Surface Modeling and Display from Range and Color Data

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Introduction

Goal

- develop robust algorithms for constructing 3D models from range & color data
- use those models to produce realistic renderings of the scanned objects



Surface Reconstuction

Step 1: Data acquisition

Obtain range data that covers the object. Filter, remove background.

Step 2: Registration

Register the range maps into a common coordinate system.

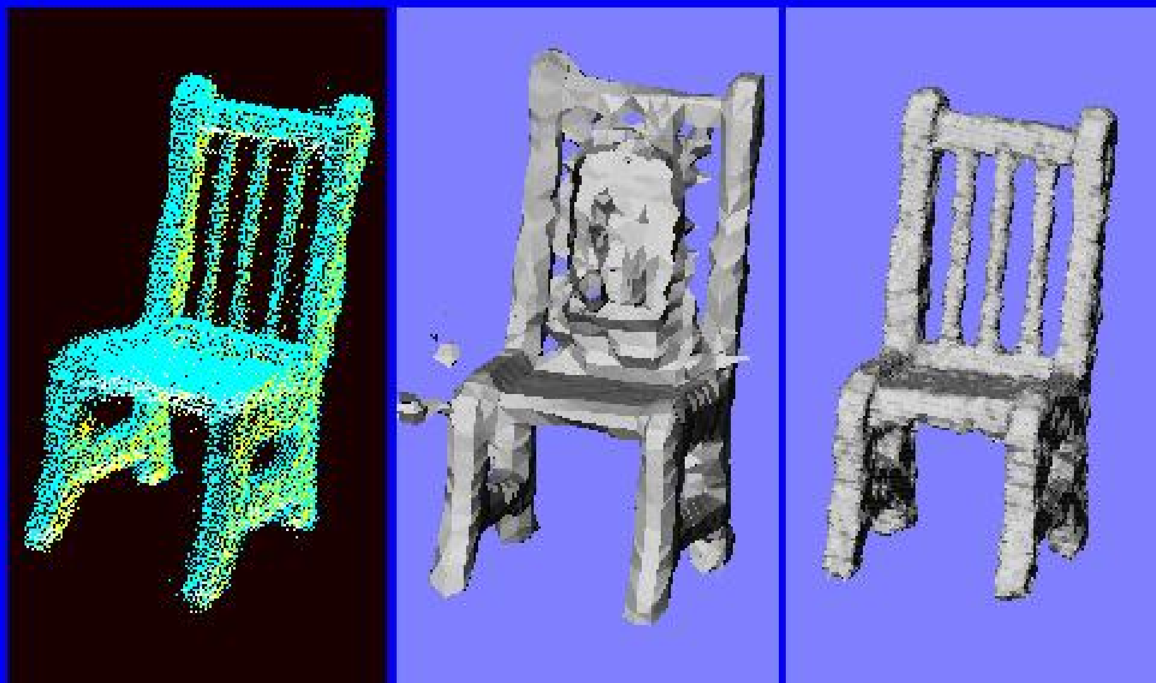
Step 3: Integration

Integrate the registered range data into a single surface representation.

Step 4: Optimization

Fit the surface more accurately to the data, simplify the representation.

Problem

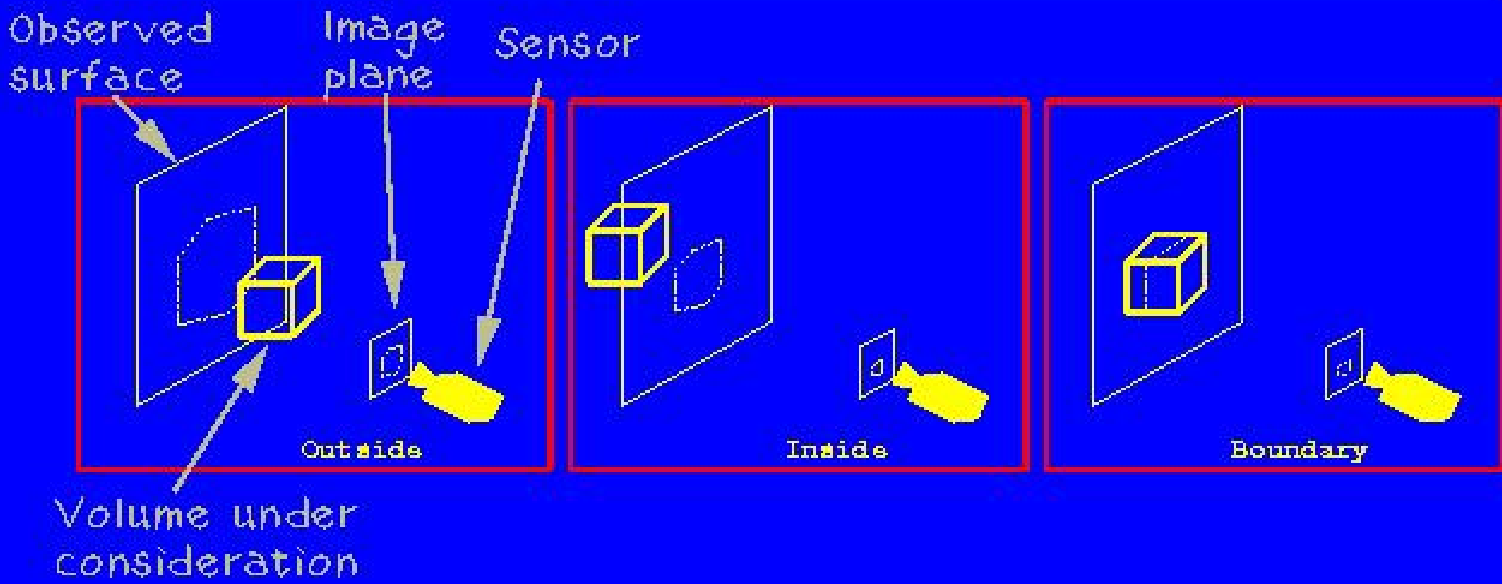


Noisy registered data

Signed distance fn & marching cubes

Hierarchical & directional space carving

Carve space in cubes



Label cubes

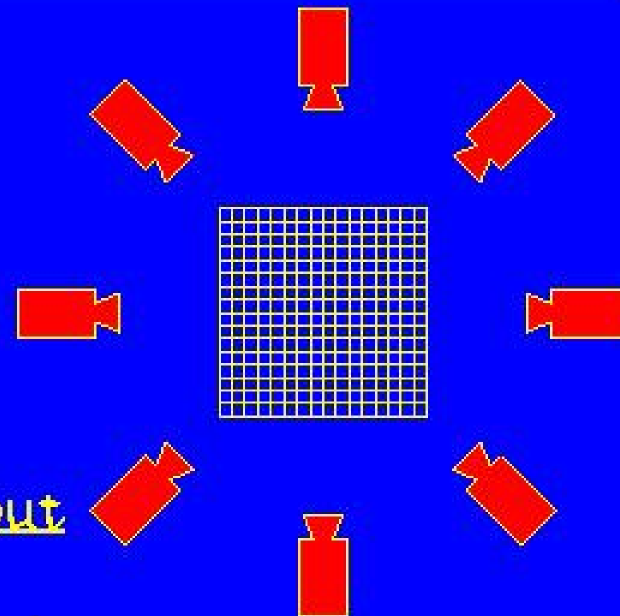
- Project cube to image plane (hexagon)
- Test against data in the hexagon

Several views

Processing order:

FOR EACH cube

FOR EACH view



Rules:

<u>any</u> view thinks cube's <u>out</u>

=> it's <u>out</u>

<u>every</u> view thinks cube's <u>in</u>

=> it's <u>in</u>

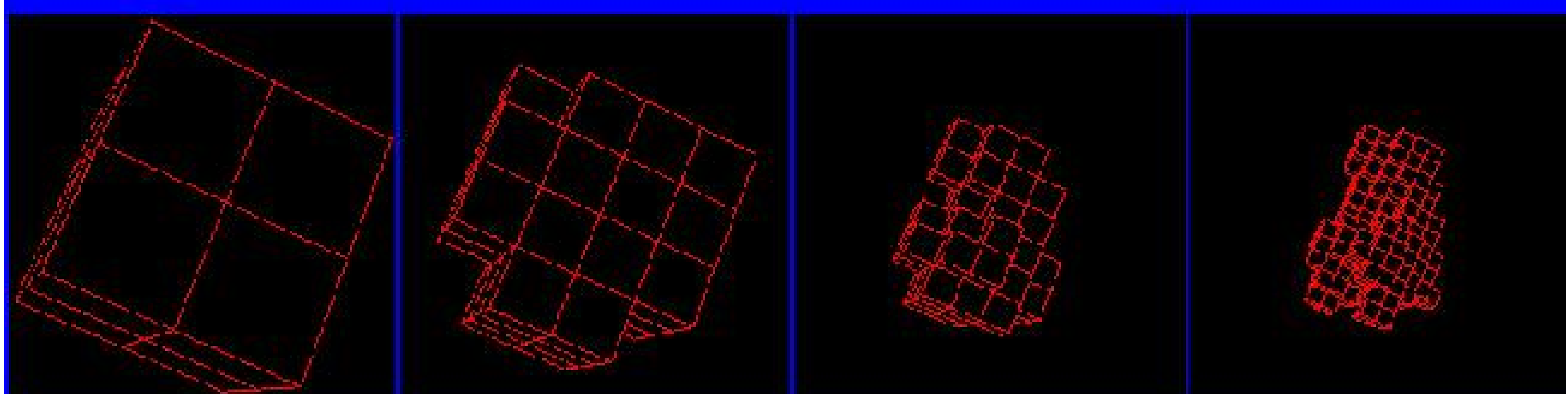
else

=> it's at boundary

Hierarchical space carving

- Big cubes => fast, poor results
- Small cubes => slow, more accurate results
- Combination = octrees

RULES:
- cube's out => done
- cube's in => done
- else => recurse



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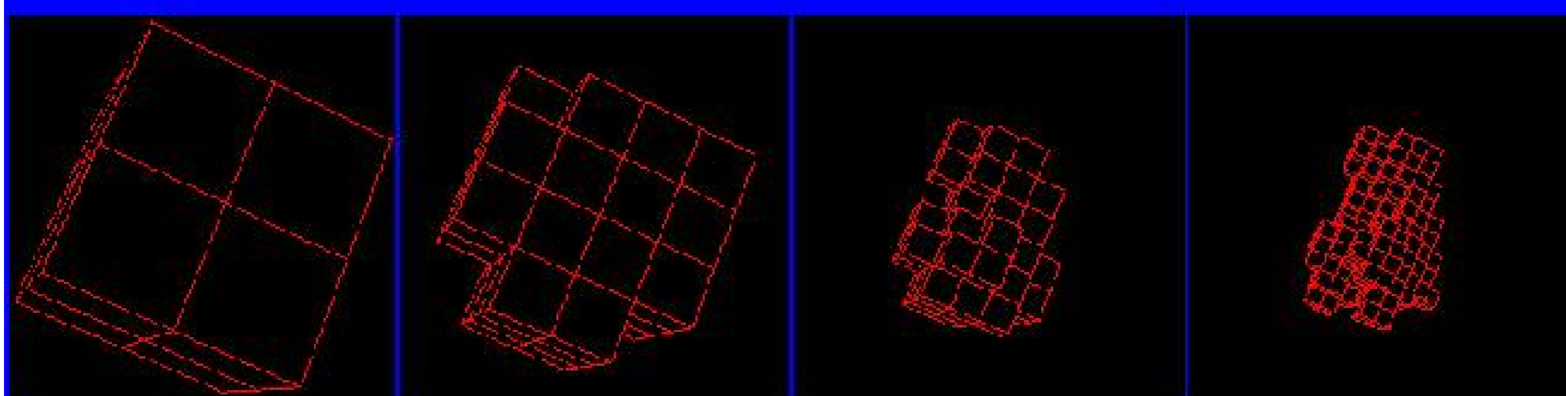
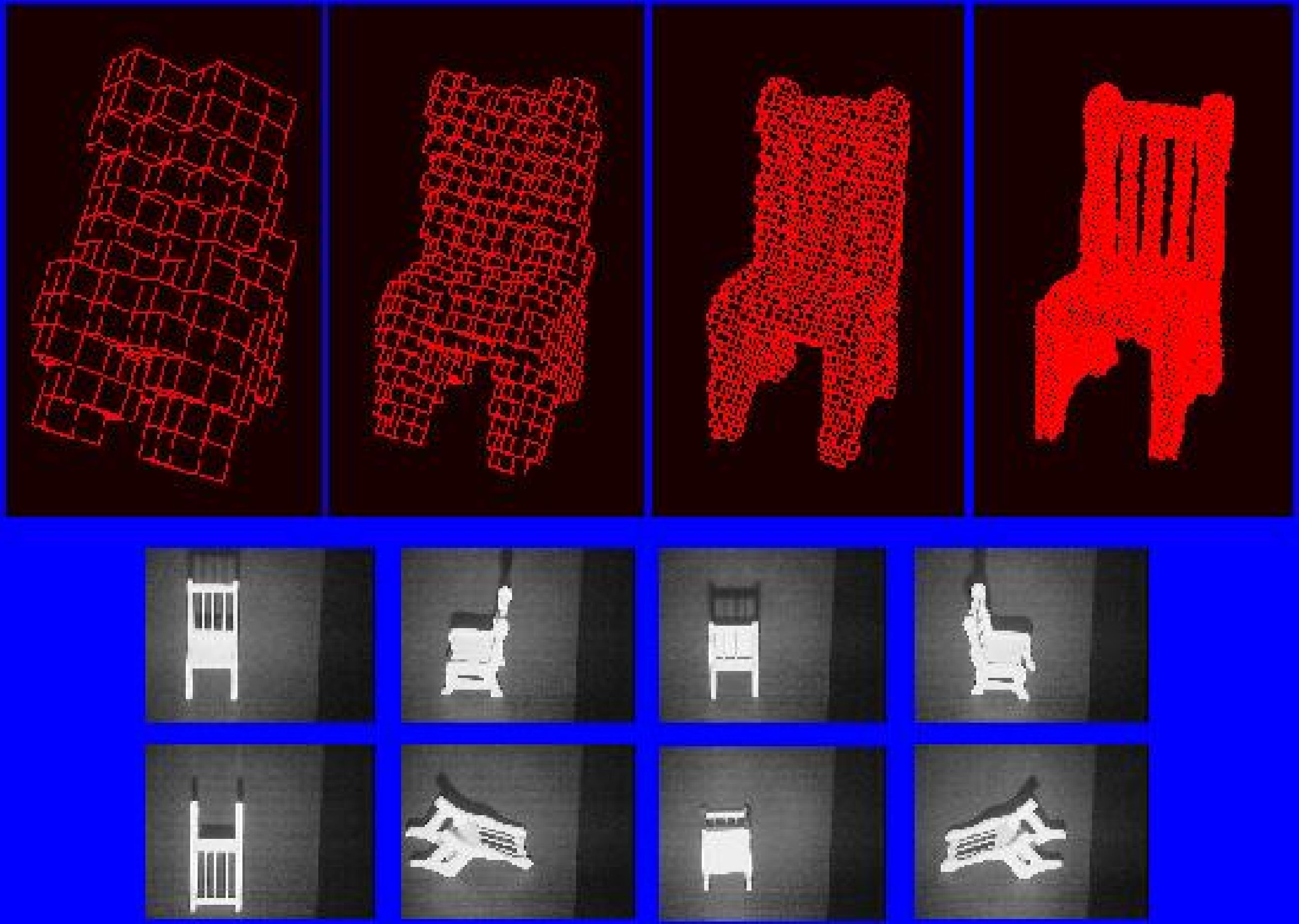
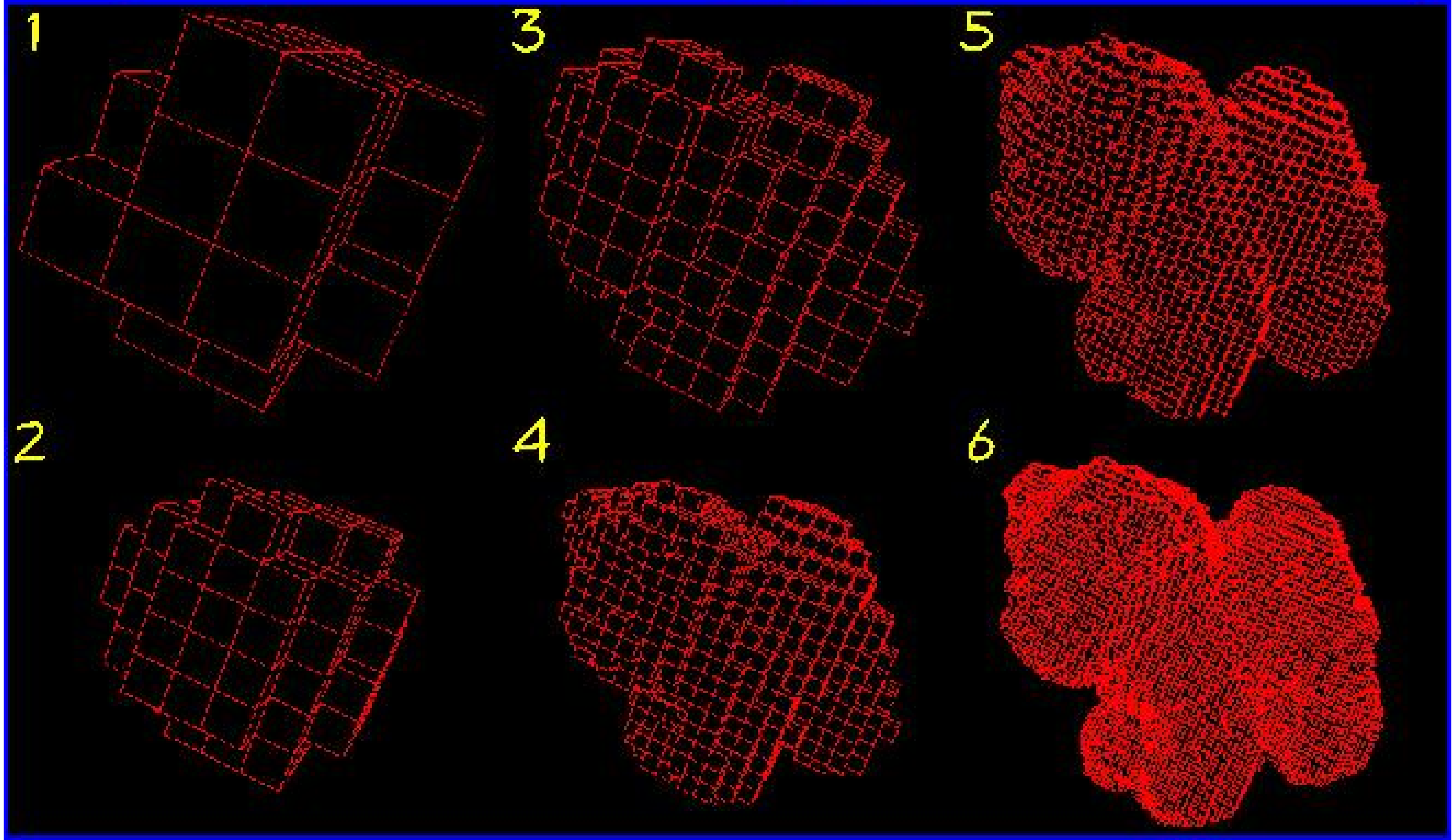
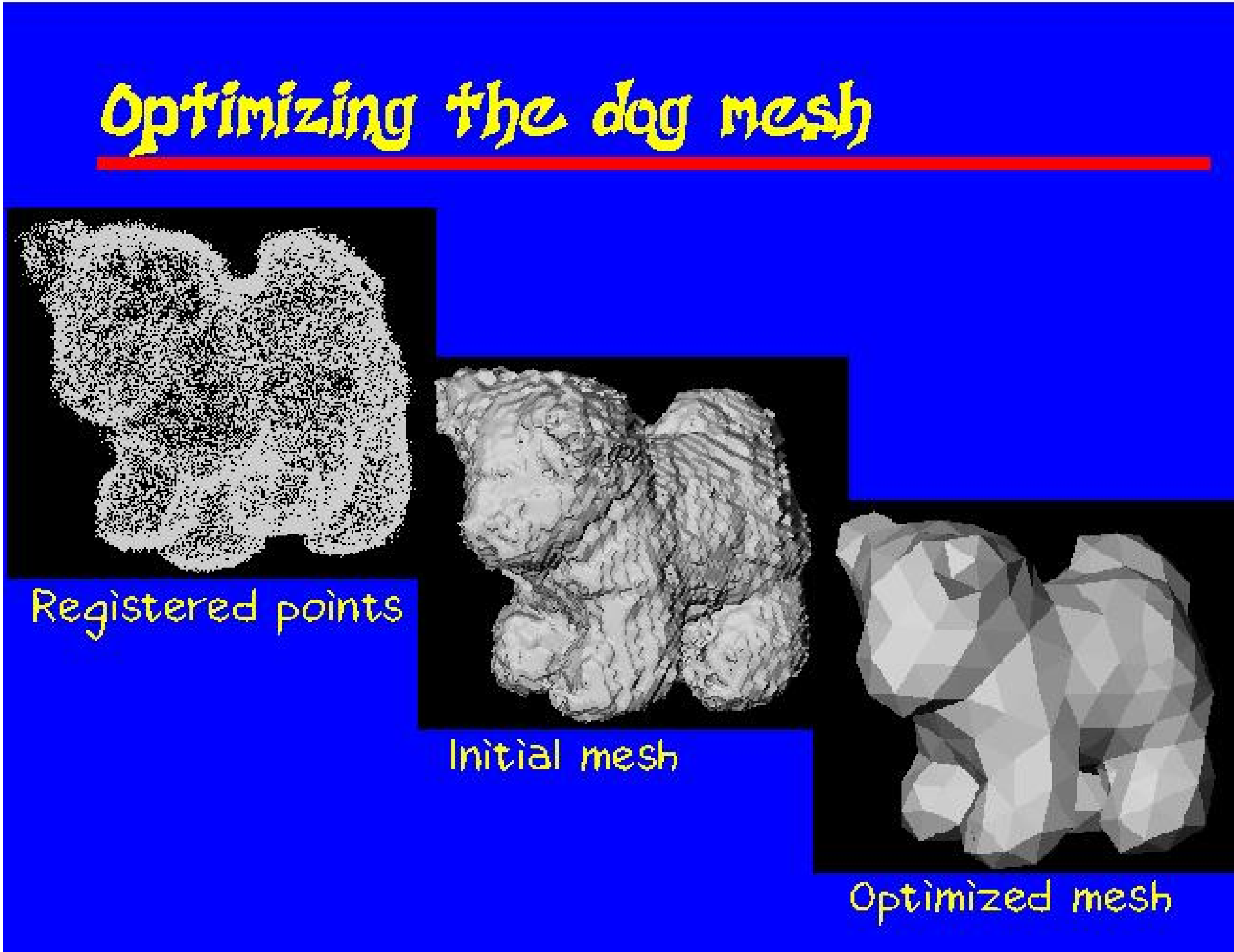


The rest of the chair



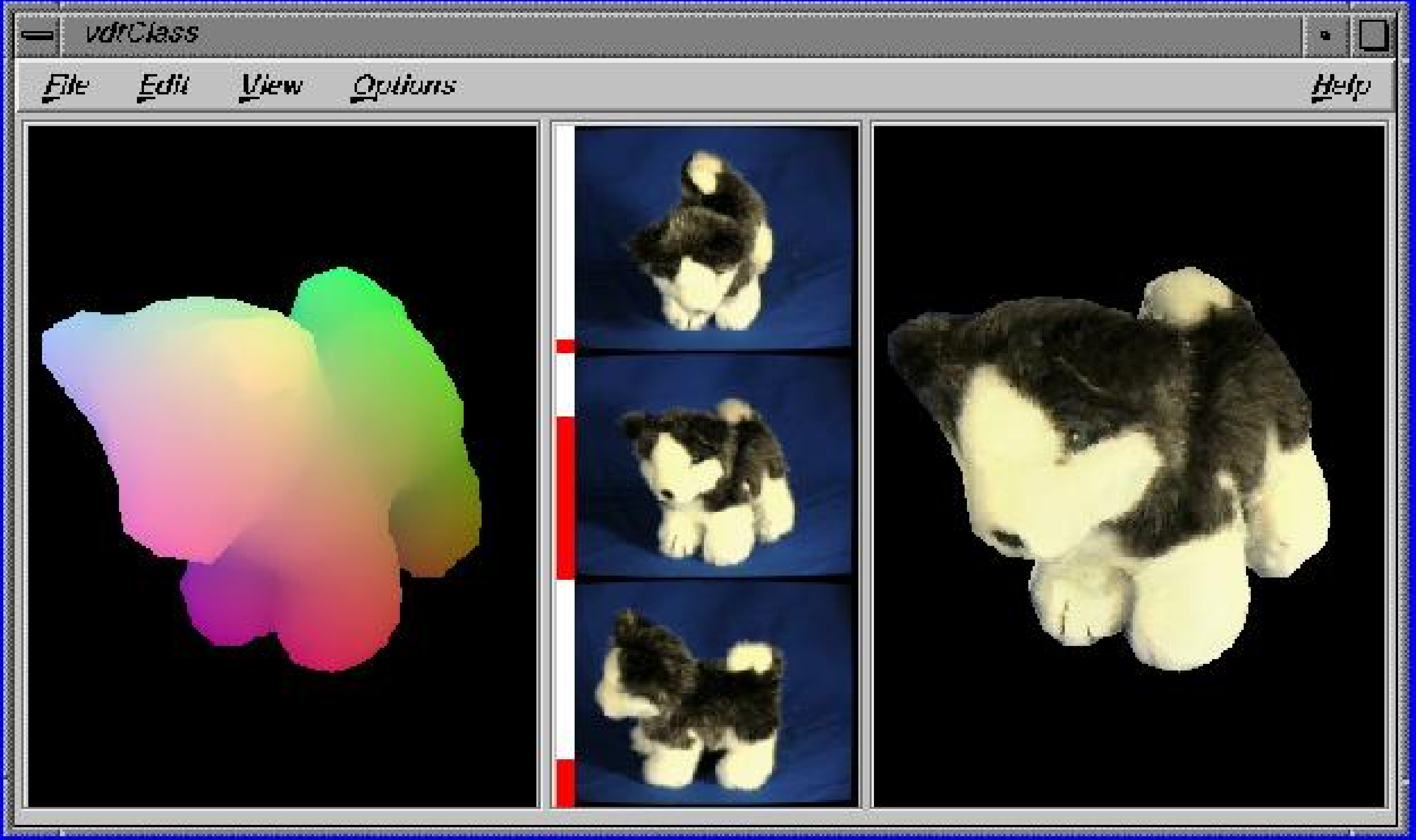
Same for a husky pup




Optimizing the dog mesh
Registered points
Initial mesh
Optimized mesh

View dependent texturing

Our viewer



Overview of VBR

Choose 3 close views

Render meshes from the current viewpoint

For each pixel
* read it from each view
* remove occluded ones
* calculate a weighted average
* paint the pixel

Reconstruction of Blood Vessel Trees from Visible Human Data

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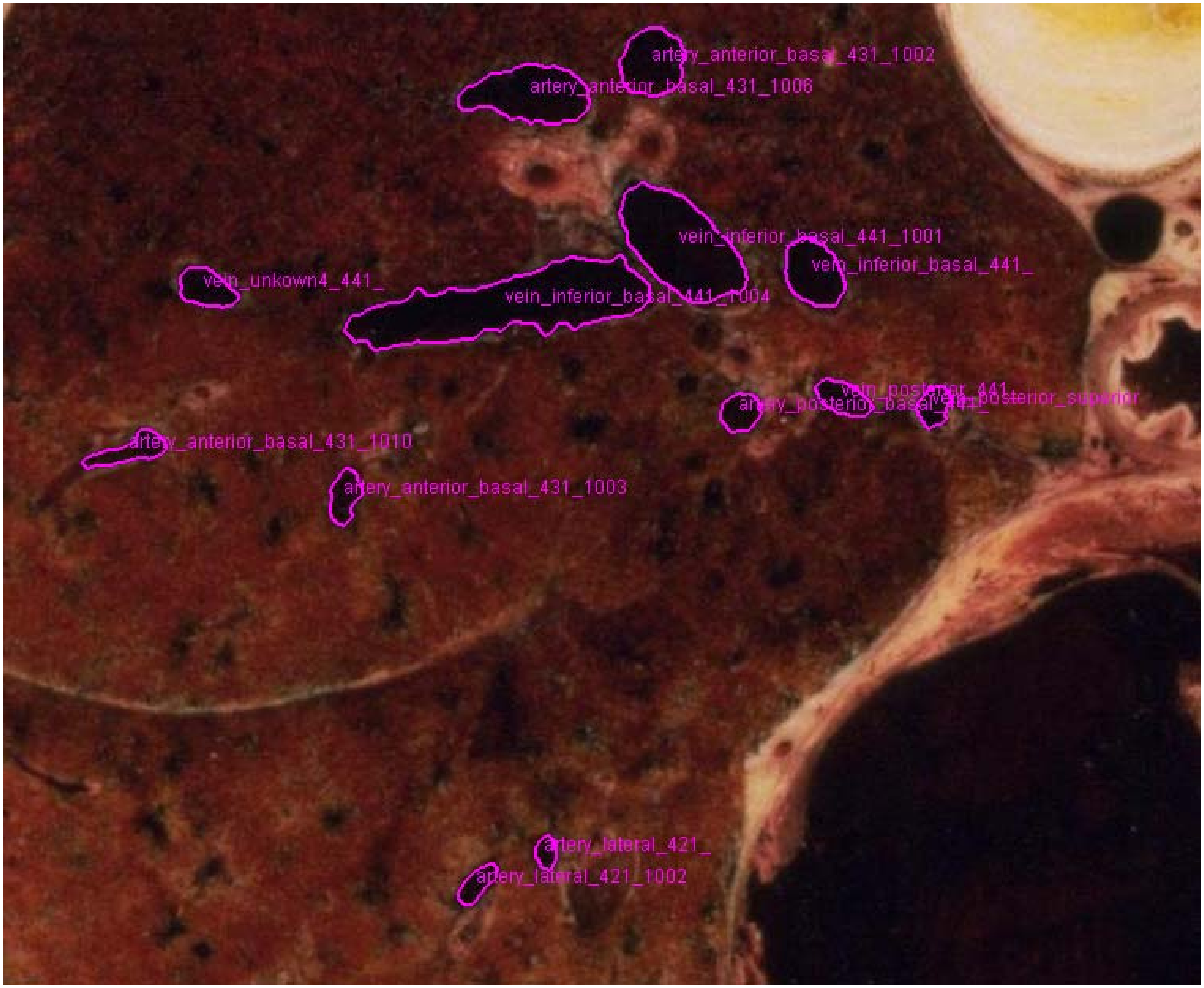
Introduction

- **Goal**
  - to reconstruct the blood vessels of the lungs from Visible Human Data
- **Computer vision**
  - semi-automation
  - low-level image processing
  - model construction

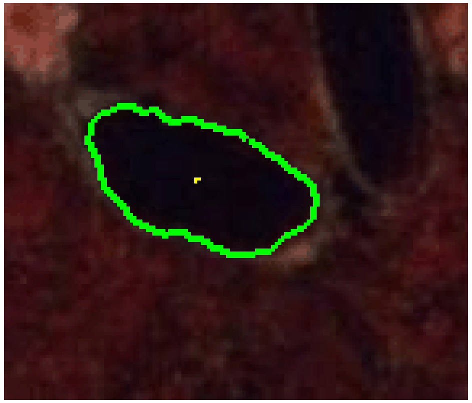
Visible Human Data: Slice through the Lung



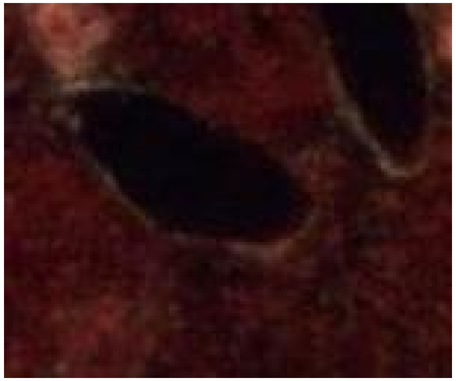
Problems Encountered

- **Data source**
  - black spots that are not blood vessels
  - variations of lighting
- **Characteristics of blood vessels**
  - similar color surrounds
  - lack of knowledge
  - close location
  - shape variety
  - continuous change not expected
  - dense data

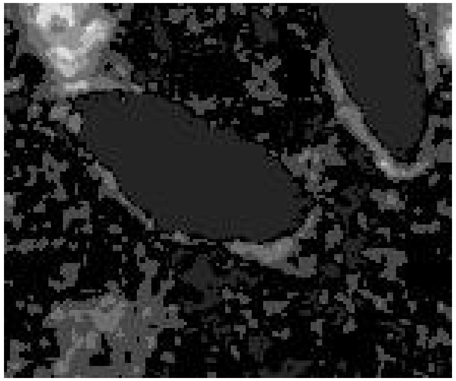
Finding the contours of a vessel being tracked (1)



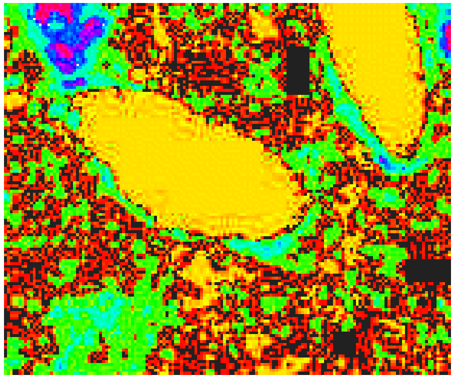
Previous contour



Current slice



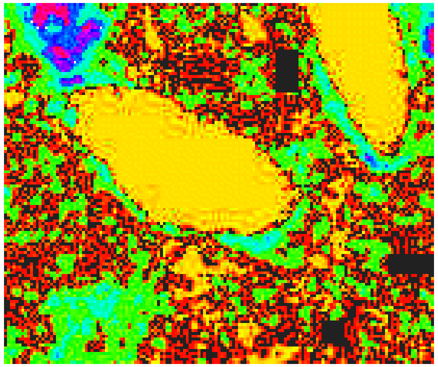
EM Segmentation



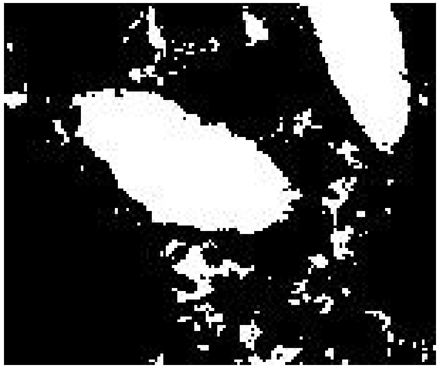
False color for the segmentation

Finding the contours of a vessel being tracked (2)

- The results after selecting regions of similar color to the tracked region



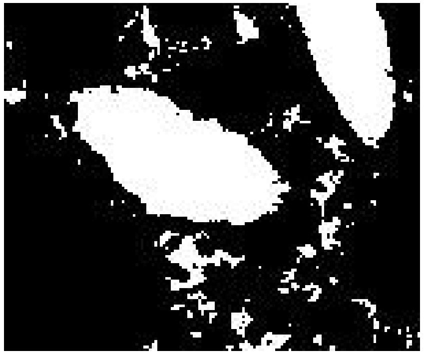
Segmentation result



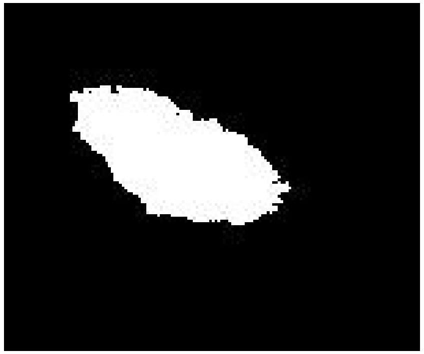
Selected regions

Finding the contours of a vessel being tracked (3)

- The results after selecting the region that overlaps most with the previous contour



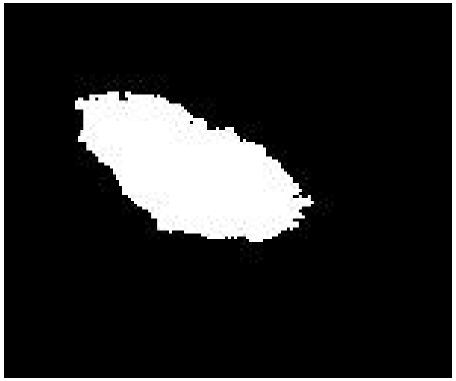
Selected regions



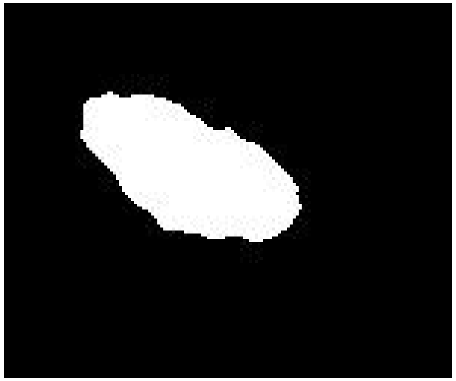
Region that overlaps most

Find the contours of a vessel being tracked (4)

- The results after morphology to close holes and remove noise



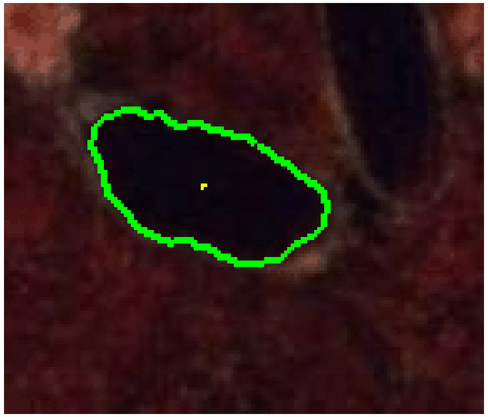
Selected region



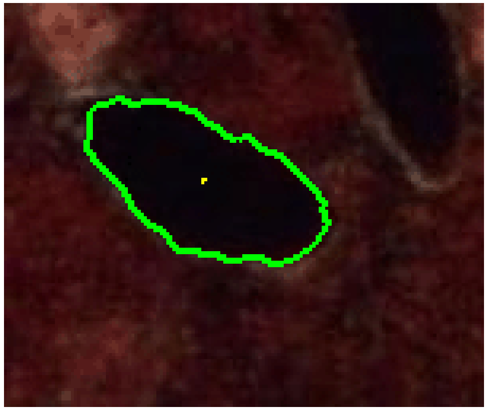
After noise removal

Find the contours of a vessel being tracked (5)

- The contour is determined through a fast-marching level-set approach



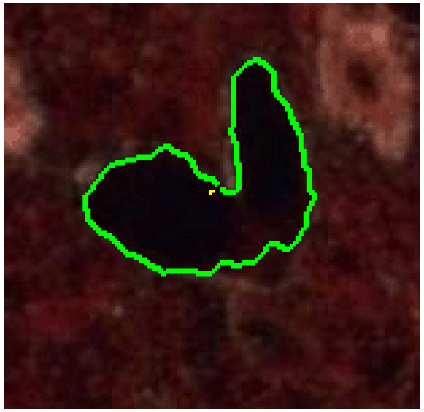
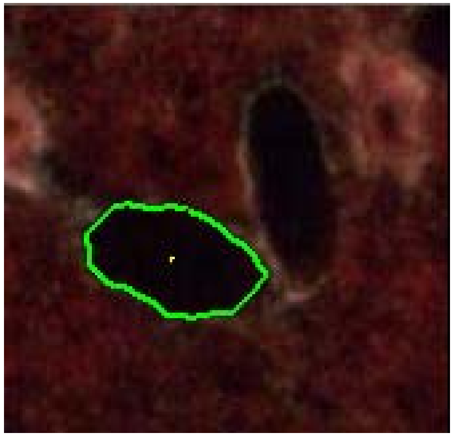
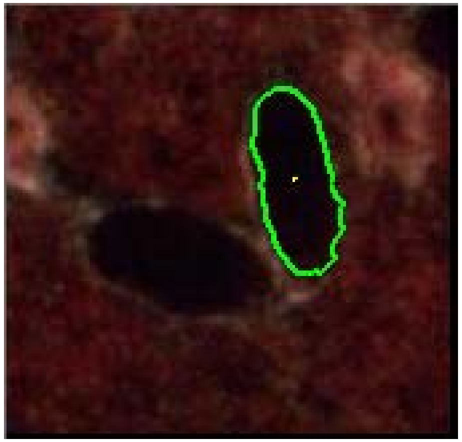
Previous contour



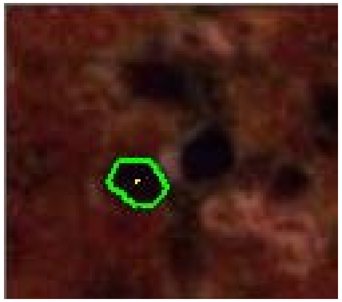
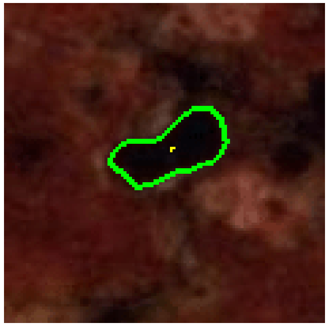
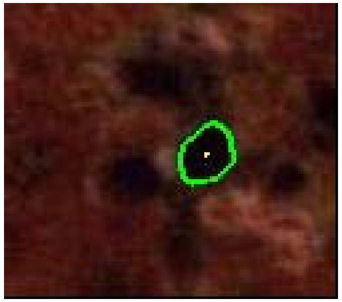
Current contour

How branching is handled

- One contour divides into two

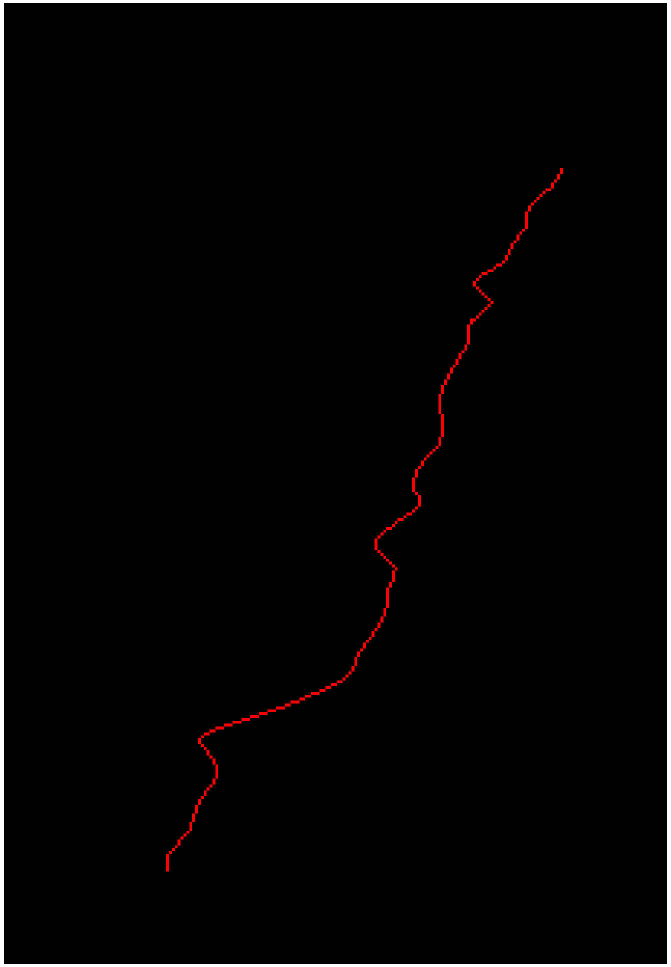
- Two contours merge into one

The use of resampling when the axis is not vertical

- **Track** the axis through the center points of found contours
- **Fit** a spline curve
- **Resample** the data perpendicular to the spline curve
- Use the resampled contours for model creation

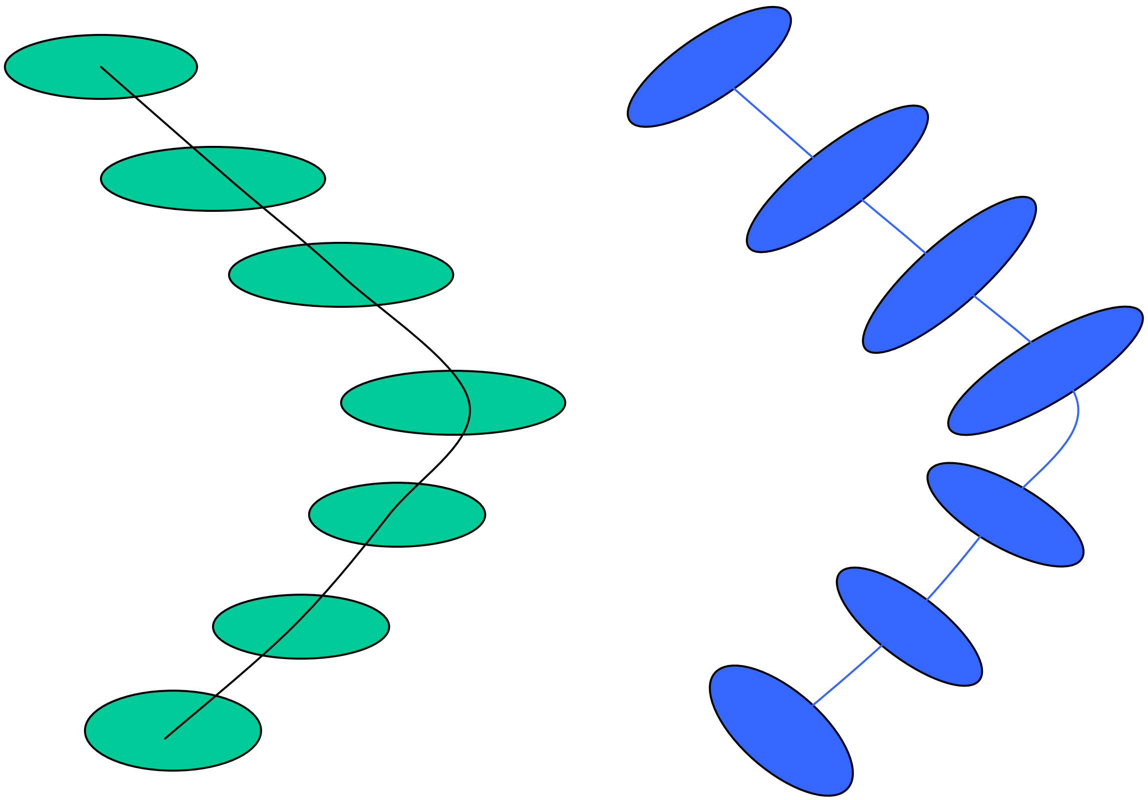
Detect the axis



Center points of found contours

Spline-fitted axis

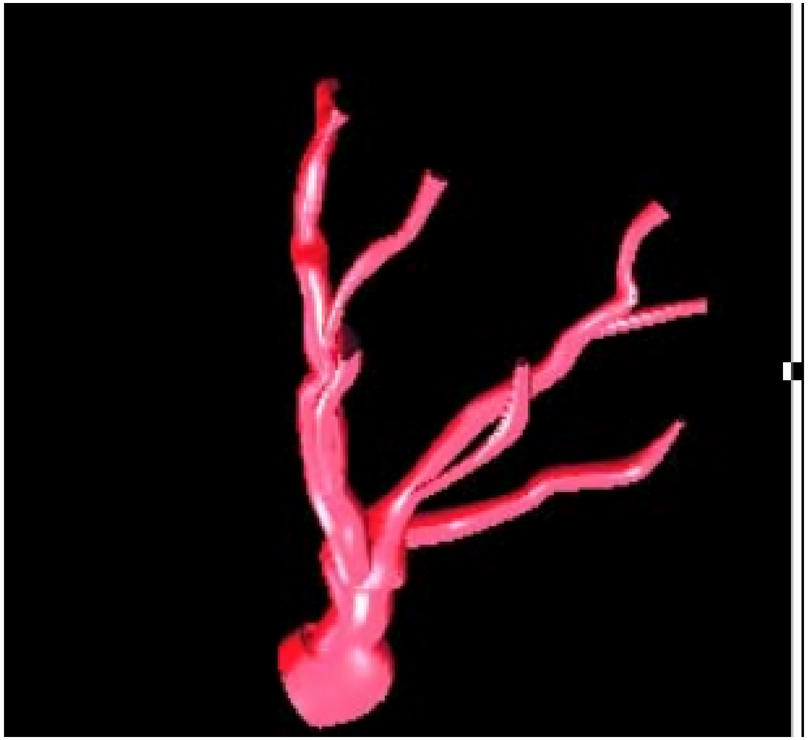
Resample the data perpendicular to the spline curve

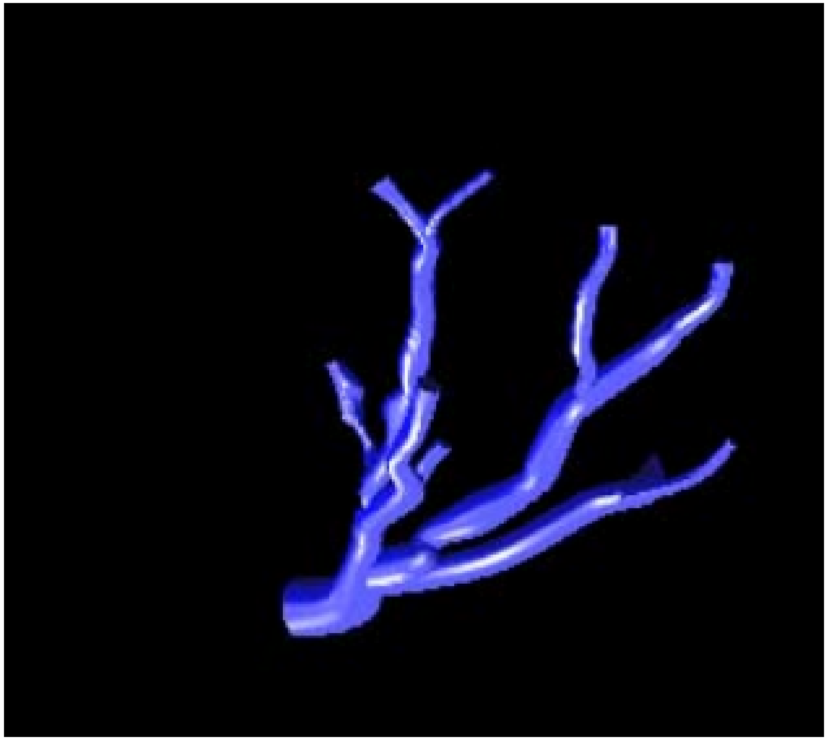


Overall Procedure for finding Vessel Trees

- The user **selects** a starting point
- The program automatically **tracks** the selected vessel and any branches it finds
- The program creates a **generalized cylinder** representation of the vessel tree
- The user may select more starting points

Some Initial Results





Artery tree from single seed Vein tree from single seed

Typical Cross Section

Results : blood vessels in right lung from previous section