Image Segmentation and Seg3D

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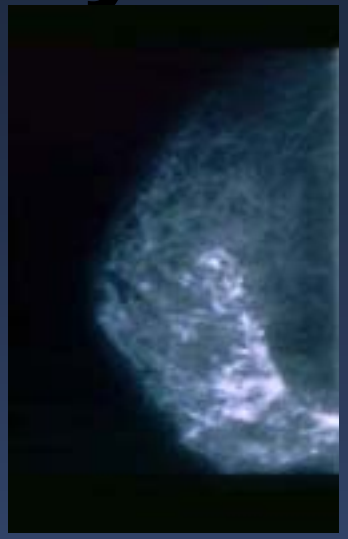
Overview

- Segmentation Intro
  - What is it
- Strategies and state of the art
- Seg3D intro

Segmentation: Why?



Detection/recognition

- Is there a lesion?

Quantifying object properties

- How big is the tumor? Is is expanding or shrinking?
- Statistical analyses of sets of biological volumes

Building models

What is Segmentation?

Different definitions/meanings

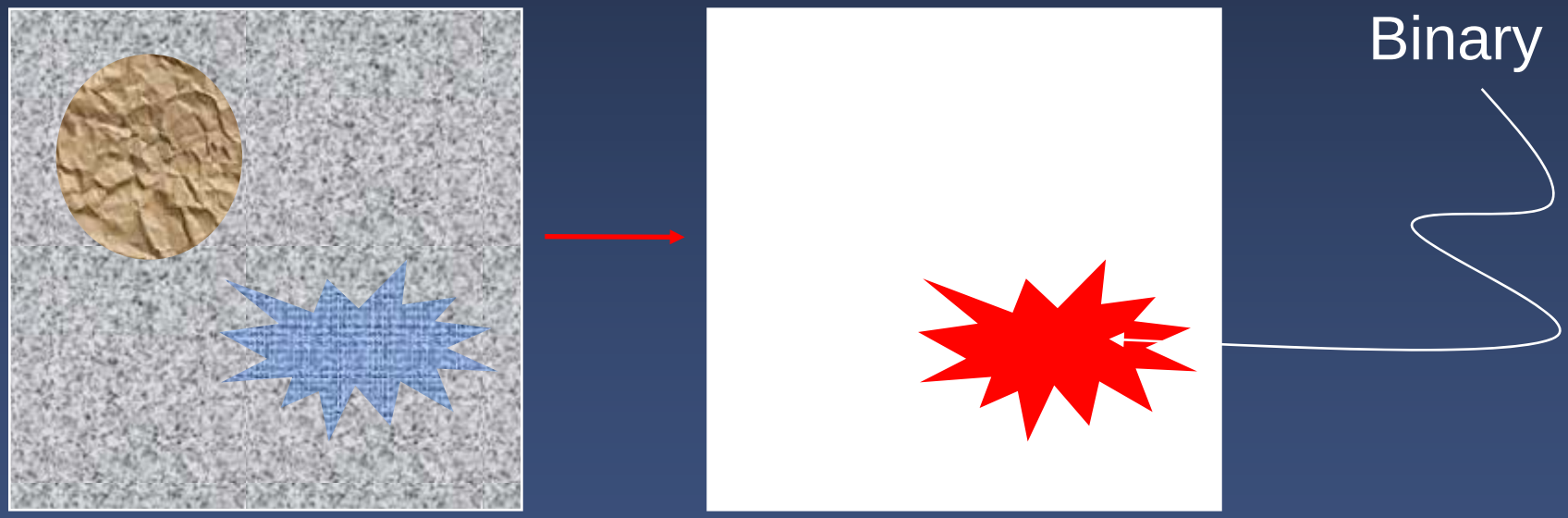
- Depends on context, person, etc.
- Application
- Type of output
  - e.g. Lines vs pixels

Different tools for different applications/needs

- Tradeoffs between general and specific
- Tradeoffs between development and processing effort

What is Segmentation?

Isolating a specific region of interest ("find the star" or "bluish thing")

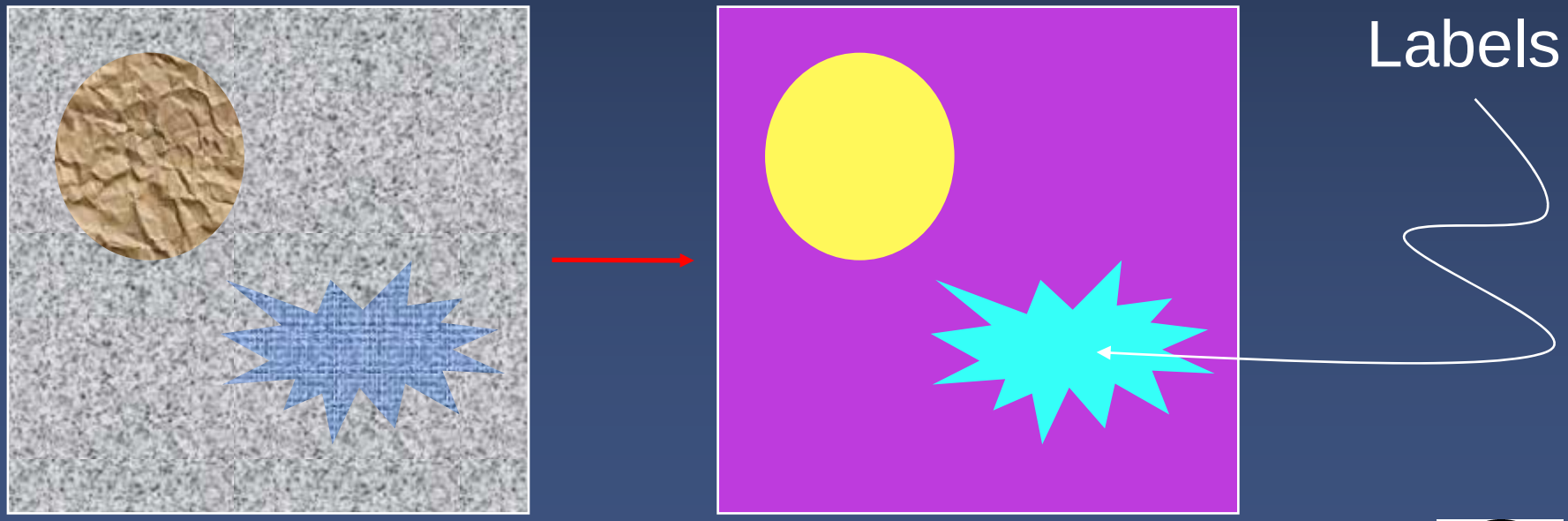


"Delineation problem"

What is Segmentation?

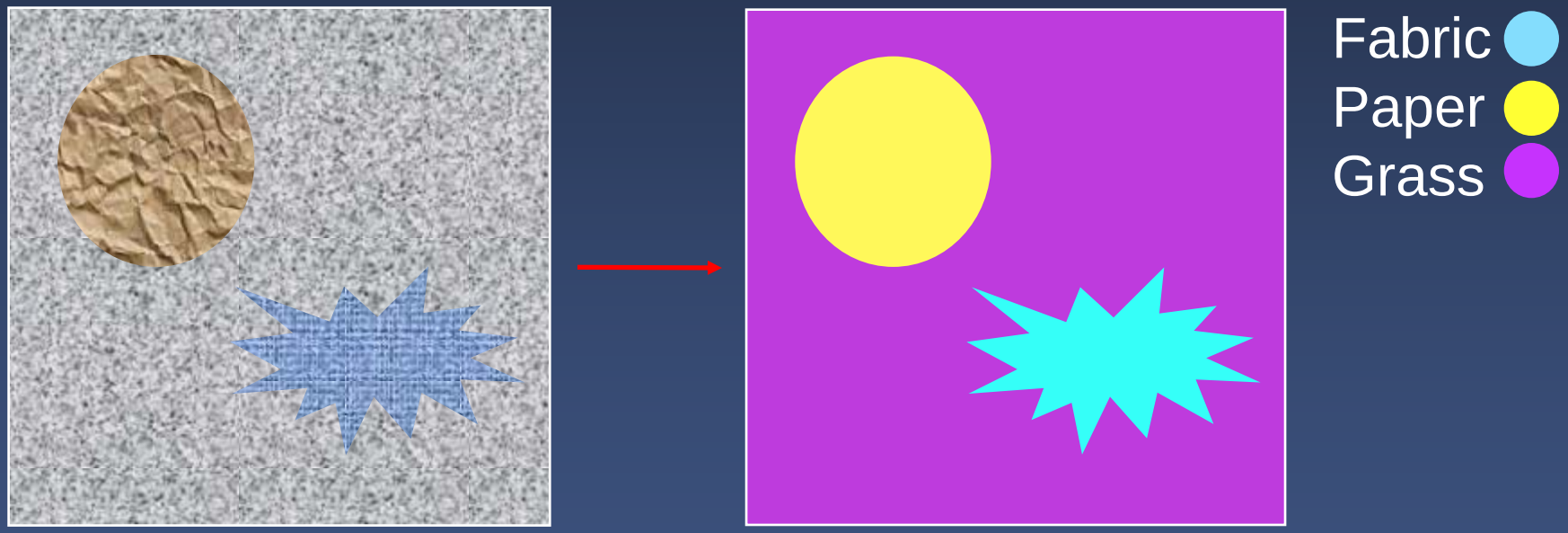
Partitioning images/volumes into meaningful pieces

"Partitioning problem"



What is Segmentation?

Assigning each pixel a type (tissue or material)



"Classification problem"

Delineation by Hand Contouring

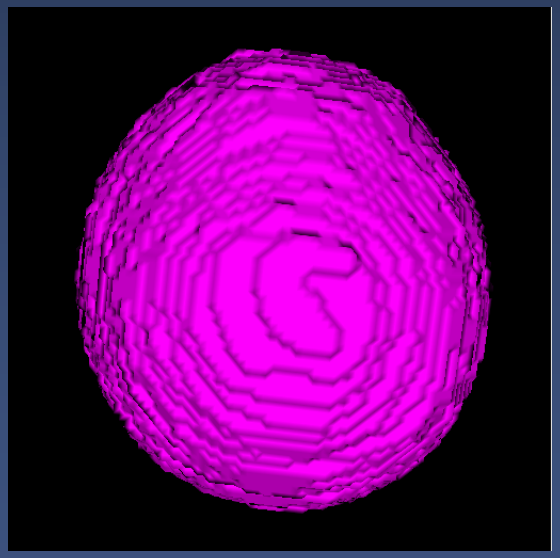
- "Quick and easy" general-purpose seg tool
- Time consuming

Delineation by Hand Contouring

3D: slice-by-slice with cursor defining bounda

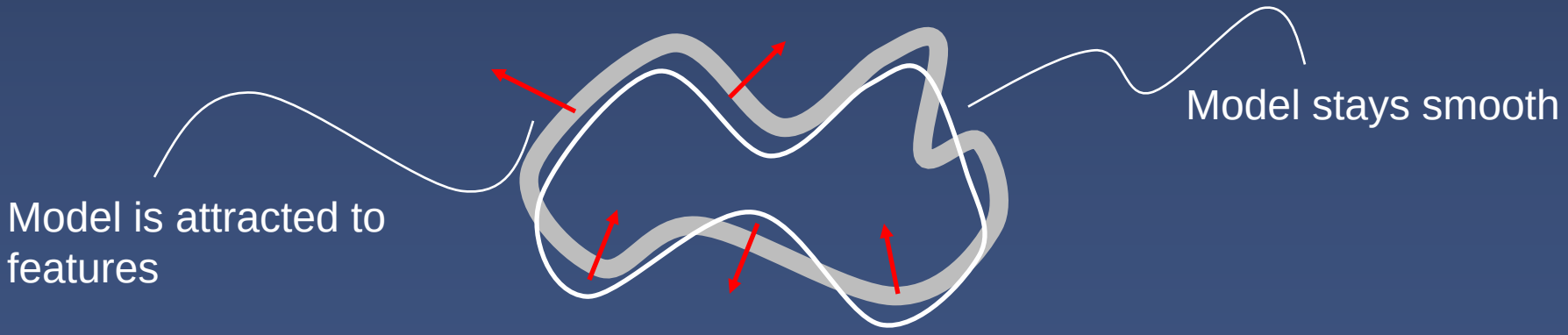
User variation (esp. slice to slice)

- 3D feedback helps



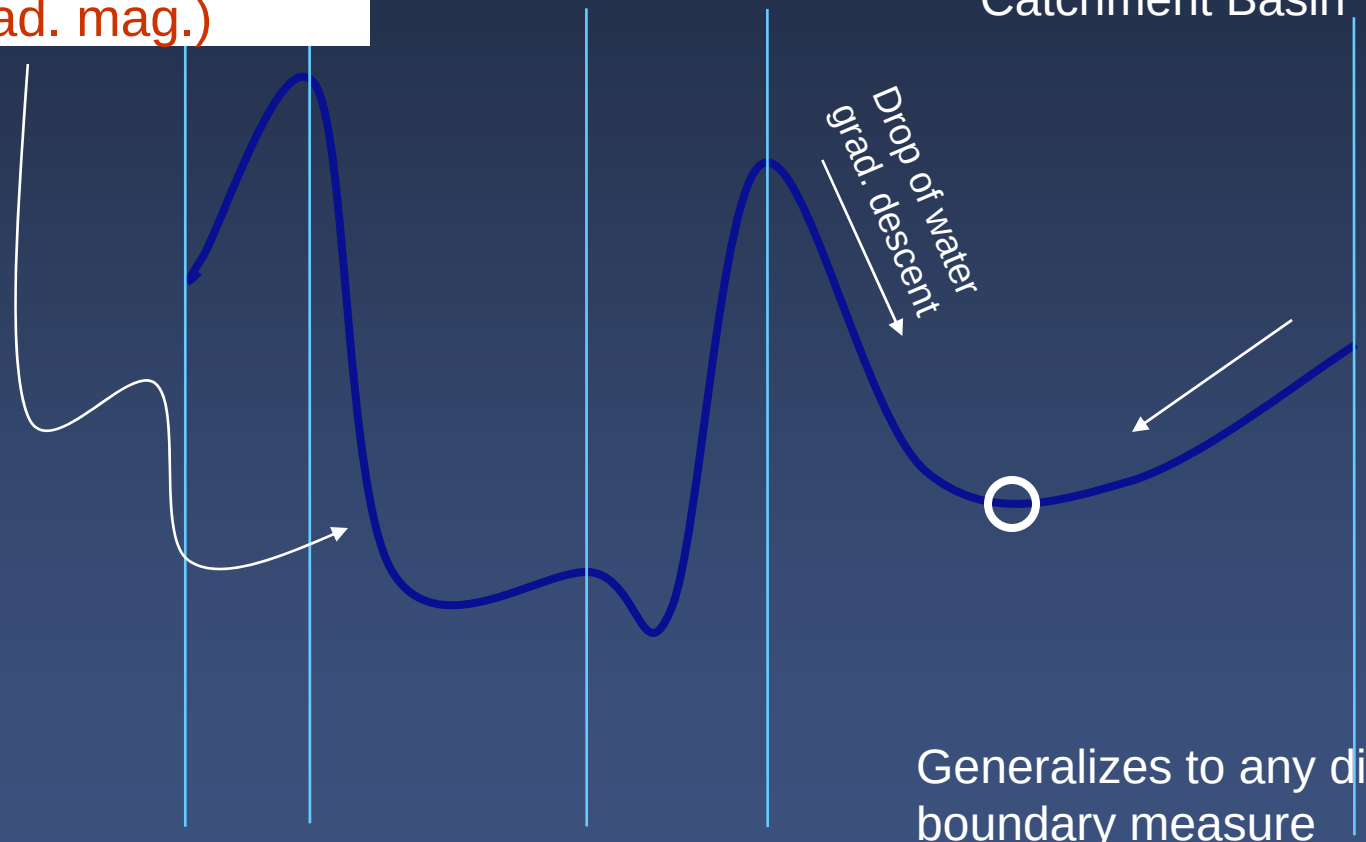
More sophisticated: Deformable (Active Contour) Models

- Snakes (polyline)
- Level sets
- Active shape / appearance (Cootes & Taylor)
  - Train models to learn certain shapes



Watershed Segmentation

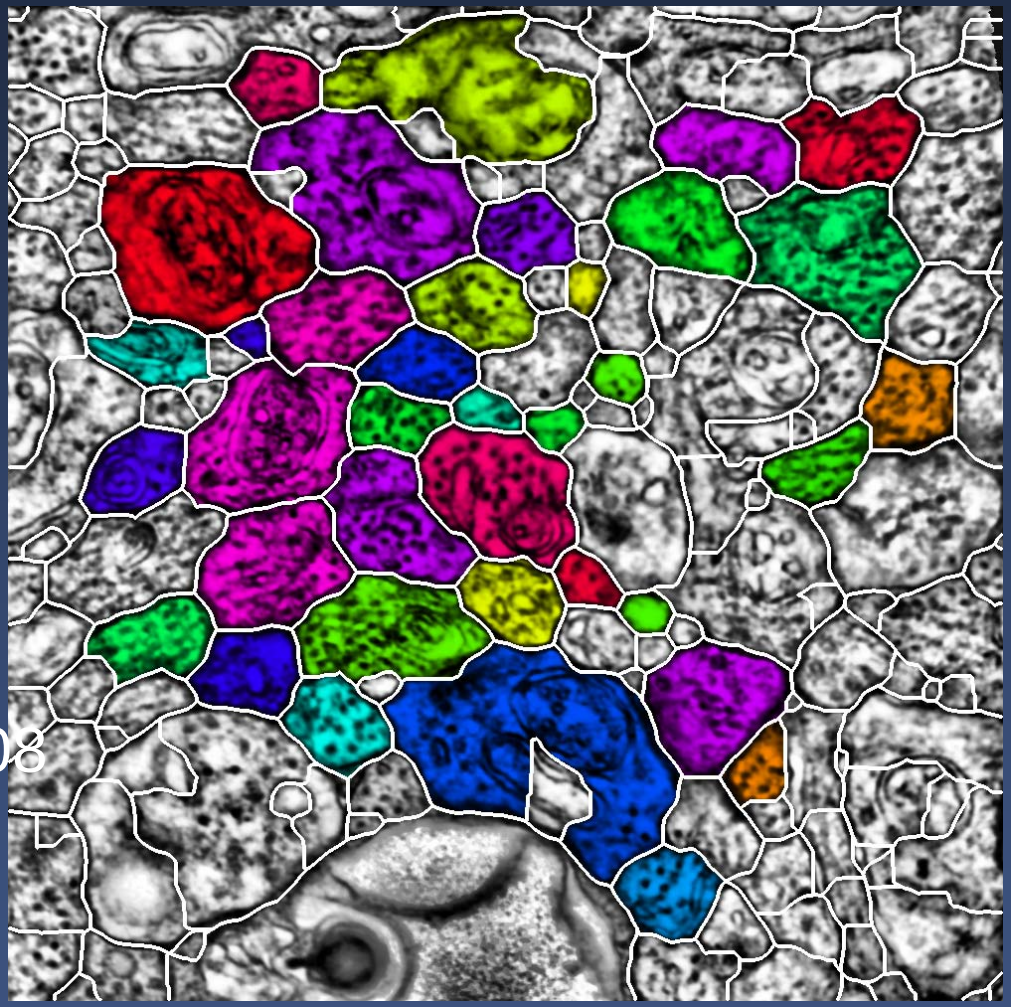
Boundary Function (e.g. grad. mag.)



Generalizes to any dimension or boundary measure

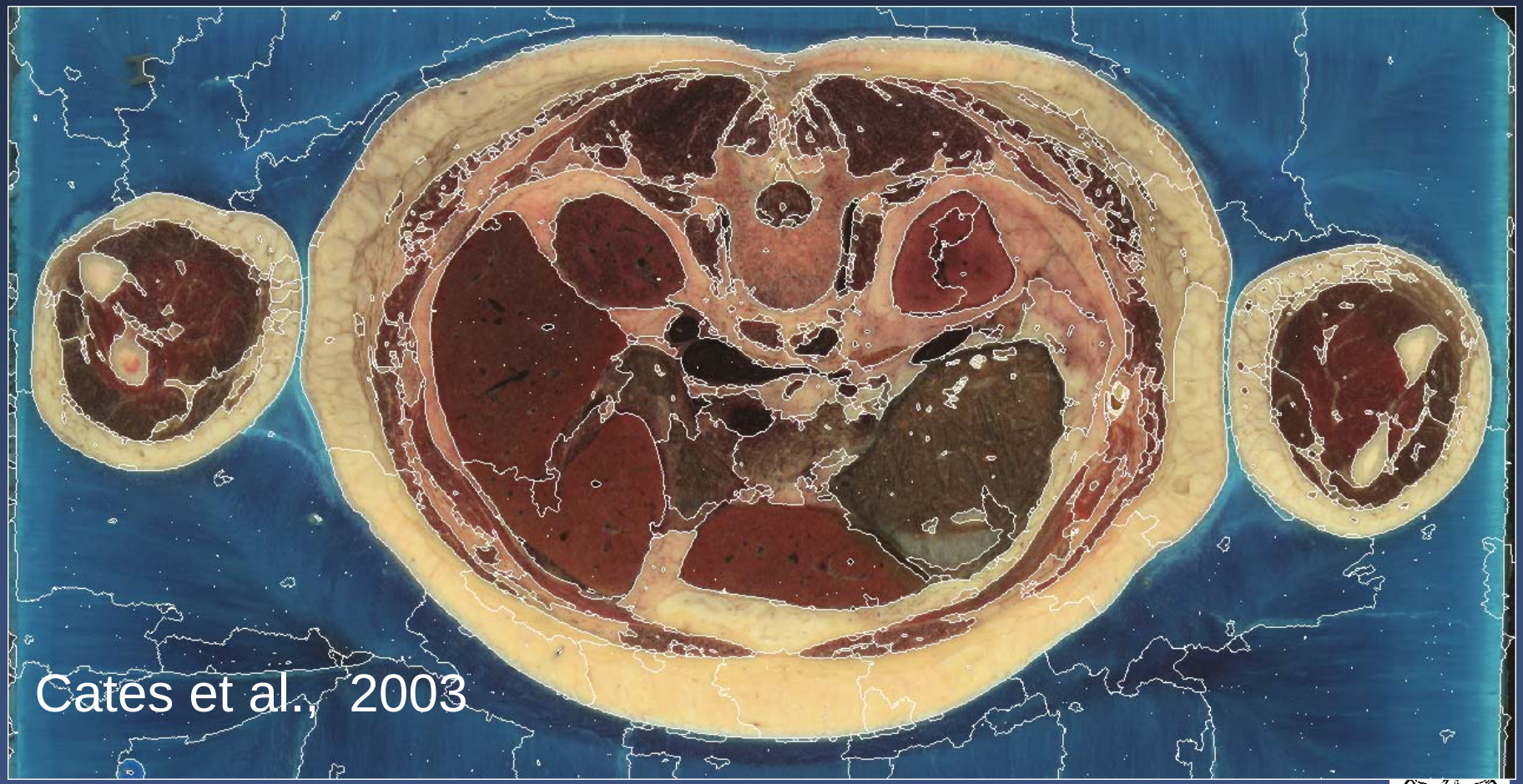
Watershed Regions

Example: Image Partitioning



Jurrus et al., ISBI 2008

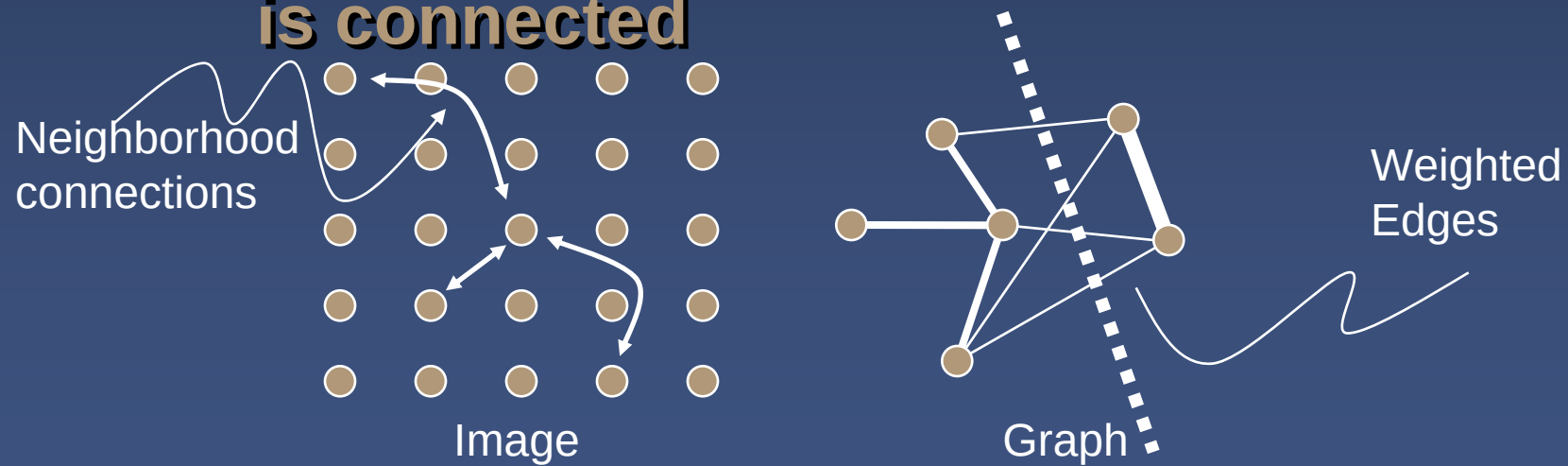
Image Partitioning



Minimum Cut (Shi and Malik `00)

Treat image as graph

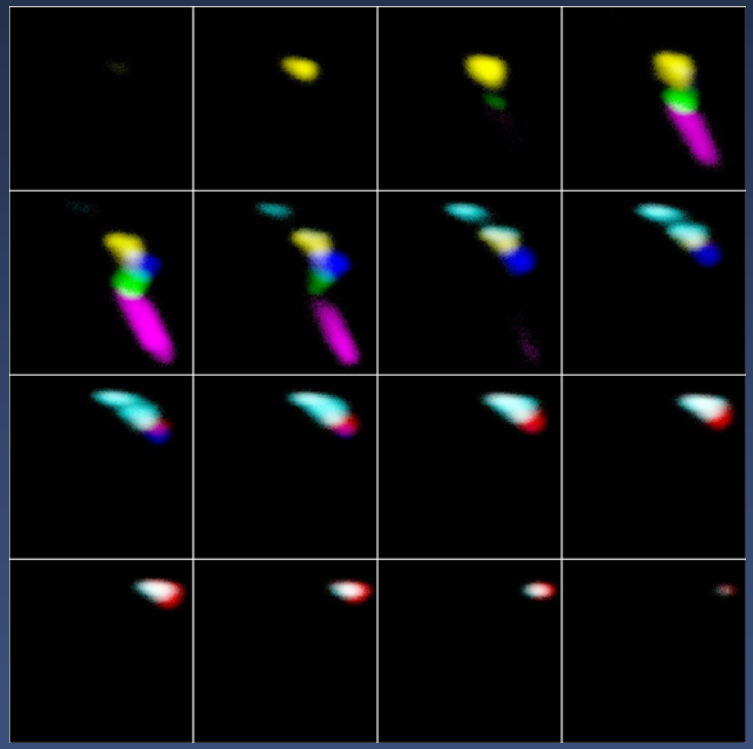
- Vertices -> pixels
- Edges -> neighbors
- Edge weights -> cost to cut
- Must define neighbors to which a pixel is connected



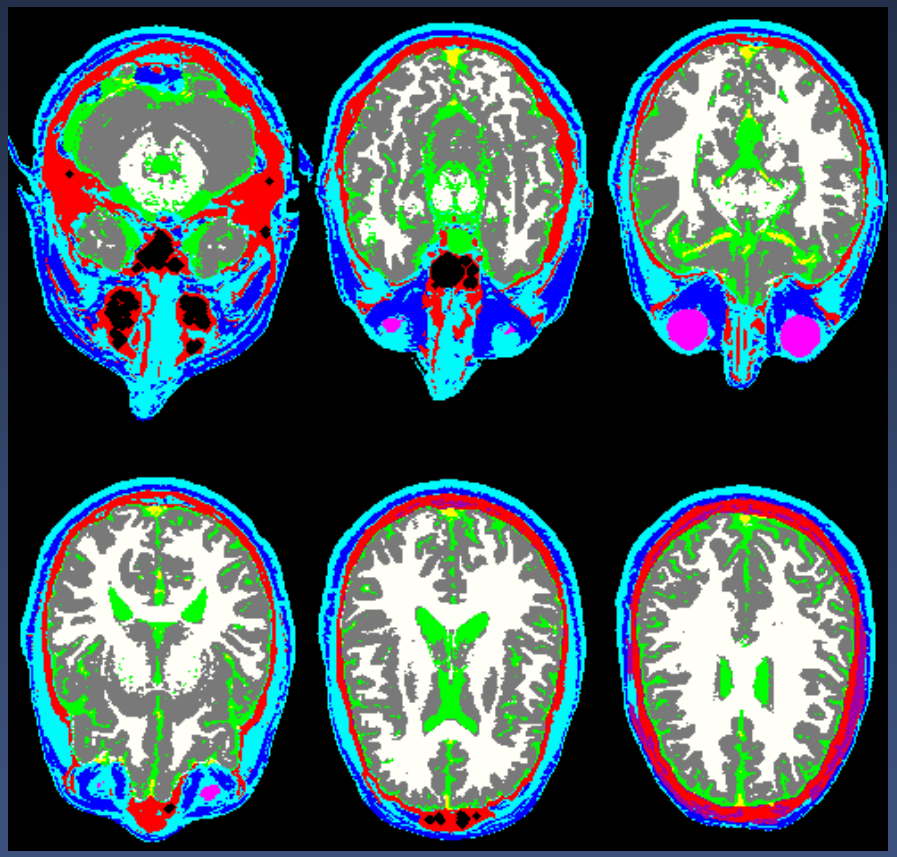
Pixel Classification

Tasdizen et al.

T1, T2, PD



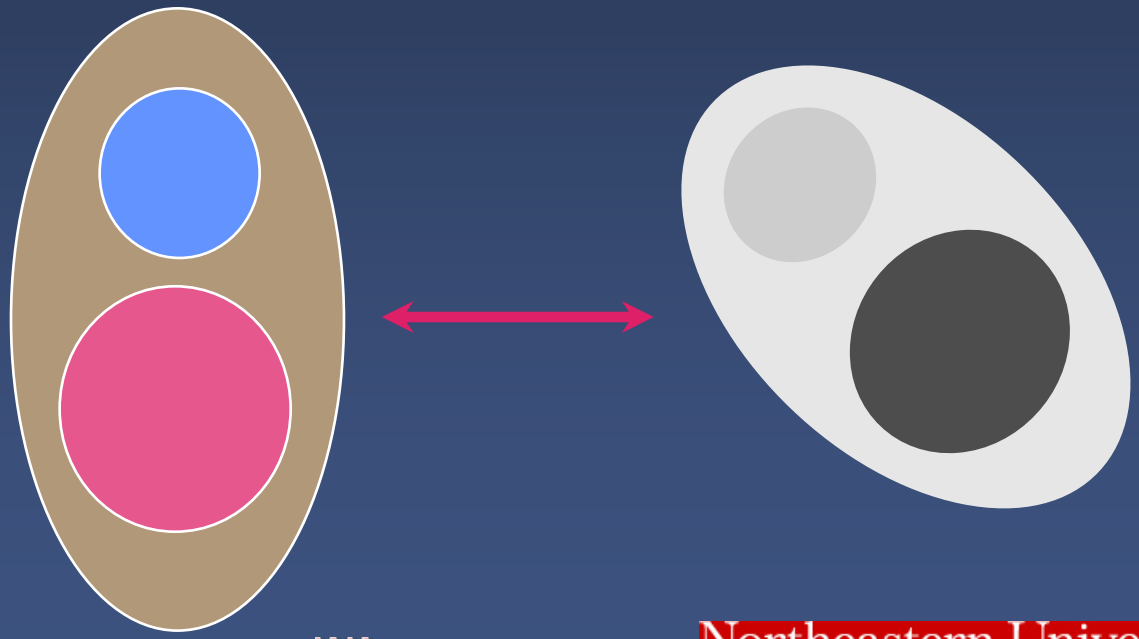
Feature Space



Classification

Registration of Templates

Align a known, segmented image to input data



So: What is The Best Way to Segment Images?

Depends…

- Kind of data: type of noise, signal, etc.
- What you are looking for: shape, size, variability
- Application specifics: how accurate, how many
- Expertise / patience: need to tune parameters

Where Do Things Stand Now?

State of the art

- Specific data and shapes
  - Train a template or model (variability)
  - Deform to fit specific data
    - e.g. active appearance/shape models
    - e.g. atlas-based statistical methods
- General data and shapes
  - So many methods
  - So may parameters
  - So few good ones in practice->hand contouring?

State of the Art Segmentation: Statistics and Learning

Intensities and image statistics

- Grey-levels and neighborhoods

Positions and templates

- Register templates with spatial knowledge

Shapes

- Learning statistics of contours and surfaces
- Nonlocal relationships
- Differential geometry

Example: Head Segmentation MRI

Tissue classification

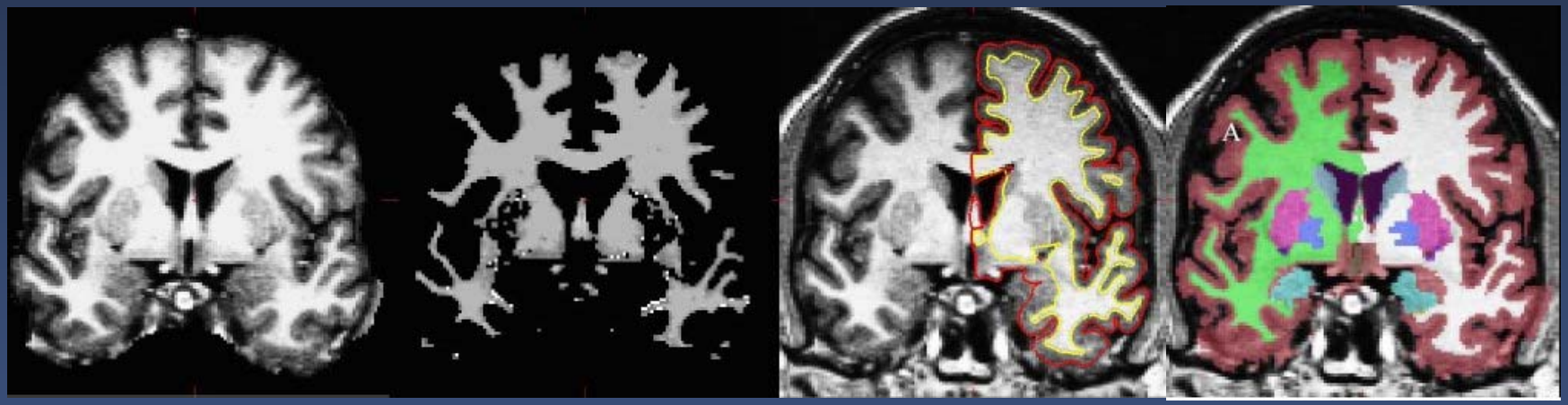
- GM, WM, CSF
- Skull stripping (nonbrain)
- Prior based on statistical template
  - Combine with registration
  - Priors on local configurations

Limbic system (subcortical structures)

- Deformable shapes with priors

FreeSurfer

Fischl and Dale MGH



MRI WM Surfaces Partition

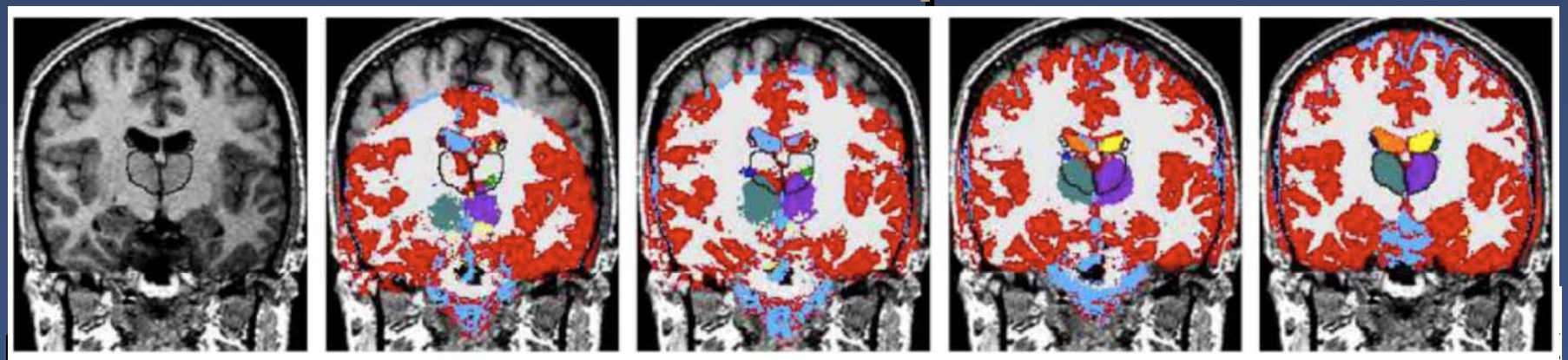
EM-Segmenter, Slicer3

Tissue classification

- Inhomogeneity correction
- Gaussian mixture model

Simultaneous classification and template

- Iterative
- Probabilistic atlas/template



Specific vs General Methods

Specific

- Automated
- Moderately reliable (user QC)
- Training/learning
- Works for specific:
  - anatomy
  - imaging modalities
  - applications
- Pathology?

Specific vs General Methods

General

- User interaction
  - -Steering
- Parameter tuning
- GUIs
- Assumptions about data
- Last resort
  - -Hand contouring

Region-Based vs Edge-Based Strategies

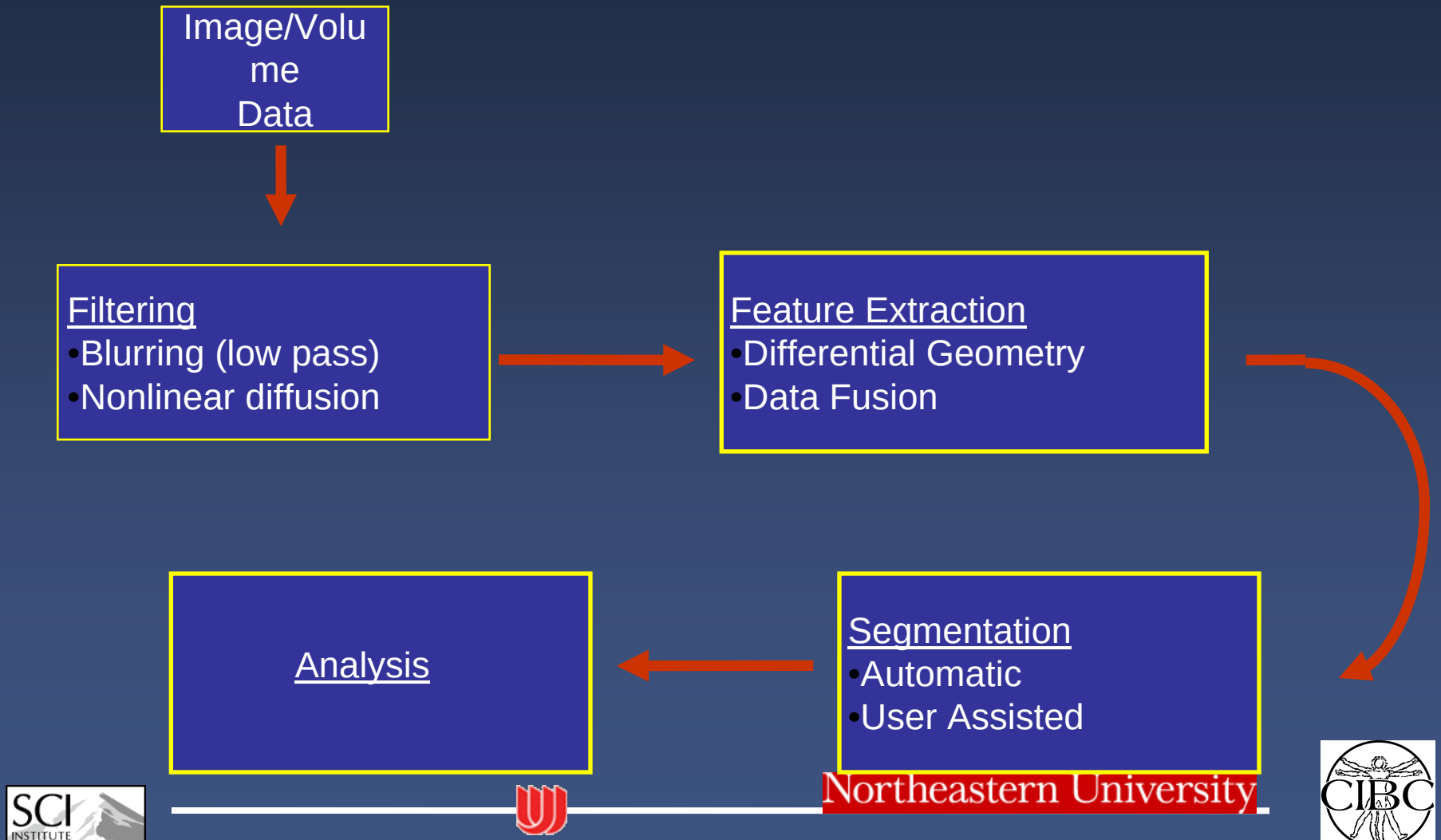
Region-based methods (connected)

- Somehow locally homogeneous
- E.g. Flood fill

Edge-based methods

- Regions are bounded by features with sharp contrast
- E.g. Canny Edge Detector

Typical Edge/Region-Based Segmentation Pipeline

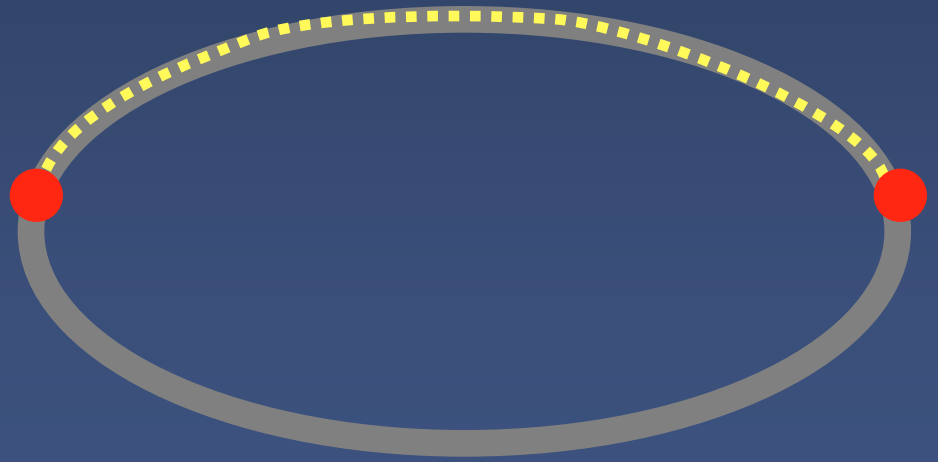


Example: Livewire

Contour follows features

- Shortest path between user-defined landmarks
- Need preprocessing and definition of “features”

Barrett, 1997



Seg3D

Goals

- End-user application
- General purpose
- User-assisted

Philosophy

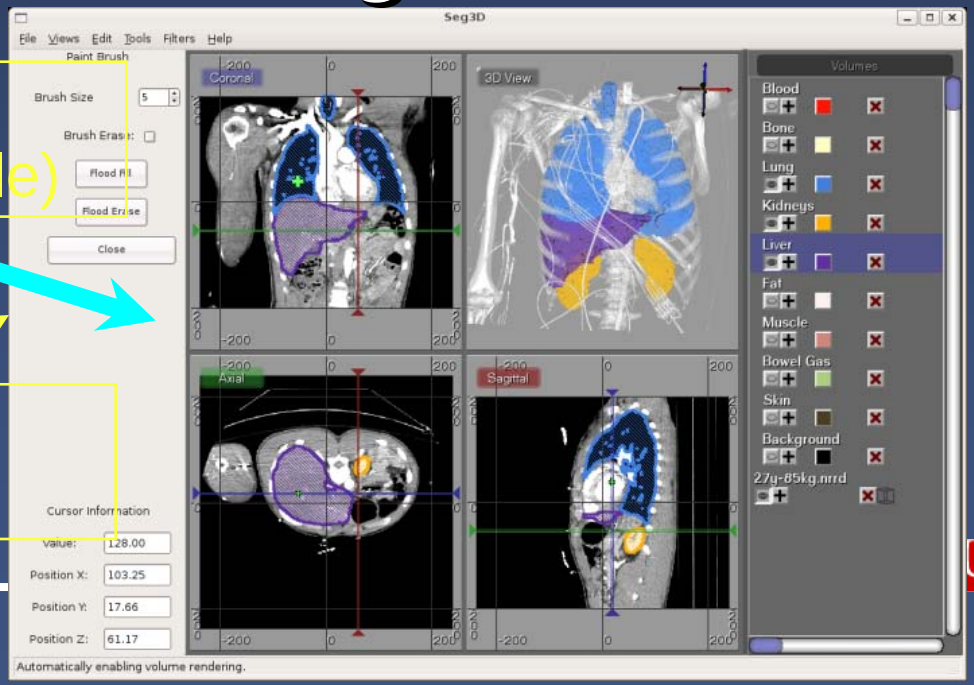
- Voxel/pixel-based
- Layers and labels, 3D photoshop-ish
- GUIs and user interaction for user-assisted segmentation
- 3D interaction to aid 2D views

Seg3D

Software engineering

- Wrapping ITK filters and image I/O
- Cross platform, WX widgets

Software design/user interface



Views (reconfigurable)

Data/ Parameters

Layers/images

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