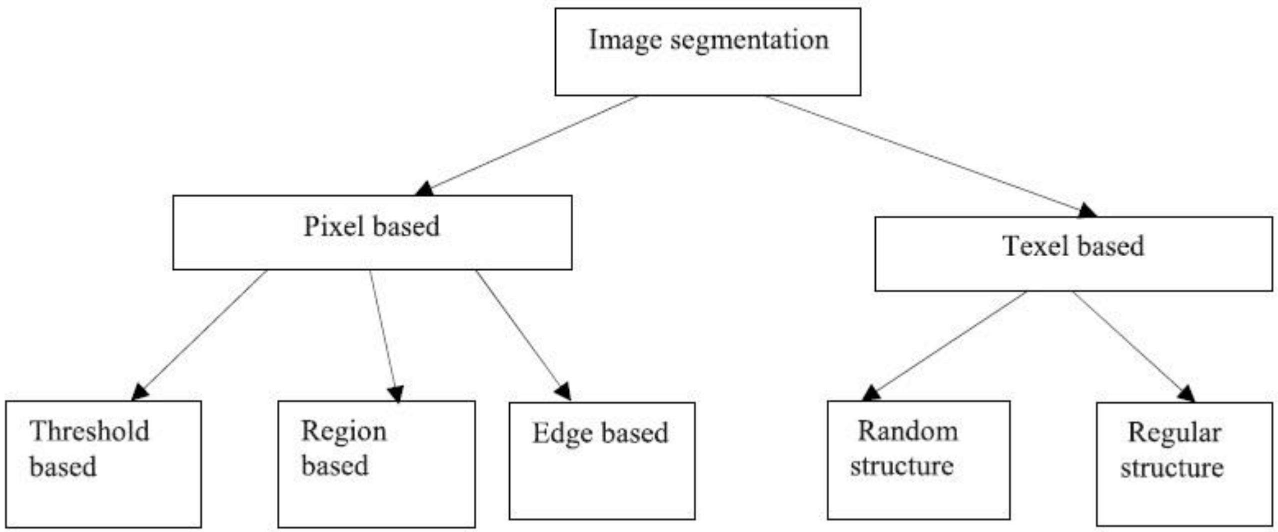

Figure 2: Image segmentation methods [2]

- Segmentation methods based on texture features are not suited for tumor segmentation [4]

GrowCut

- Multi-label segmentation based on cellular automaton theory
- Pixels are treated as cells
- Cellular automaton is a quad-tuple: (Z^n, S, N, δ)
- At each discrete time step, each cell tries to 'attack' its neighbors.
- State of each cellular automaton is a triplet: $S_p = (l_p, \theta_p, C_p)$
- Attacking strength is weighted by a linear decreasing function

$$g_{lin}(I_p, I_q) = 1 - \frac{||I_p - I_q||}{c_{max}} \geq 0$$

Figure 3: Evolution steps [6]

Extension

- Idea: pre-initialize the ROI by region measures as much as possible
  - Reduces user interaction significantly
  - Reduces runtime, subjectivity and uncertainty
  - Incorporates global image statistics

- Possible pre-initialization methods:
  - Otsu’s method, GMM, mean shift

- Use a bounding box
  - Further accelerates segmentation
  - Provides rough information about the position and size of the lesion

Example

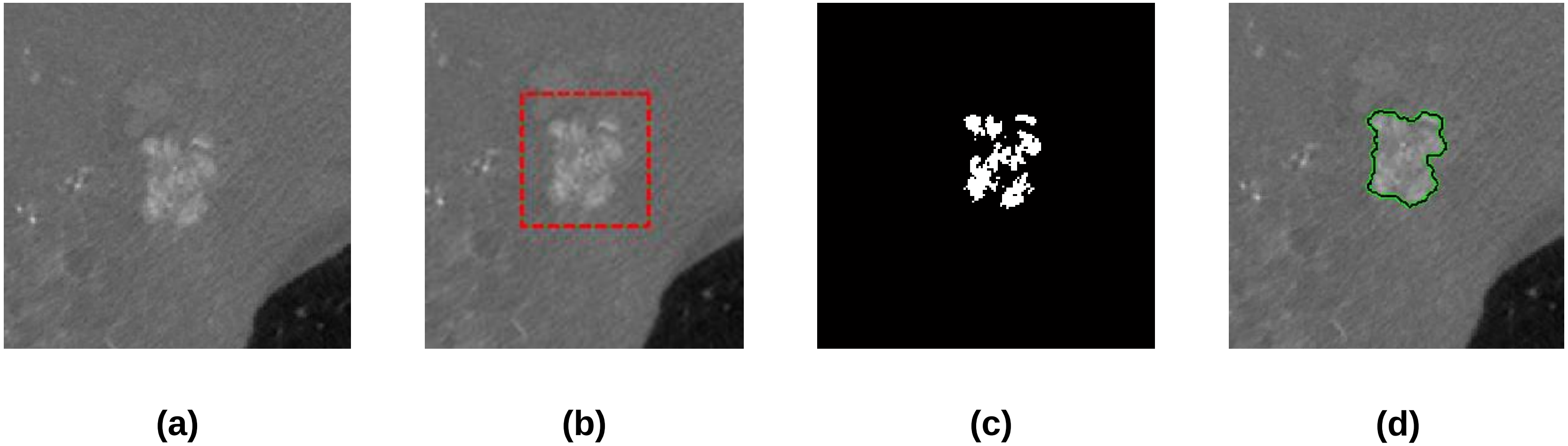

Figure 4: Segmentation example. (a) Original image, (b) ROI on original image, (c) foreground seeds template, (d) segmentation result

- Volume seeds are better than surface seeds [7]
- Segmentation outcome improves as the number of seeds increases [7]

Evaluation

- Segmentation accuracy
  - Rand Index, MI, ASSD, Homogeneity
- Performance
  - Runtime, memory consumption
- User interaction
  - Evaluate impact of different user inputs
- Evaluation data
  - Berkeley Segmentation Benchmark [8]
  - Anonymized clinical datasets from real patients

Summary

- TACE is a minimally invasive tumor treatment
- Choose user guided segmentation approach for tumors which vary greatly in size, position and shape
- GrowCut enables multi-label segmentation based on cellular automaton theory
- Optimize this method by incorporating global image statistics
- Thereby reduce user interaction with an appropriate initialization

Thank you for your attention!

Literature

[1] Jia He, et al.: Interactive Segmentation Techniques Algorithms and Performance Evaluation, SpringerBriefs in Electrical and Computer Engineering, 2014

[2] Umaa Mageswari S, et al.: An Experimental Study and Analysis of Different Image Segmentation Techniques, Procedia Engineering 64 (2013) 36 – 45, 2013

[3] T. Vallin Spina, et al.: User steered image segmentation using live markers. volume 6854 of CAIP, pages 211–218. Springer, 2011

[4] K. Popuri, et al.: 3D variational brain tumor segmentation on a clustered feature set, Int J Comput Assist Radiol Surg. 2012 Jul;7(4):493-506, 2012

[5] L. Grady (2006) Random walks for image segmentation. IEEE Trans Pattern Anal Mach Intell 28(11):1768–1783, 2006

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[7] E. Moschidis, et al.: A Systematic Performance Evaluation of Interactive Image Segmentation Methods Based on Simulated User Interaction, ISBI'10 Proceedings of the 2010 IEEE international conference on Biomedical imaging, p. 928-931, 2010

[8] http://www.eecs.berkeley.edu/Research/Projects/CS/vision/bsds/, last visited: 11/2014

[9] A. Moga, et al.: A parallel marker based watershed transformation. In *ICIP96*, II: 137–140, 1996