Introduction to Medical Imaging

(5XSA0)

Image Segmentation

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This chapter: Segmentation

* Subdivide images into regions or objects
* What a "region" or object is, is usually application-dependent
* The problem is often the absence of a ground truth
* Also: when to stop segmenting?

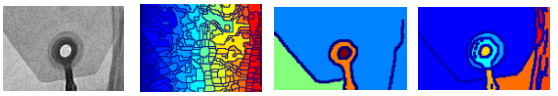


Image of ECG pad | Oversegmentation | Undersegmentation | "Good" segmentation

Segmentation: Basic approaches

* **"Top-down": based on *discontinuity***
  - Pixels belonging to different objects will have different gray values
  - Partition an image based e.g. on edges
* **"Bottom-up": based on *similarity***
  - Pixels belonging to the same object will have similar gray values
  - Partition an image based on similarity criterion

What we will see today

Implementations, using MATLAB, of the following techniques:

* Point and line detection for segmentation
* Thresholding
* Region-based segmentation
* Watershed transform

Point detection

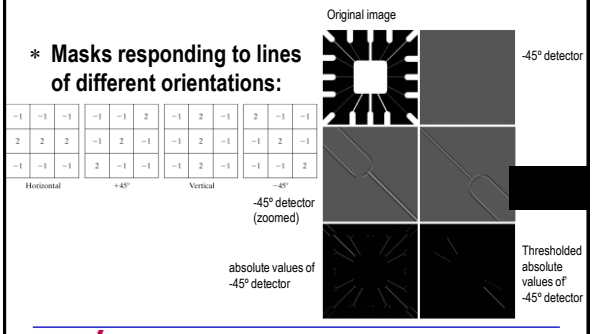
* Look for a point that is different from its neighborhood
* Apply an isolating mask to calculate:

$$R = w_1 z_1 + w_2 z_2 + \ldots + w_9 z_9$$

* A point is detected at the center of the mask if $|R| \geq T$ where T is a threshold

Line detection

* Masks responding to lines of different orientations:



Point and line detection in MATLAB

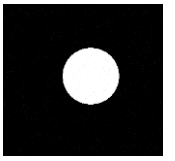
```
g = abs( imfilter (double(f), w ) ) >=T;
```

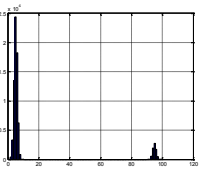
- 2D filtering
- Input image
- Threshold
- Binary image giving point locations
- Convert to double!
- Mask

* How to set T?
* In a first instance, by examining the values of the feature image
* More on thresholding later

Thresholding

* Simple and computationally efficient
* Threshold selection uses intensity information → histogram
* Example: bimodal histogram





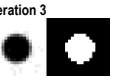
Optimal Thresholding

* What value of T will give us the best segmentation?
* Gonzalez and Woods:
  - Initialize T (e.g. halfway between min and max)
  - Iteratively set T=0.5*(μ1+μ2), where μ1, μ2 the mean values of pixels with value larger or smaller than T, respectively
  - Until T converges

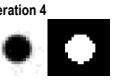
Iteration 1

Iteration 2

Iteration 3

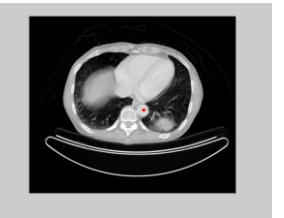


Iteration 4



Region Growing

* Start from a seed point, selected manually or automatically
  - Several seed points are also possible
* Include new neighboring points in the region based on some similarity criterion



* Image from http://www.mathworks.com/matlabcentral/fileexchange/19084

Region Growing in MATLAB

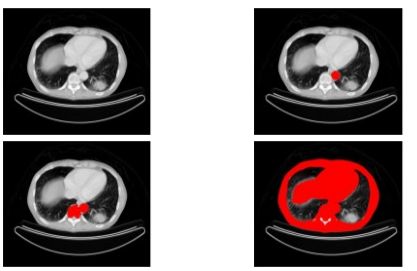
* Function (from textbook, *not* Image Processing Toolbox):

```
[g, NR, SI, TI] = regiongrow(f, S, T);
```

* Input:
  - `f` : image
  - `S` : seed points (scalar→all points with this value, array → 1's for seed points and 0's for non-seed points)
  - `T` : threshold (scalar → global threshold, array → local threshold at each point)
* Output:
  - `g`: segmentation result (different labels per region)
  - `NR`: # of regions
  - `SI`: final seed image
  - `TI`: image of pixels that passed threshold test

Region Growing in MATLAB

* Play with seed points & thresholds



References

– Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using Matlab", Pearson Education, 2004
  – Chapter 10