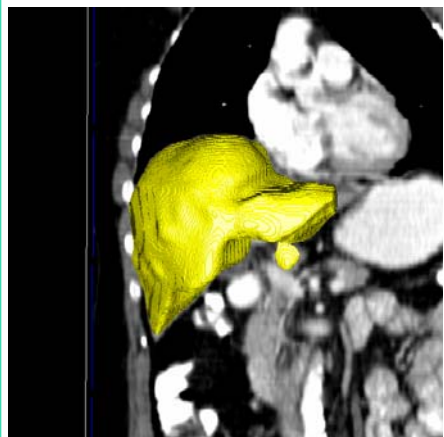


Problem – Editing of Automatic Segmentation Results

Want to use natural “seeded” segmentation interface to fix results of incorrect automatic segmentation

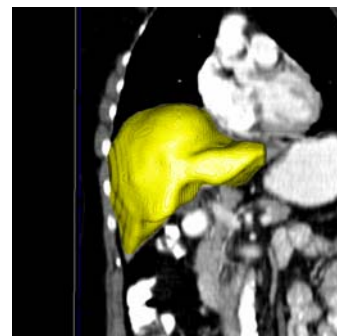
Incorrect automatic segmentation



User interaction



Desired result



Desired result

- 1: Independence (no knowledge) of automatic process
- 2: Operation local to interaction site
- 3: Fast operation
- 4: 3D modification, despite interaction on a 2D plane
- 5: Data-driven solution

Formulation

Formulate as a joint energy minimization with presegmentation and interaction

For each pixel i :

$$p_i = \begin{cases} 1 & \text{if } v_i \text{ was presegmented as object,} \\ 0 & \text{if } v_j \text{ was presegmented as background.} \end{cases}$$

Want to solve for x_p , the probability that pixel i belongs to the object, by minimizing:

$$Q(x) = E_{\text{Data/Interaction}} + \gamma E_{\text{Presegmentation}}$$

$$Q(x) = \sum_{e_{ij}} w_{ij} (x_i - x_j)^2 + \gamma \left(\sum_i (1 - p_i) x_i + \sum_i p_i (1 - x_i) \right)$$

Where the weights are determined from the image via:

$$w_{ij} = \exp(-\beta(g_i - g_j)^2)$$

where g_i indicates the intensity at voxel i . A voxel i set as a seed is fixed to $x_i = 1$ (object) or $x_i = 0$ (background). Note that it is not necessary to have both object and background seeds.

If x represents real-valued voxel probability: Random walker (linear system solve)

If x represents binary voxel membership: Graph cuts (max-flow/min-cut solve)

Locality

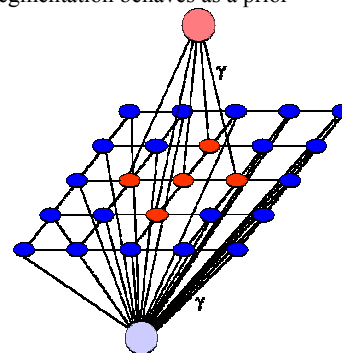
In order to enforce locality of interaction, we make γ a function of distance from interaction seeds:

$$\gamma_i = \kappa \exp\left(-\frac{d(i, S)}{\sigma}\right)$$

where $d(i, S)$ denotes the distance from voxel i to any seed (i.e., set S), the parameter σ effects the locality of the interaction and κ indicates the overall strength of the prior segmentation

Graph interpretation

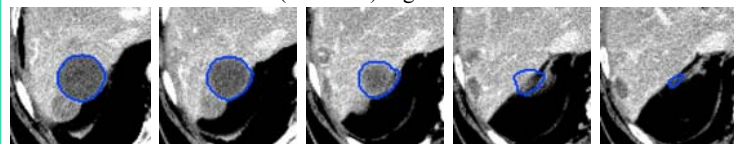
Previous segmentation behaves as a prior



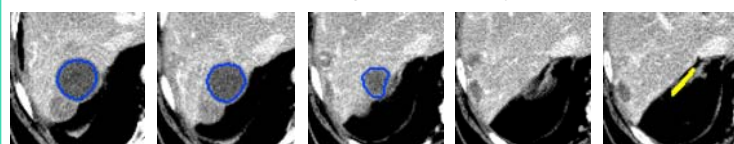
Allowing interpretation as “T-links”

3D

Initial (incorrect) segmentation:



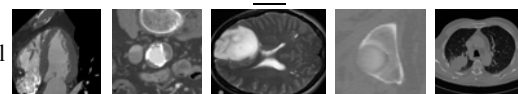
Edited result - background seeds in yellow



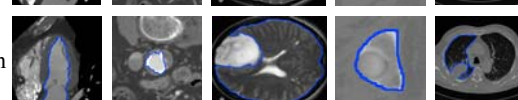
Results

2D

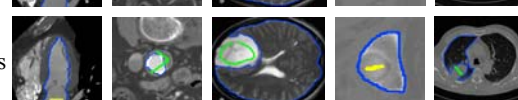
Original



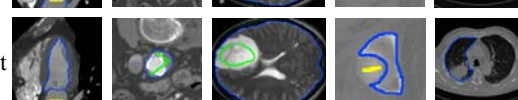
Presegmentation



Edit seeds



Final result



Green seeds – Object

Yellow seeds – Background