UI-Net: Interactive Artificial Neural Networks for Iterative Image Segmentation Based on a User Model

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Outline

Introduction
  Hepatic Lesion Embolization
  Interactive Image Segmentation

Methods
  Interactive Network Topology
  User Simulation

Experiments and Evaluation

Outlook
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"Why an interactive segmentation?"
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"Why an interactive segmentation?"

"How to make CNNs interactive?"
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Transcatheter Arterial Chemoembolization (TACE)

Roughly segmented tumor and subsequently generated vessel tree

Tumor
Feeding vessels
Catheter
Tumor Therapy – Impact of Segmentation Quality

Occluded vessel stops feeding healthy tissue

Additional vessel still feeding the tumor

Why an exact segmentation?

- segmented volume too big → healthy tissue gets occluded (toxicity increases)
- segmented volume too small → tumor growth unimpeded (efficacy decreases)
Hepatic Lesion Segmentation – C-Arm CT Volumetric Input Data
Hepatic Lesion Segmentation – Outcome
Interventional Segmentation Environment

Exam Room

Control Room
Interventional Segmentation Environment

Exam Room

Control Room
Interventional Segmentation Environment

Exam Room

Control Room
Interactive Segmentation Interface Prototypes

- Fully manual segmentation takes a lot of time; accurate outcome
- Fully automatic segmentation can take a lot of time to compute; quality correlated with size of ground truth database
- Interactive segmentation introduces a feedback loop for the user via seed points and scribbles

⇒ Idea: increase efficiency during segmentation via assisted interaction
Interactive Segmentation Interface Prototypes

Manual Segmentation

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Interactive FCN – Seed Update

a) Current seed mask with background and foreground seeds

b) Compute segmentation mask based on a), compare to ground truth

c) User selects misclassified image element position(s) from difference mask

d) User updates seed mask

e) Compute improved segmentation mask w. r. t. old segmentation mask
Interactive FCN – Proposed Topology Changes

Traditional FCN training procedure (left) and proposed training method by user simulation (right).
Interactive FCN – Proposed Topology Changes

Traditional FCN training procedure (left) and proposed training method by user simulation (right).
Interactive FCN – User Seed Mask Integration

Schematic FCN computation including user information as additional input.

Purple arrows represent further computational layers based on the U-net topology.
Interactive FCN – User Seed Mask Integration

Input channels: gray value image, seed mask
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Interactive FCN – Rule-Based Simulated User Input

User Model: Probabilistic seed placement using difference mask from GT and current segmentation.
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Interactive FCN Results – Without a User Model

UI-nets trained with **a)** varying contour width and **b)** randomized seed masks for initial seeding.
Interactive FCN Results – With a User Model

Segmentation quality after one to five iterations: c) interactive UI-net and d) GrowCut.
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Example Workflow:
1. Click on **Show Hint** to observe an outline of the object to segment.
2. While observing the object, use the windowing sliders to adjust the pixel values in the image to improve object to background contrast, or choose **Automatic Windowing**.
3. Draw seed points, lines, or complex shapes onto the image, representing either foreground/object or background regions, until you are satisfied with the result. Try not to draw directly on the contour line of the object, but clearly inside or outside of it.
   * Play around with all the controls. If things get out of hand, you can always easily **Restart**.

   **Tip:** use the left and right mouse buttons for easy foreground and background seed label drawing without changing labels via the +/- buttons above.
Thank you for your attention!

Are there any questions?

Participation: www.bit.ly/vcbmseg

User Study

In order to participate in the user study, please fill in the password provided in your invitation. If you did not receive an invitation, but like to participate in the study, please just send me a short request per email.

Thank you!