Image Segmentation and Seg3D

Ross Whitaker

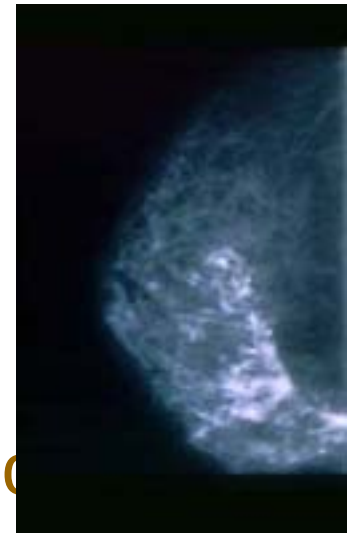
SCI Institute, School of Computing

University of Utah

Overview

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

Segmentation: Why?



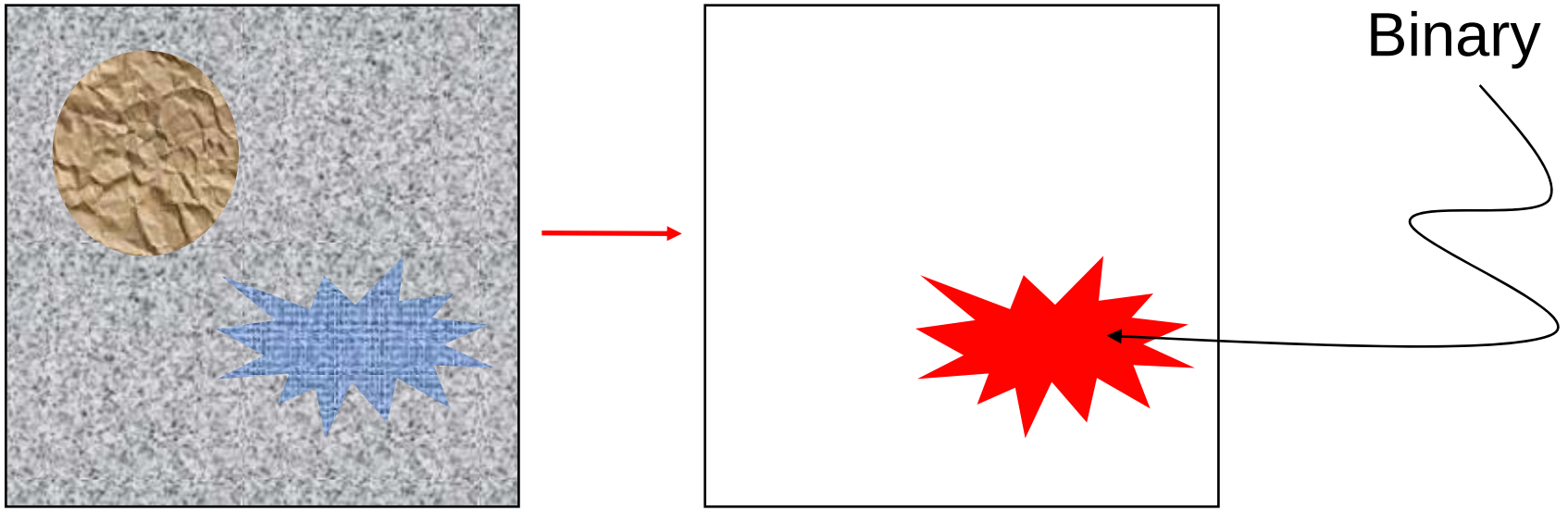
- Detection/recognition
  - Is there a lesion?
- Quantifying object properties
  - How big is the tumor? Is is expanding o shrinking?
  - Statistical analyses of sets of biological volumes
- Building models

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

What is Segmentation?

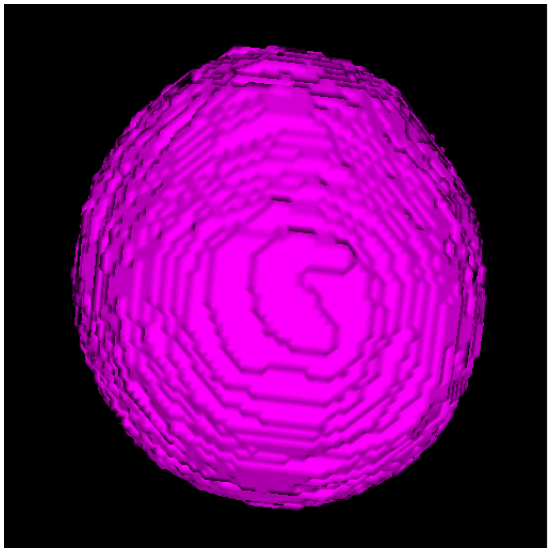
- Isolating a specific region of interest (“find the star” or “bluish thing”)



“Delineation problem”

Delineation by Hand Contouring

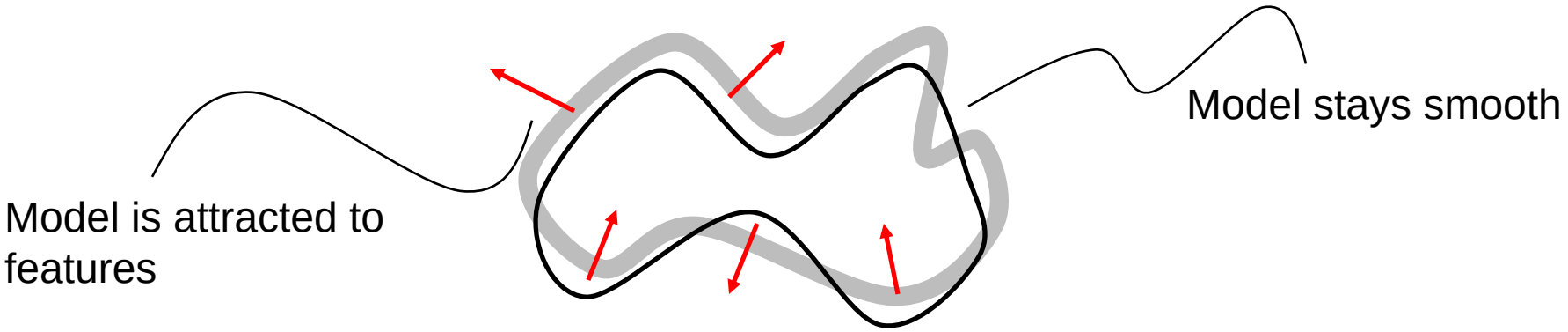
- “Quick and easy” general-purpose seg tool
- Time consuming



- 3D: slice-by-slice with cursor defining boundary
- User variation (esp. slice to slice)

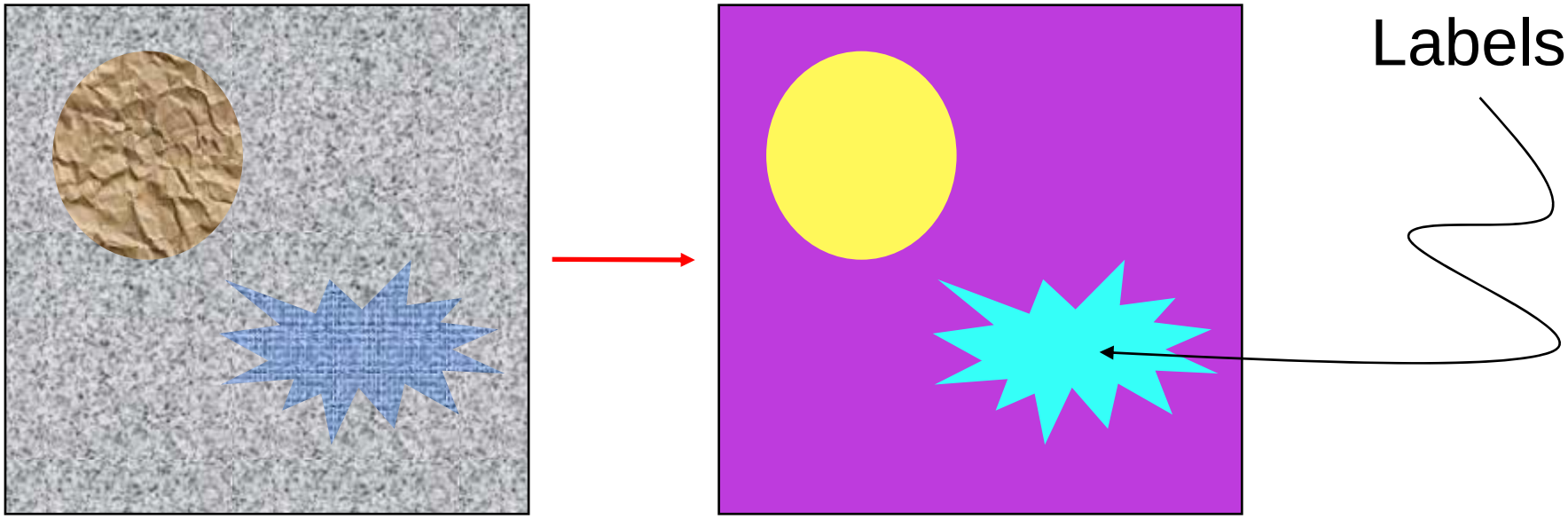
Deformable Models

- Snakes (polyline)
- Level sets
- Active contours
  - Train models to learn certain shapes



What is Segmentation?

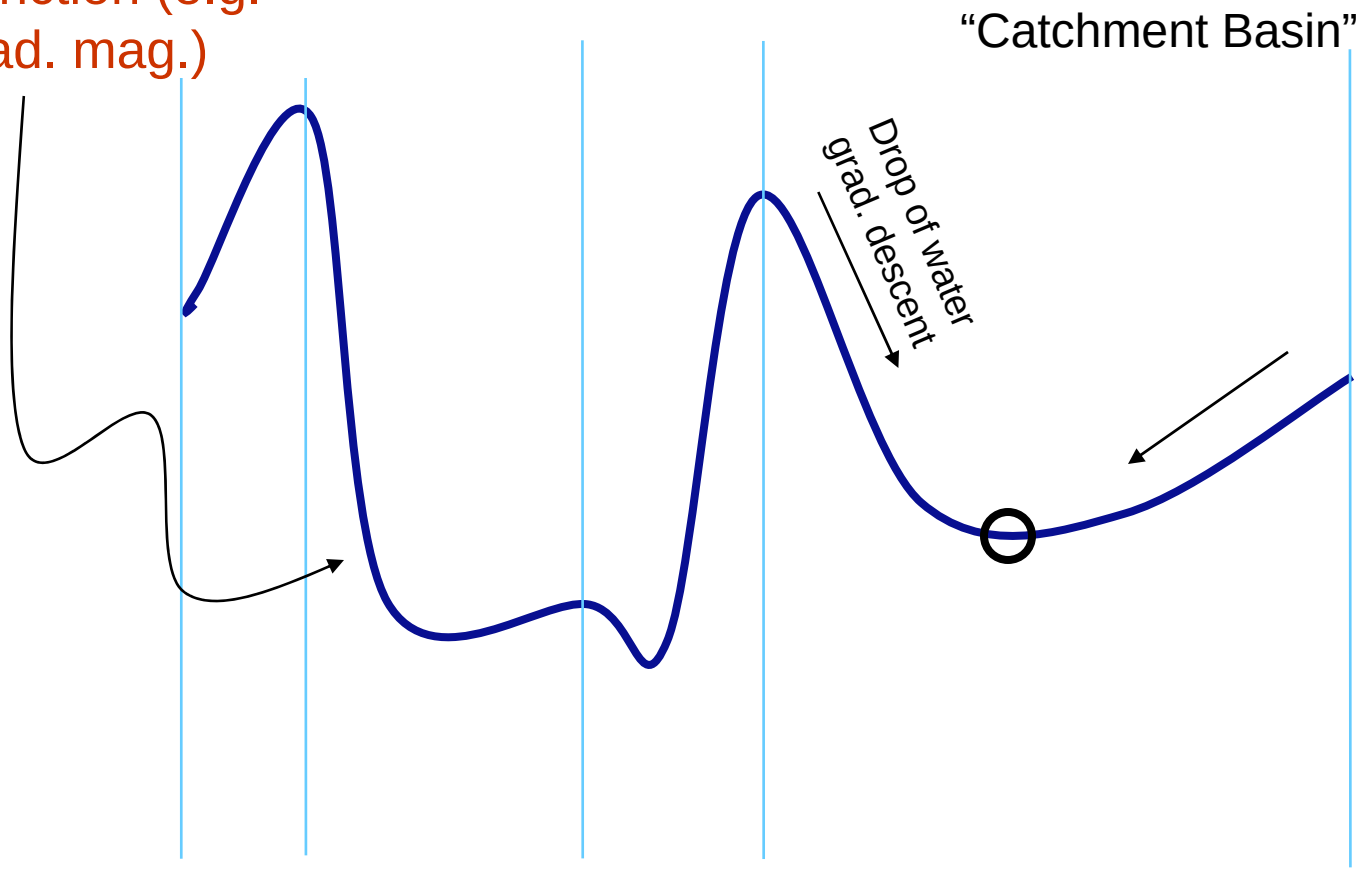
- Partitioning images/volumes into meaningful pieces



"Partitioning problem"

Watershed Segmentation

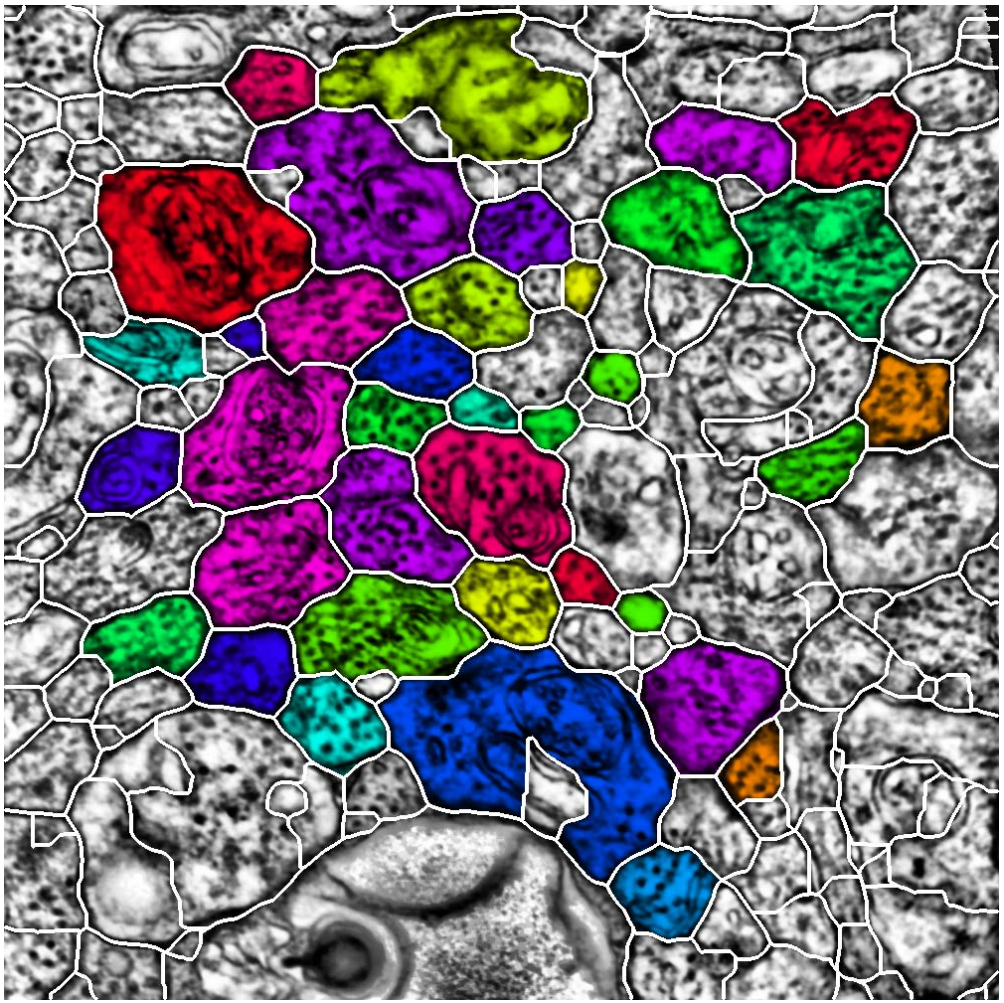
Boundary Function (e.g. grad. mag.)



Watershed Regions

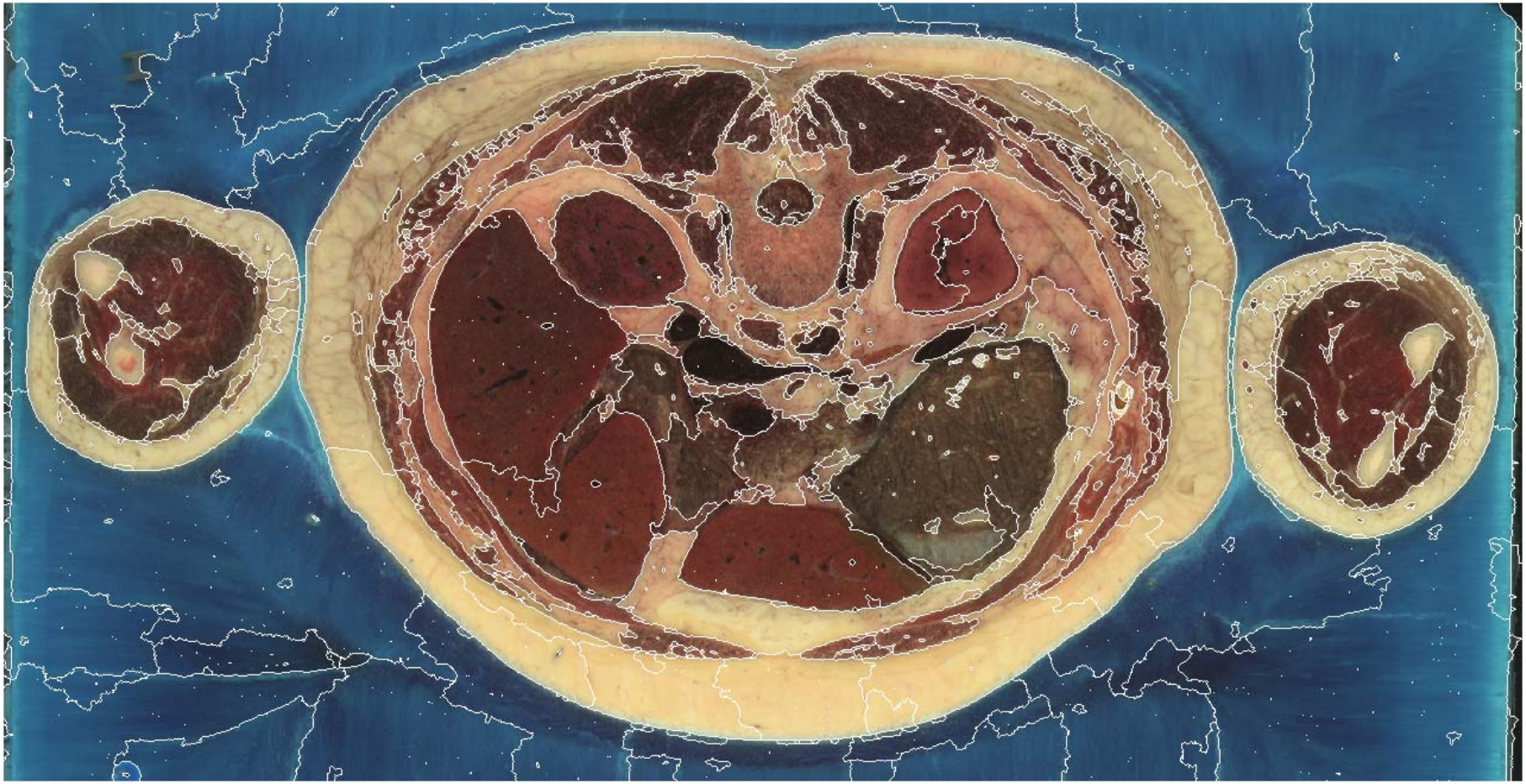
Generalizes to any dimension or boundary measure

Image Partitioning



Jurrus et al., ISBI 2008

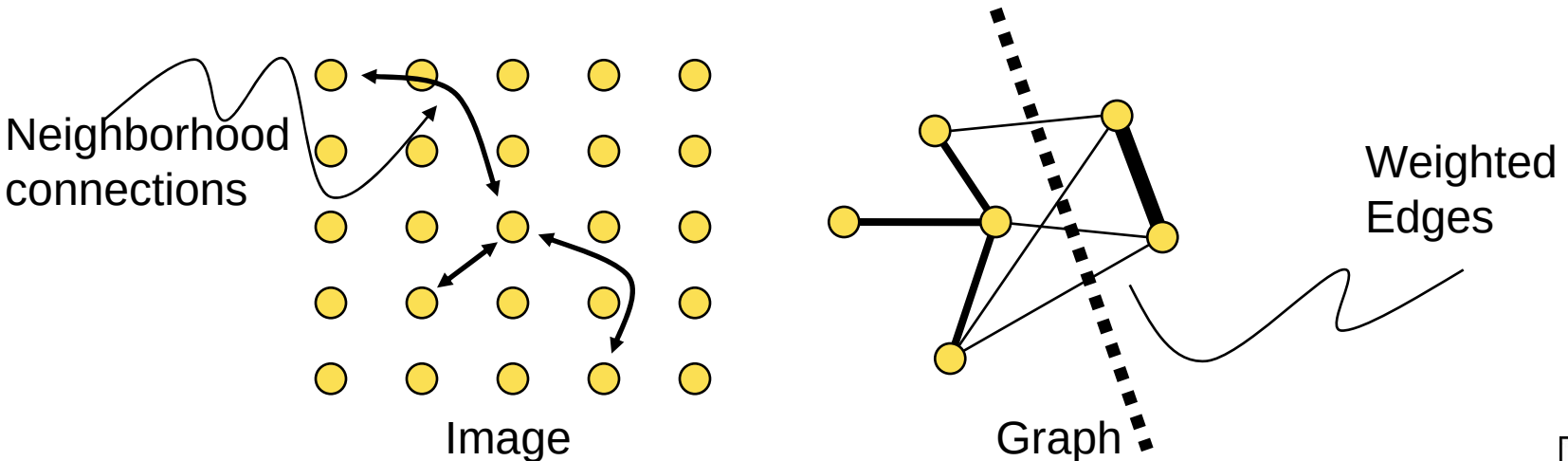
Image Partitioning



Cates et al., 2003

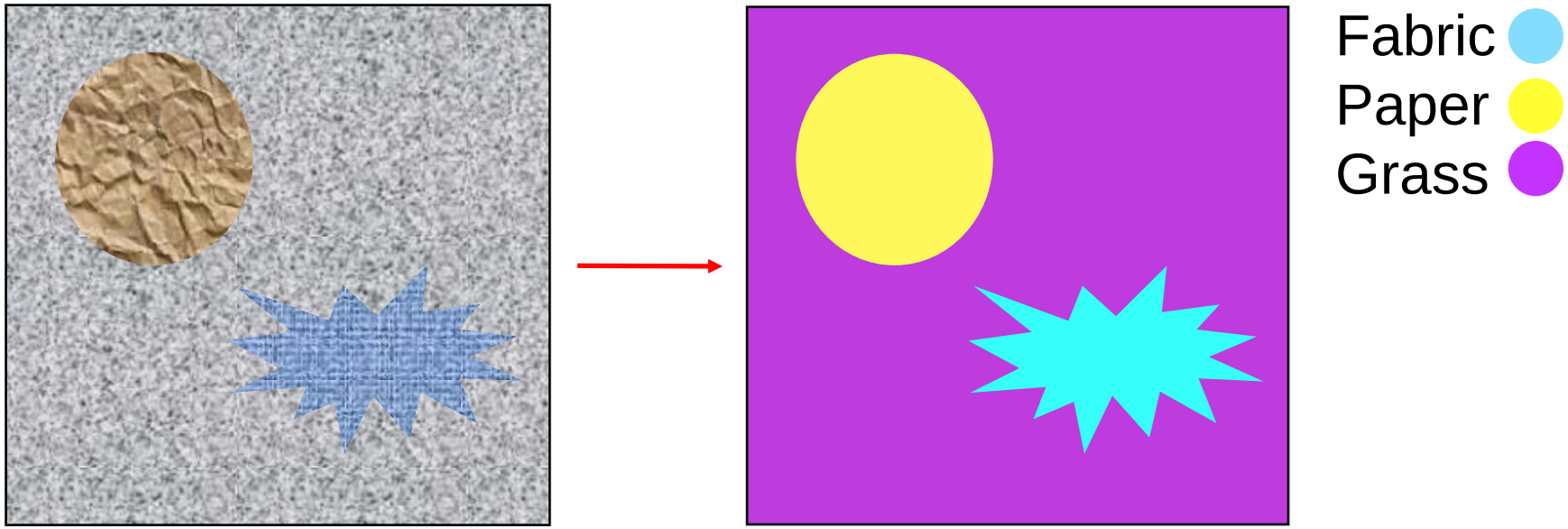
Minimum Cut (Shi and Malik `00)

- Treat image as graph
  - Vertices -> pixels
  - Edges -> neighbors
  - Must define a neighborhood stencil (the neigbhors to which a pixel is connected)



What is Segmentation?

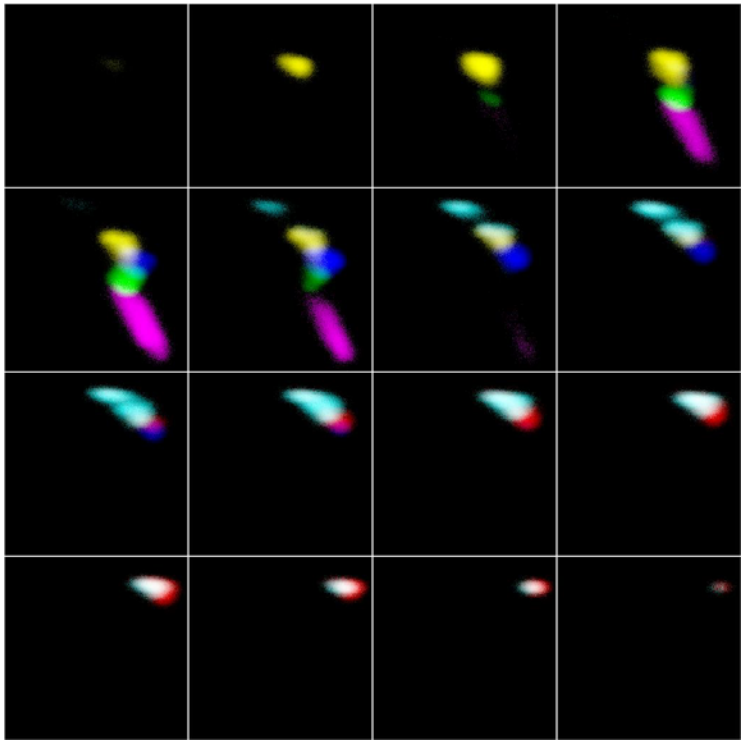
- Assigning each pixel a type (tissue or material)



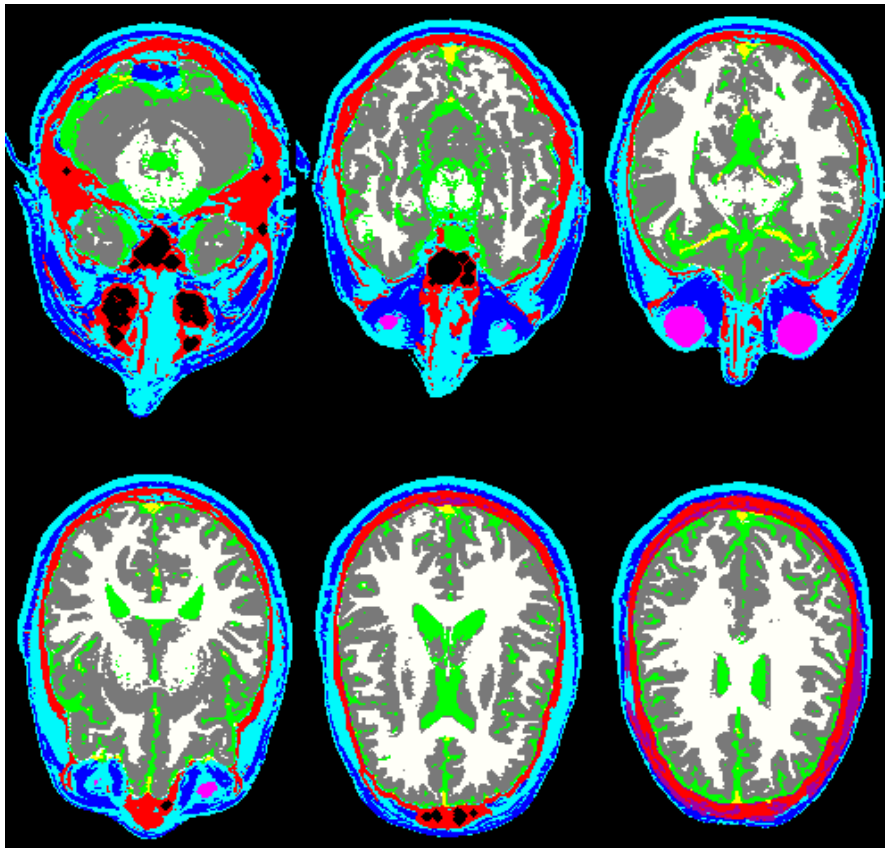
"Classification problem"

Pixel Classification

T1, T2, PD



Feature Space

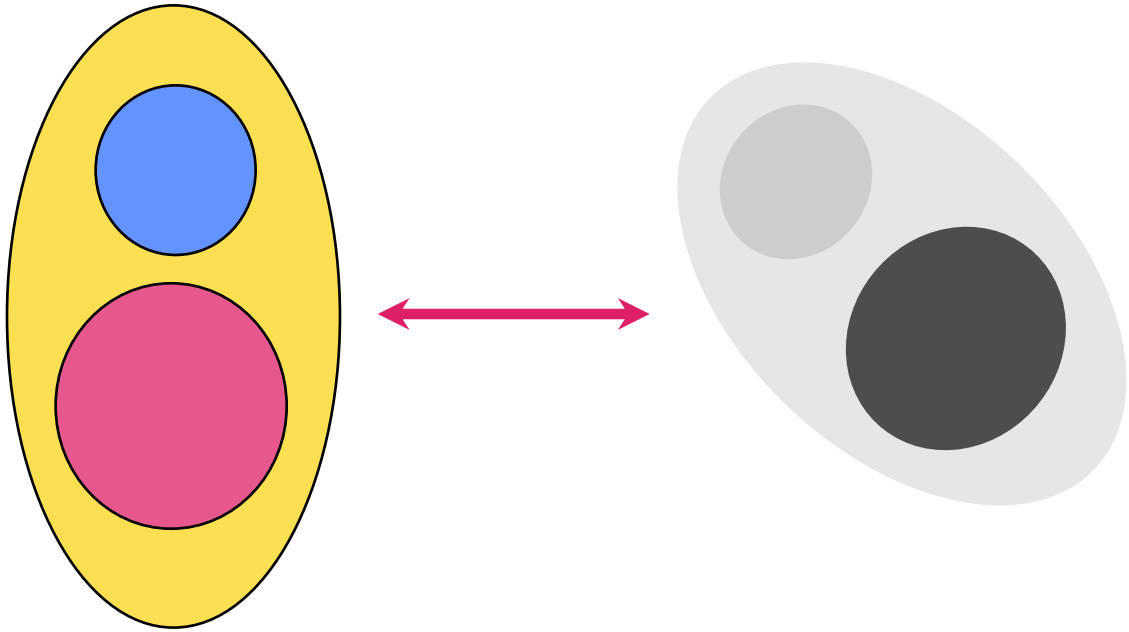


Classification

Tasdizen et al.

Registration of Templates

- Align a known, segmented image to input data



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
- State of the art
  - Specific data and shapes
    - Train a template or model (variability)
    - Deform to fit specific data
  - General data and shapes
    - So many methods

State of the Art Segmentation: Statistics and Learning

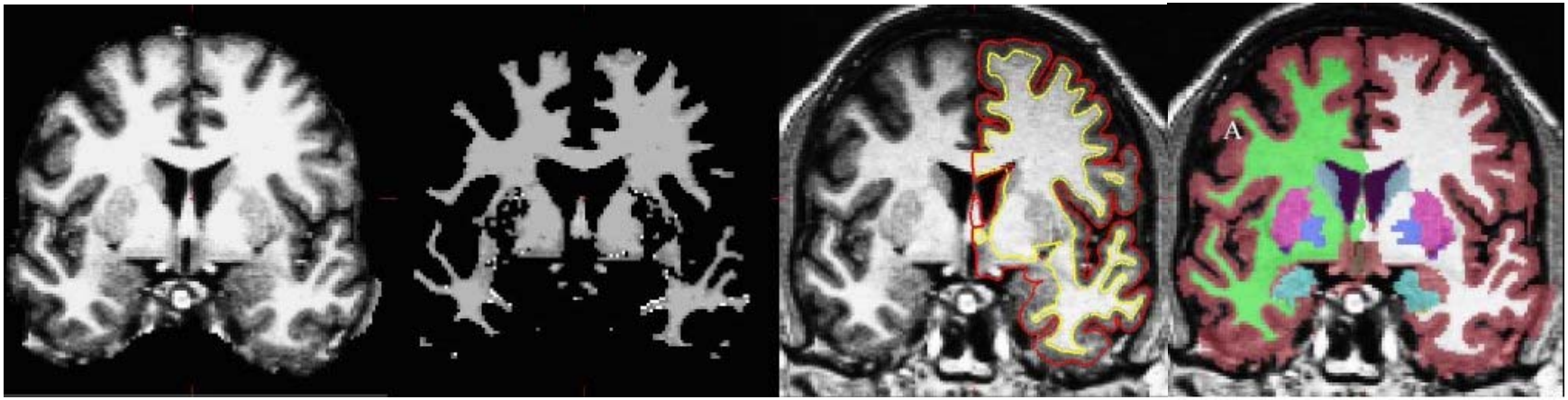
- Intensities and image statistics
  - Grey-levels and neighborhoods
- Positions and templates
  - Register templates with spatial knowledge
- Shapes
  - Learning statistics of contours and surfaces
  - Nonlocal relationships

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 Anders MGH



MRI WM Surfaces Partition

EM-Segmenter, Slicer3

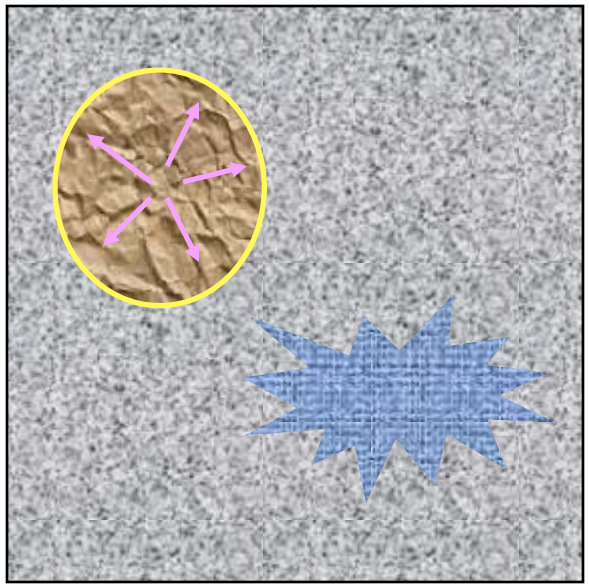
- Tissue classification
  - Inhomogeneity correction
  - Gaussian mixture model
- Simultaneous classification and template
  - Iterative

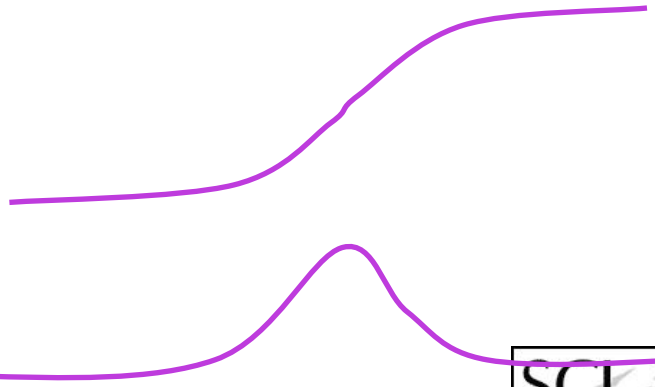
Specific vs General Methods

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

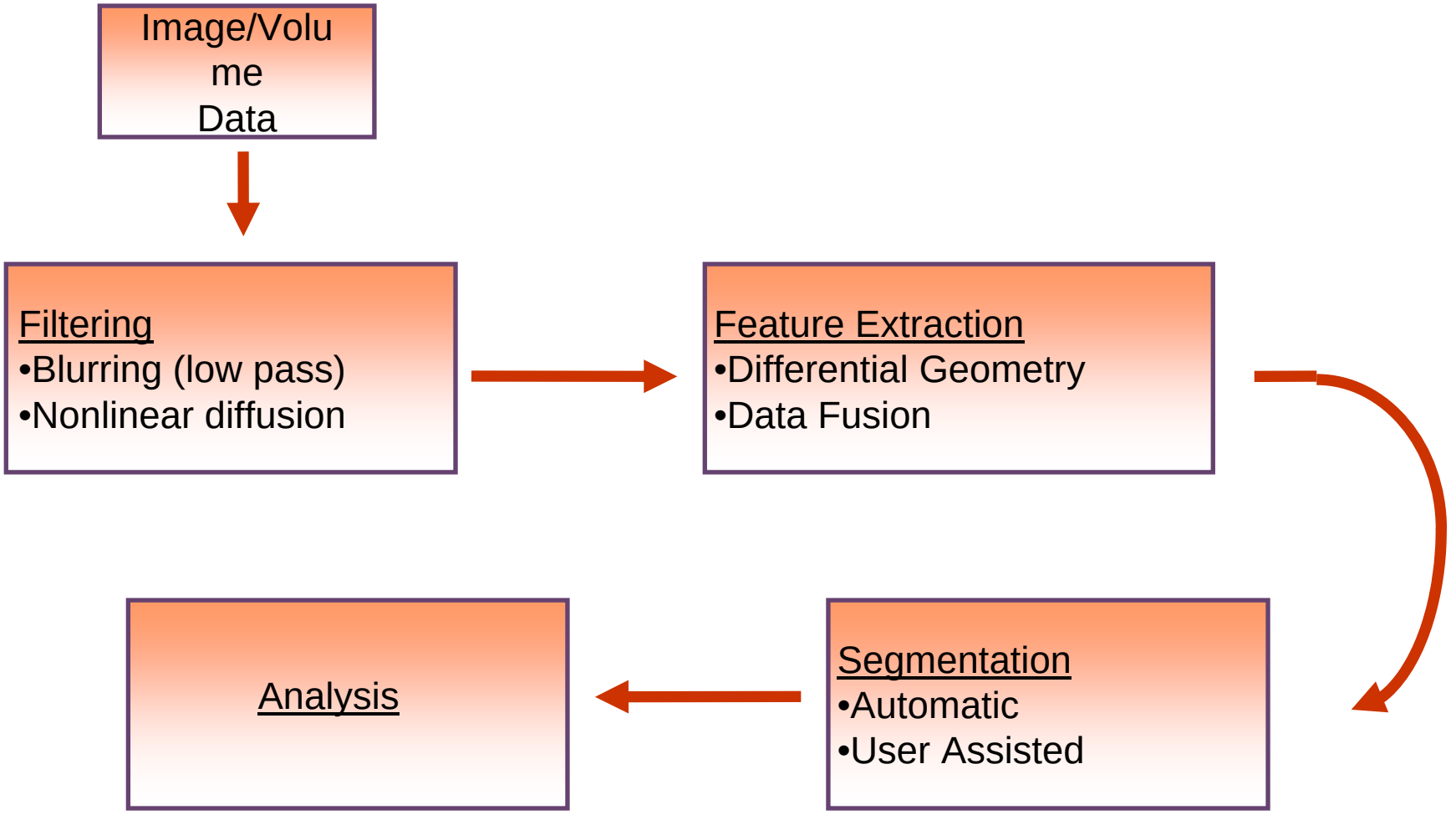
General Purpose Segmentation Strategies

- Region-based methods (connected)
  - Regions are locally homogeneous (in some property)
  - Regions satisfy some property (to within an tolerance)
  - E.g. Flood fill
- Edge-based methods
  - Regions are bounded by features
  - Features -> sharp contrast
  - E.g. Canny Edges



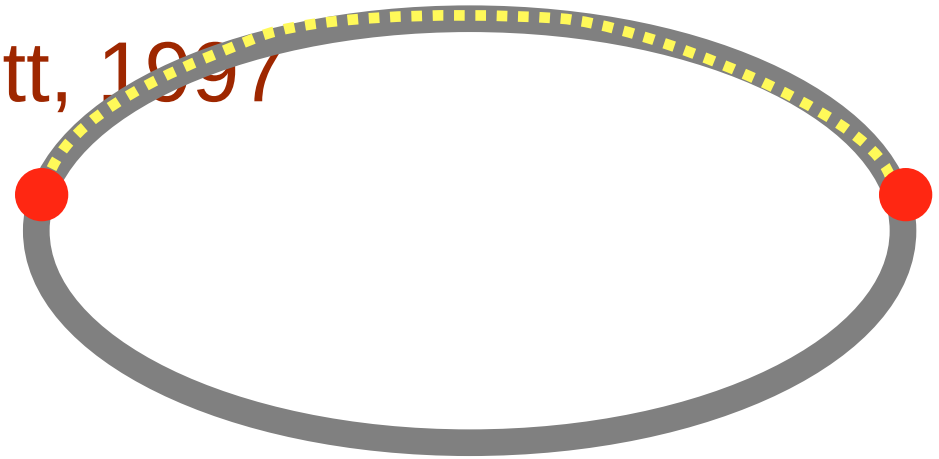


Typical Edge/Region-Based Segmentation Pipeline



Example: Livewire

- Contour follows features
  - Shortest path between user-defined landmarks
  - Need preprocessing and definition of “features”
- Barrett, 1997



Seg3D

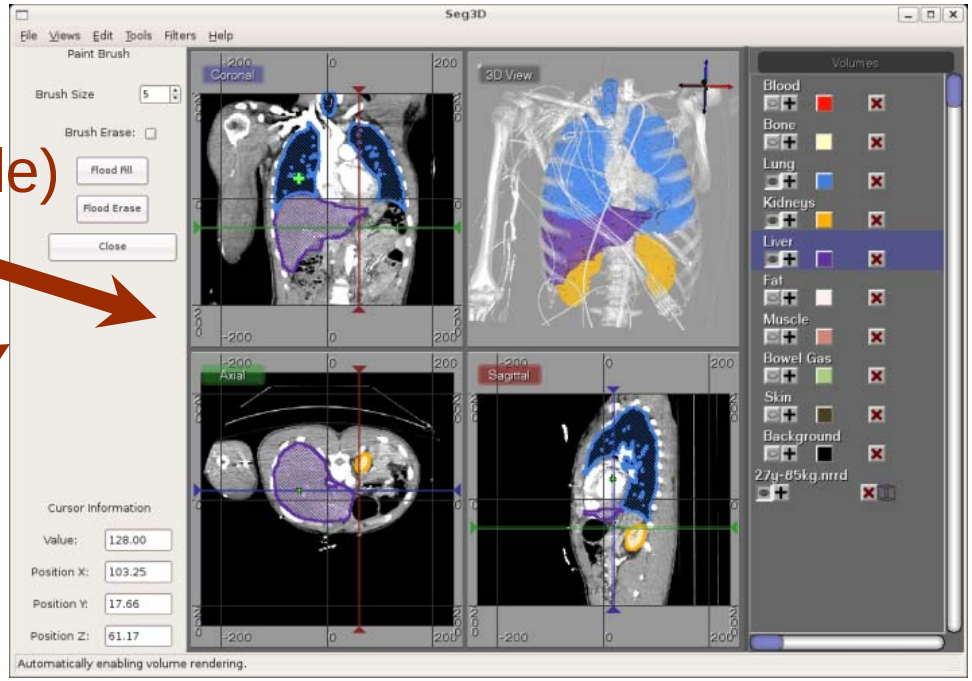
- Goals
  - End-user application
  - General purpose
  - User-assisted
- Philosophy
  - Voxel/pixel-based
  - Layers and labels, 3D photoshop
  - GUIs and user interaction for user-assisted segmentation
  - 3D interaction to aid 2D views

Seg3D

- Software engineering
  - Wrapping ITK filters and image I/O
  - Cross platform, WX widgets
- Software design/user interface

Views (reconfigurable)

Data/ Parameters



Layers/image s


CIBC


SCI
INSTITUTE


CIBC


SCI
INSTITUTE


SCI
INSTITUTE