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 it 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 segmentation tool

Time consuming
Delineation by Hand Contouring

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

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

Model is attracted to features
Model stays smooth
Watershed Segmentation

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

“Catchment Basin”

Drop of water grad. descent

Watershed Regions

Generalizes to any dimension or boundary measure

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Example: Image Partitioning

Jurrus et al., ISBI 2008
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
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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
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

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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

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EM-Segmenter, Slicer3

Tissue classification

- Inhomogeneity correction
- Gaussian mixture model

Simultaneous classification and template

- Iterative
- Probabilistic atlas/template
Specific methods are typically automated and moderately reliable, requiring user quality control (QC). They involve training or learning and are specific to certain anatomies, imaging modalities, and applications. The question of pathology is also raised in this context.
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

Image/Volume Data

Filtering
- Blurring (low pass)
- Nonlinear diffusion

Feature Extraction
- Differential Geometry
- Data Fusion

Analysis

Segmentation
- Automatic
- User Assisted

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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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