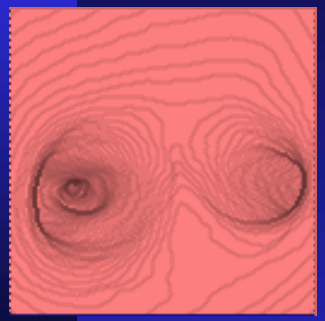
# Virtual Bronchoscopic approach for combining 3D CT and endoscopic video



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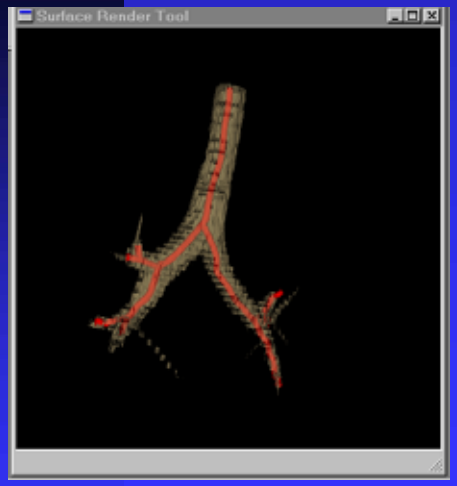


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[2]University of Iowa, Iowa City, IA 52246

*SPIE Med. Imaging 2000*, San Diego, CA, 12 February 2000

# Virtual Endoscopy:

- New field: 1994.
  - Virtual bronchoscopy (VB) -- focus on chest
- VB Needs: better reporting, path planning, bridge to live bronchoscopy
- CT-only reporting: Summers98, Vining99
- CT-Bronchoscopy linkage: Bricault98

# Our Work:

- ***Complete pulmonary assessment***
  - ***3D CT Assessment → Bronchoscopy***
    - ***Suite of graphics tools to* augment vision**
- ***Case Study***
  - ***Multimedia report***
  - ***Bronchoscopic guidance***

# Remainder of Presentation:

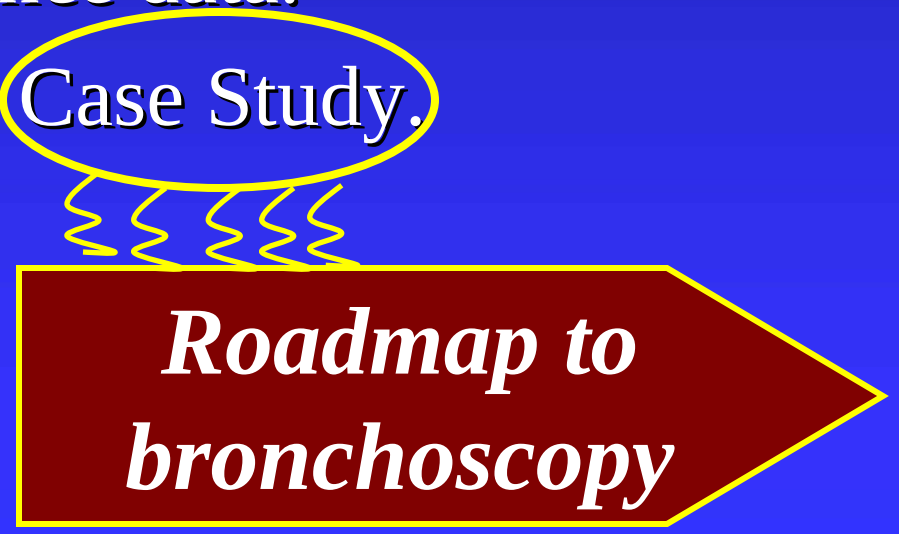
I. Two-stage CT-to-Videobronchoscopy paradigm

II. CT-only examples: Humans

III. CT-video progress: bronchoscopy training device

# Two-Stage CT-Video Paradigm

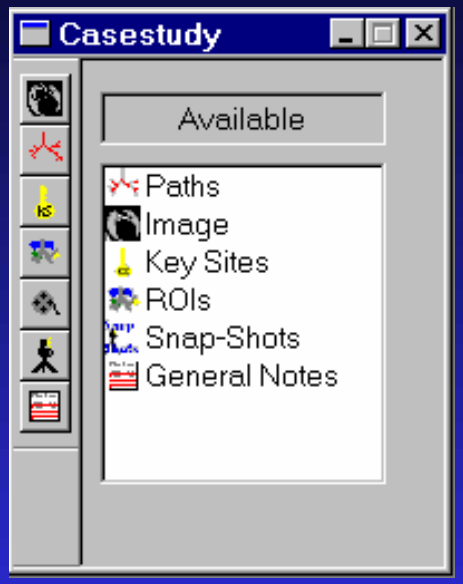
- Stage 1 (CT Assessment)
  1. Create new Case Study.
  2. Invoke graphics tools.
  3. Identify key sites.
  4. Compute guidance data.
  5. Build complete Case Study.



- Stage 2 (Bronchoscopy)

1. Load Case Study.
2. Invoke graphics tools.
3. Do virtual-guided bronchoscopy.
4. Perform biopsy.

# Case Study:



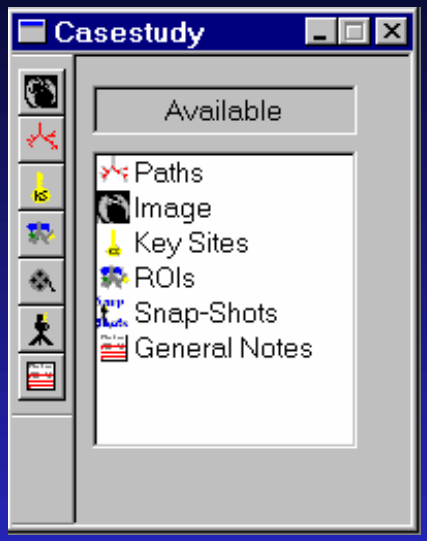

- Multimedia report
  - → 3D CT assessment
- Supplemental plan
  - → guide bronchoscopy

➢ ***Build with Graphics/Processing Tools***

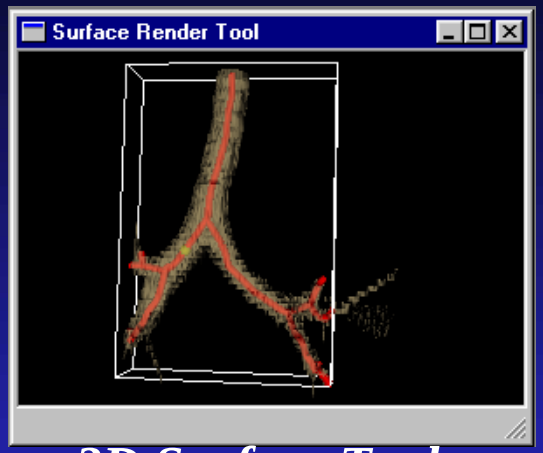
# Elements of Case Study:

1. Data Sources
   - 3D CT Image
   - Bronchoscopic Video
2. Data Abstractions
   - Root Site
   - Key Sites
   - Paths
   - Tree
3. Reporting Abstractions
   - Snapshots
   - Plots
   - Movies
   - Case Notes
   - Measurements

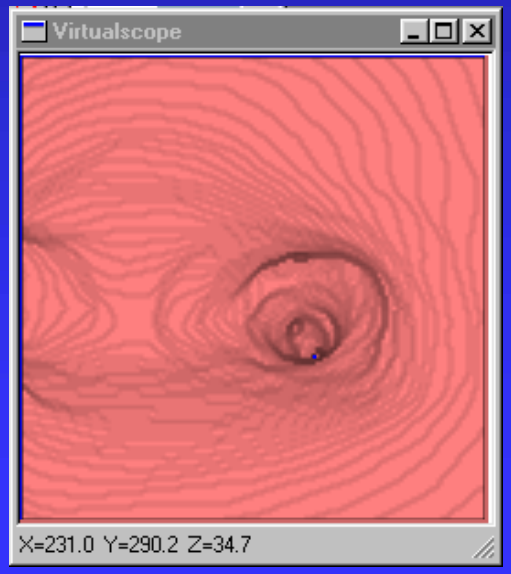
# Graphics Tools - 1



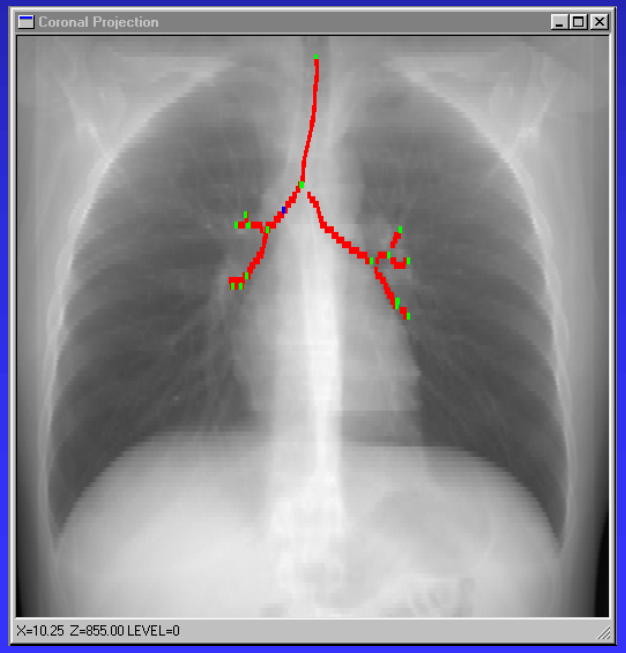

*Case Study Manager*




*3D Surface Tool*

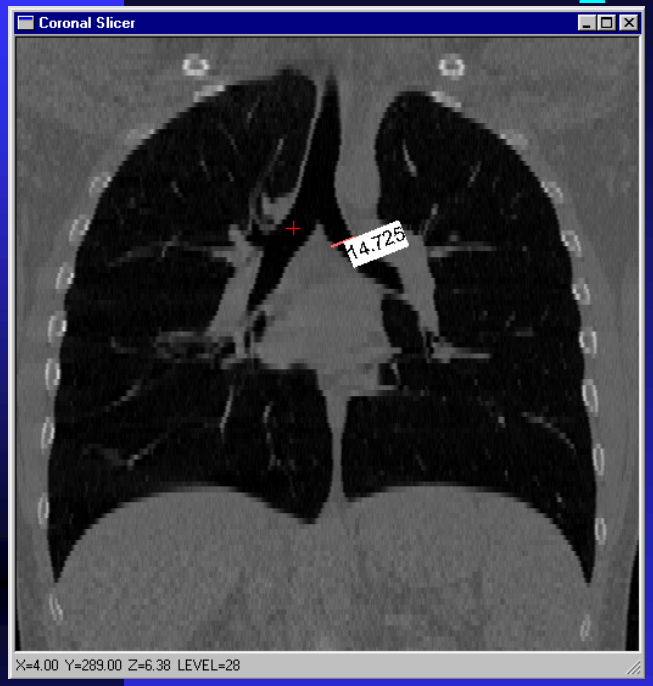



*Virtualscope*

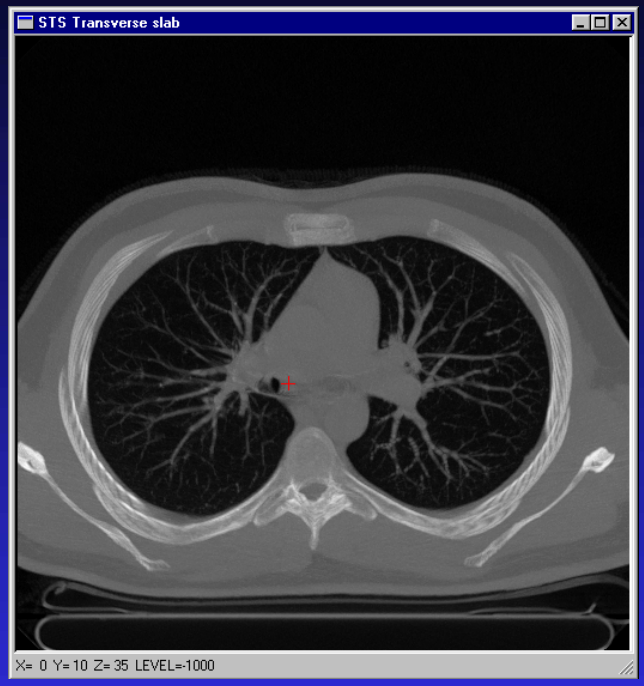



*Projection Tool (Coronal)*

# Graphics Tools - 2

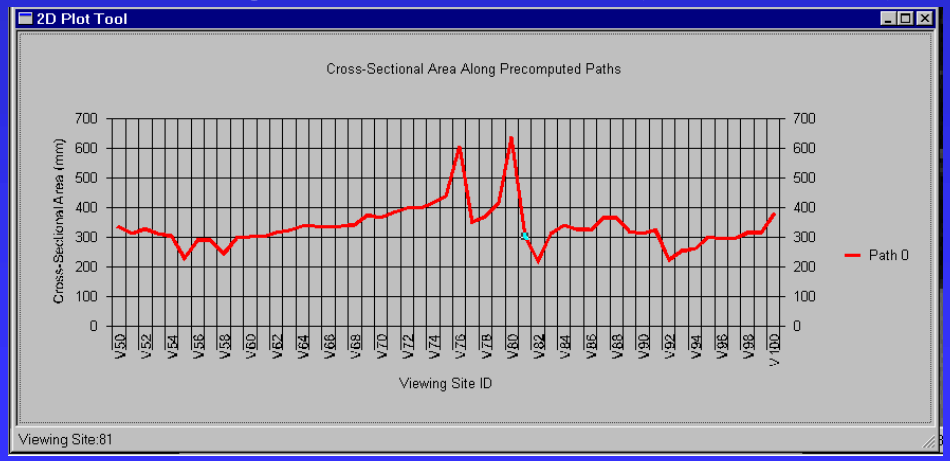



*Slicer Tool (MPR View, Coronal)*




*Sliding Thin Slab Tool (Transverse)*


*Cross Section Tool (Horizontal)*




*Plot Tool*

# II. CT-only Examples

## Example 1: Healthy Female

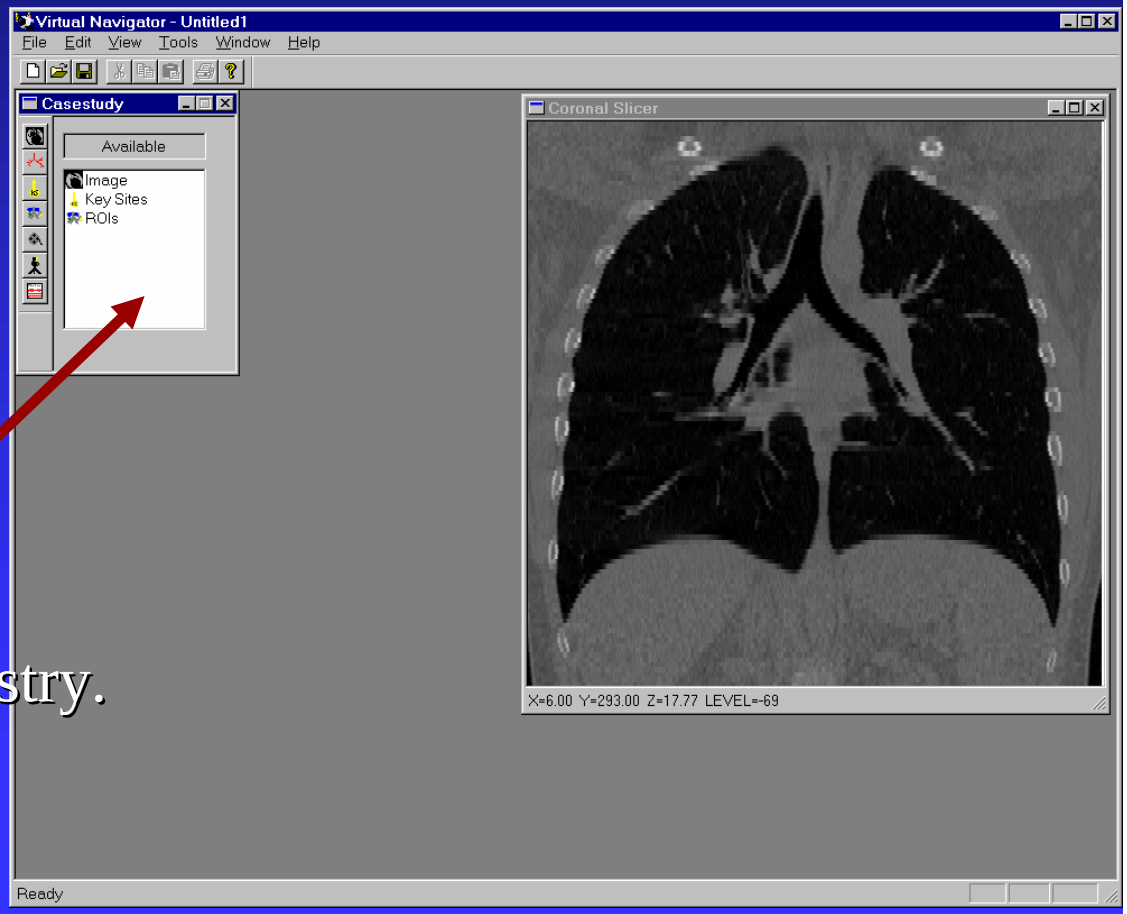
- 3D EBCT image at 90% TLC
- 115 slices; 512x512 per slice
- 3.0mm slice thickness; 0.684mm [x-y] resol.

➢ Emphasize automatic tree generation

# Stage 1 (CT Assessment)

1. **Create new Case Study.**
2. Invoke graphics tools.
3. Identify Key Sites.
4. Compute guidance data.
5. Build complete Case Study.

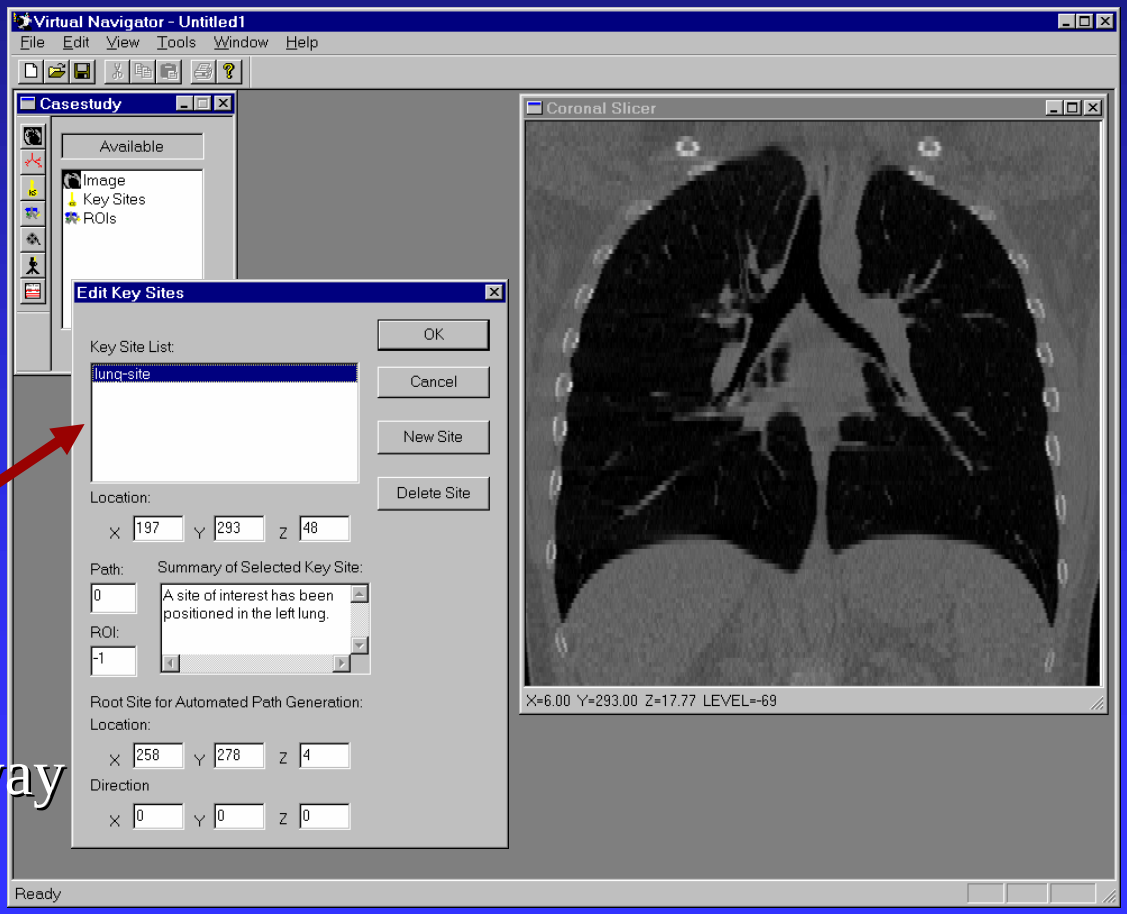
Case Study registry.



# Stage 1 (CT Assessment)

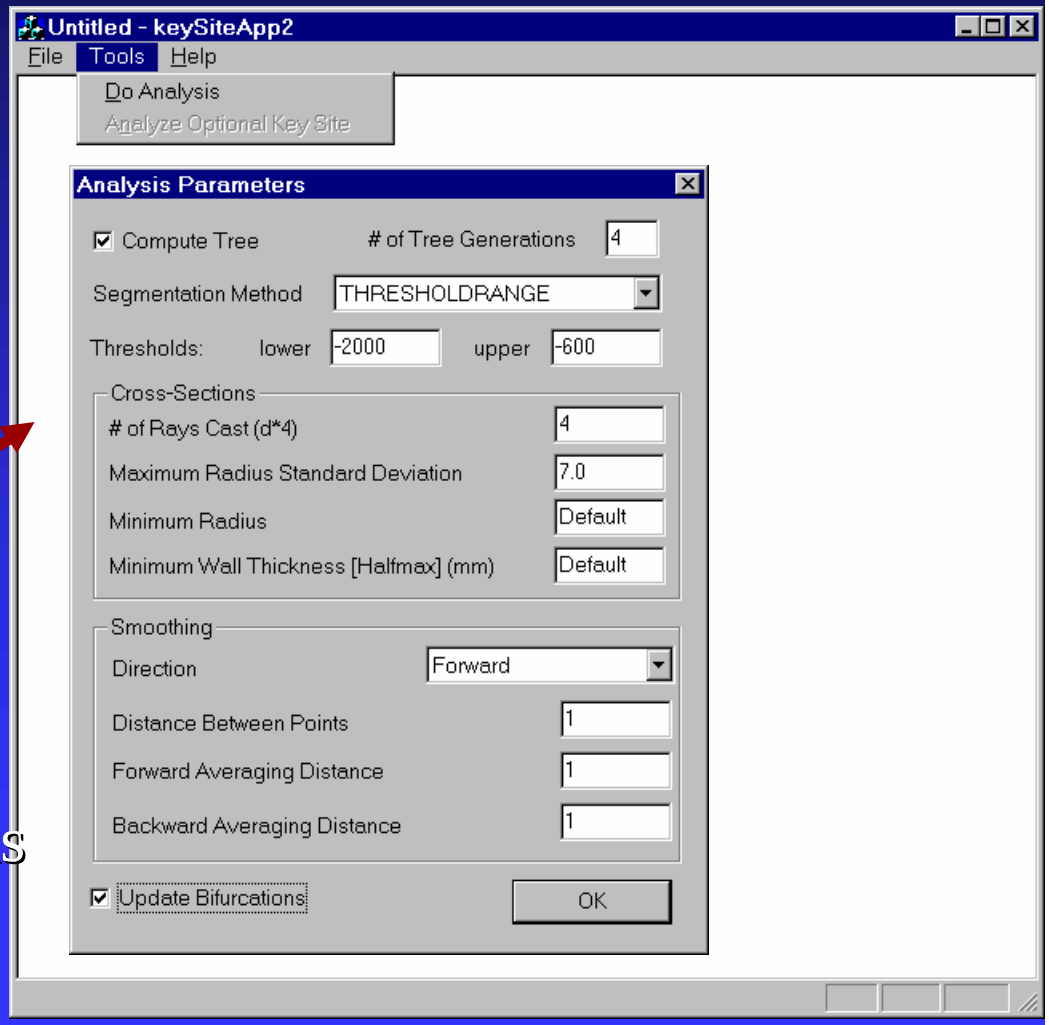
1. Create new *Case Study*.
2. Invoke Graphics tools.
3. **Identify Key Sites.**
4. Compute guidance data.
5. Build complete Case Study.

Set up data for Key sites and airway tree calculation.



# Stage 1 (CT Assessment)

1. Create new *Case Study*.
2. Invoke graphics tools.
3. Identify Key Sites.
4. **Compute guidance data.**
5. Build complete Case Study.

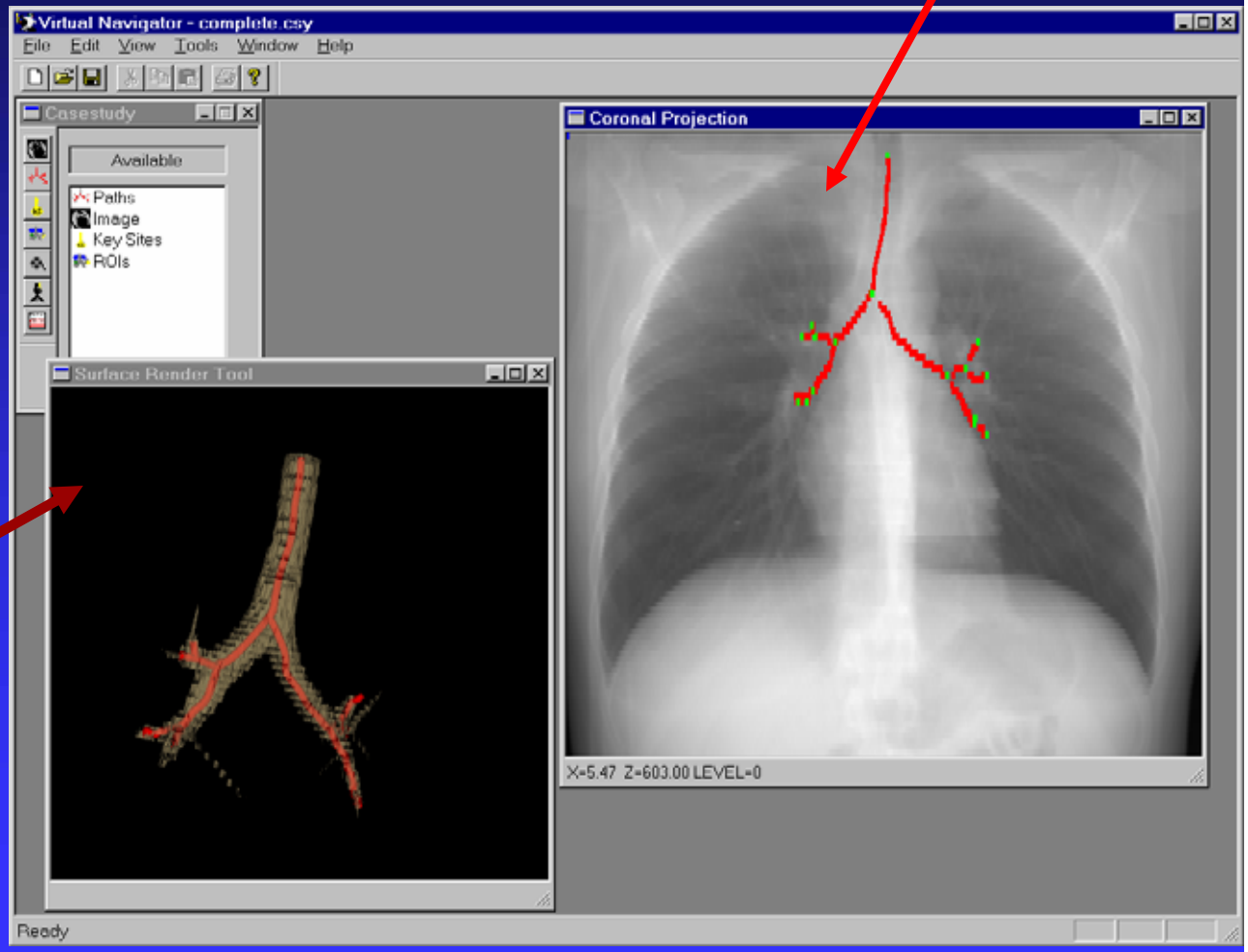



Invoke automated run to compute airway tree and paths to defined key sites.

# Stage 1 (CT Assessment)

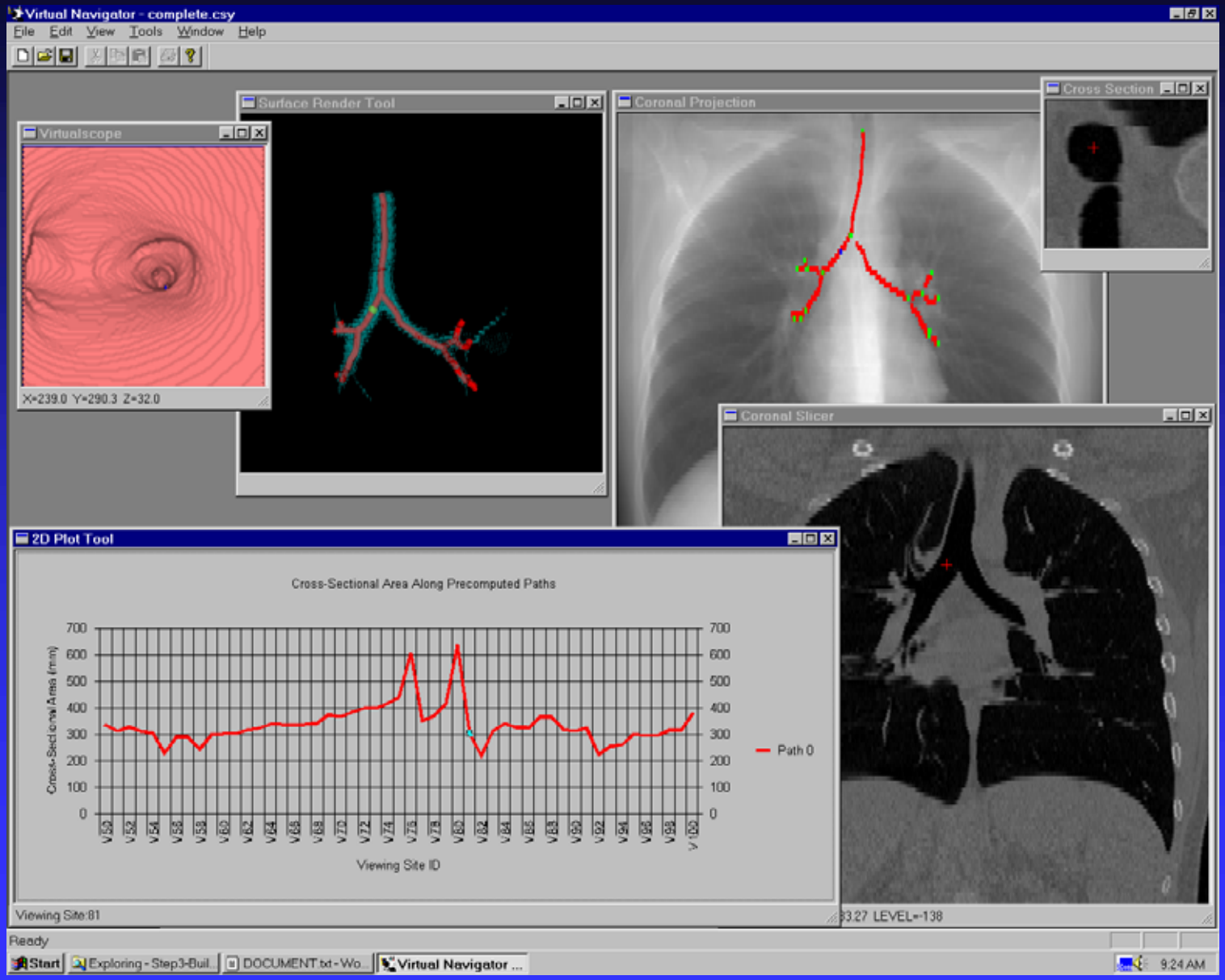
1. Create new *Case Study*.
2. Invoke graphics tools.
3. Identify Key Sites.
4. Compute guidance data.
5. **Build complete Case Study.**

Coronal weighted-sum projection showing extracted airway tree.

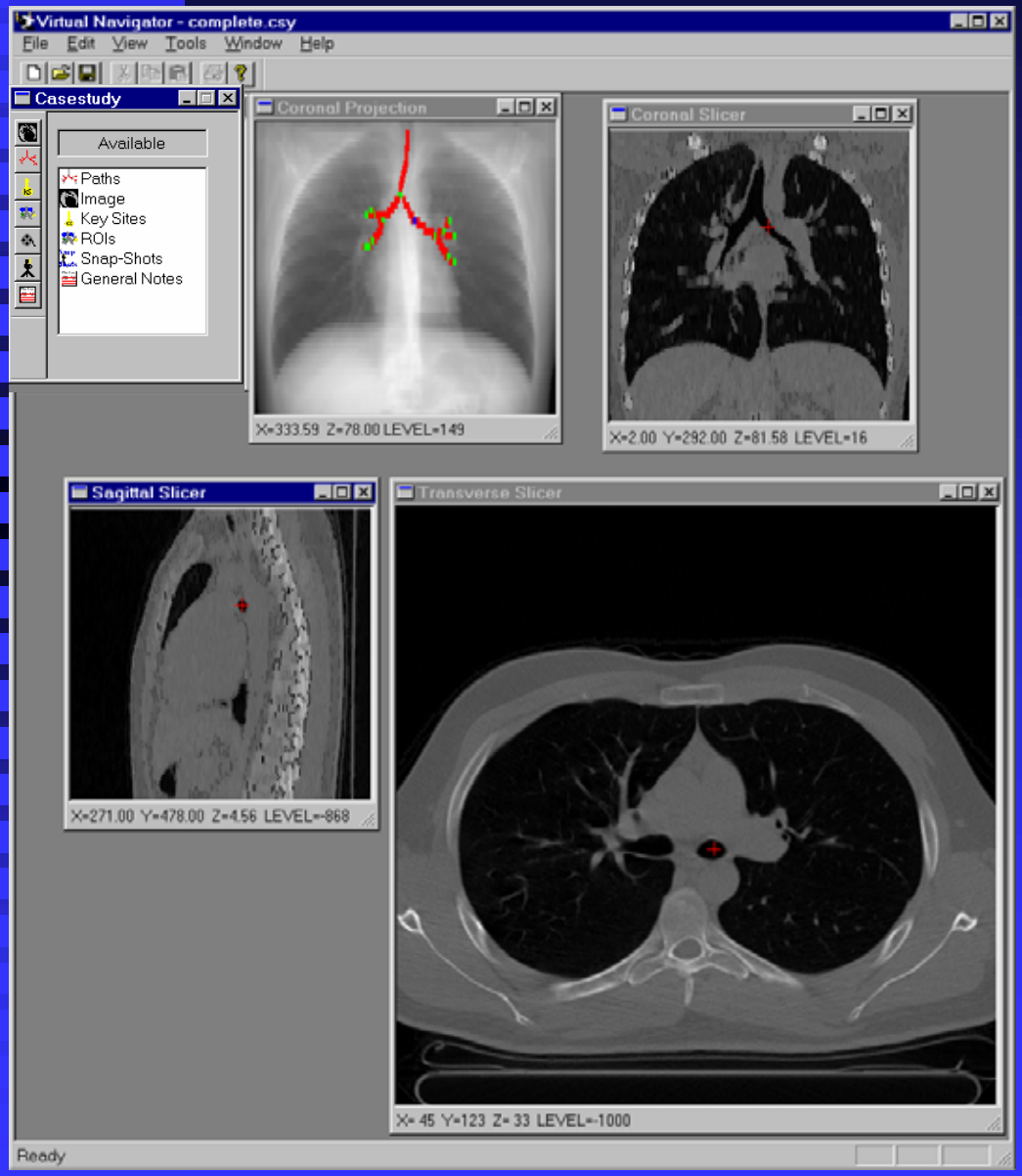


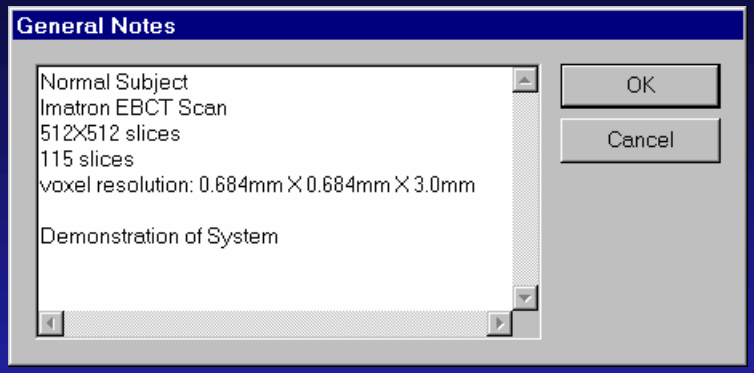

Rendered airway tree, with extracted paths through airways.

# Composite Case Study -- Part 1

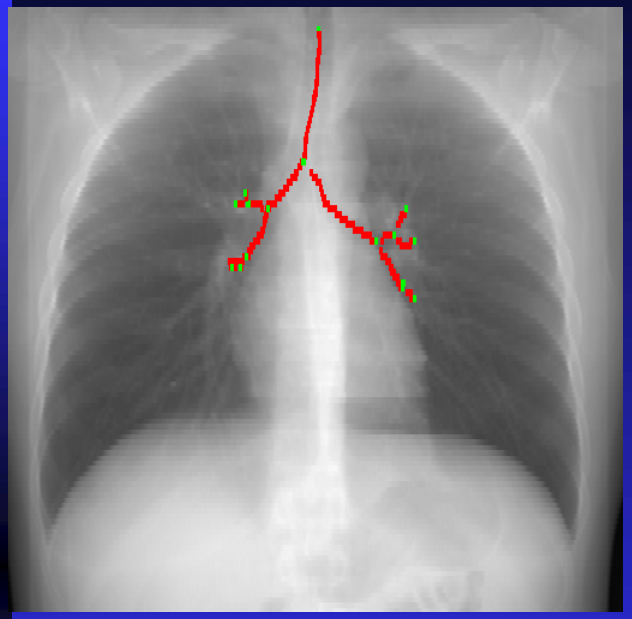


# Composite Case Study - part 2

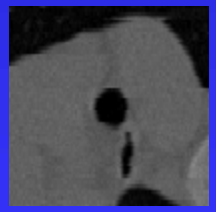


# Complete Case Study – Snapshots are saved.



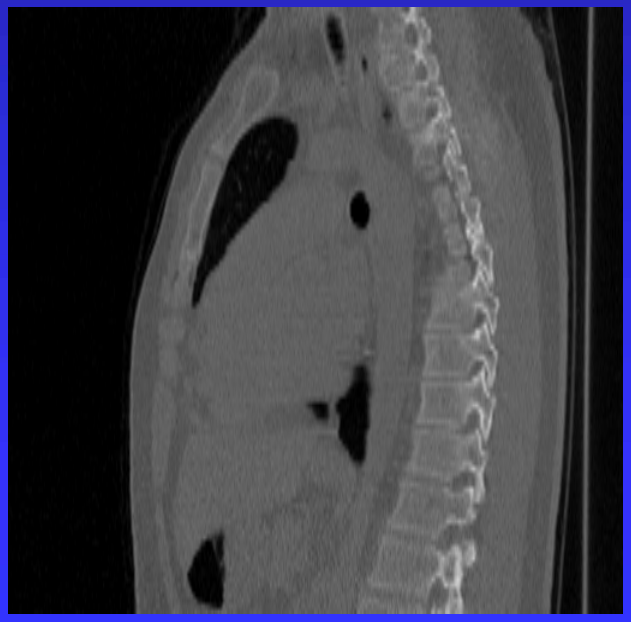
Coronal weighted-sum projection with extracted tree.



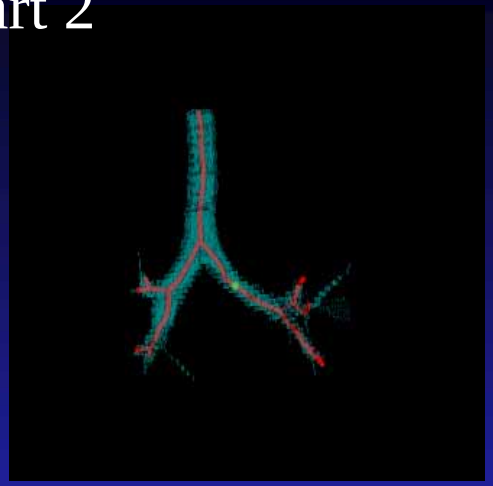
Oblique cross-section.

Coronal Slicer view.

Sagittal Slicer view.



# Complete Case Study - part 2

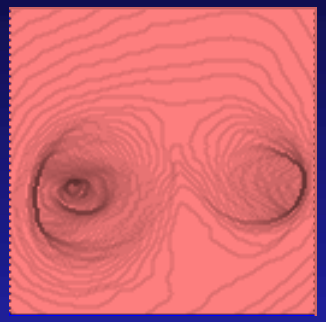


Rendered airway tree with extracted airway paths.

Transverse Sliding Thin Slab (STS) view.

Transverse slice image.

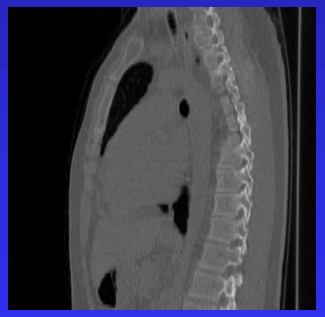
# **Viewable *Movie Sequences*** saved with final Case Study



Virtualscope

Tranverse Slicer

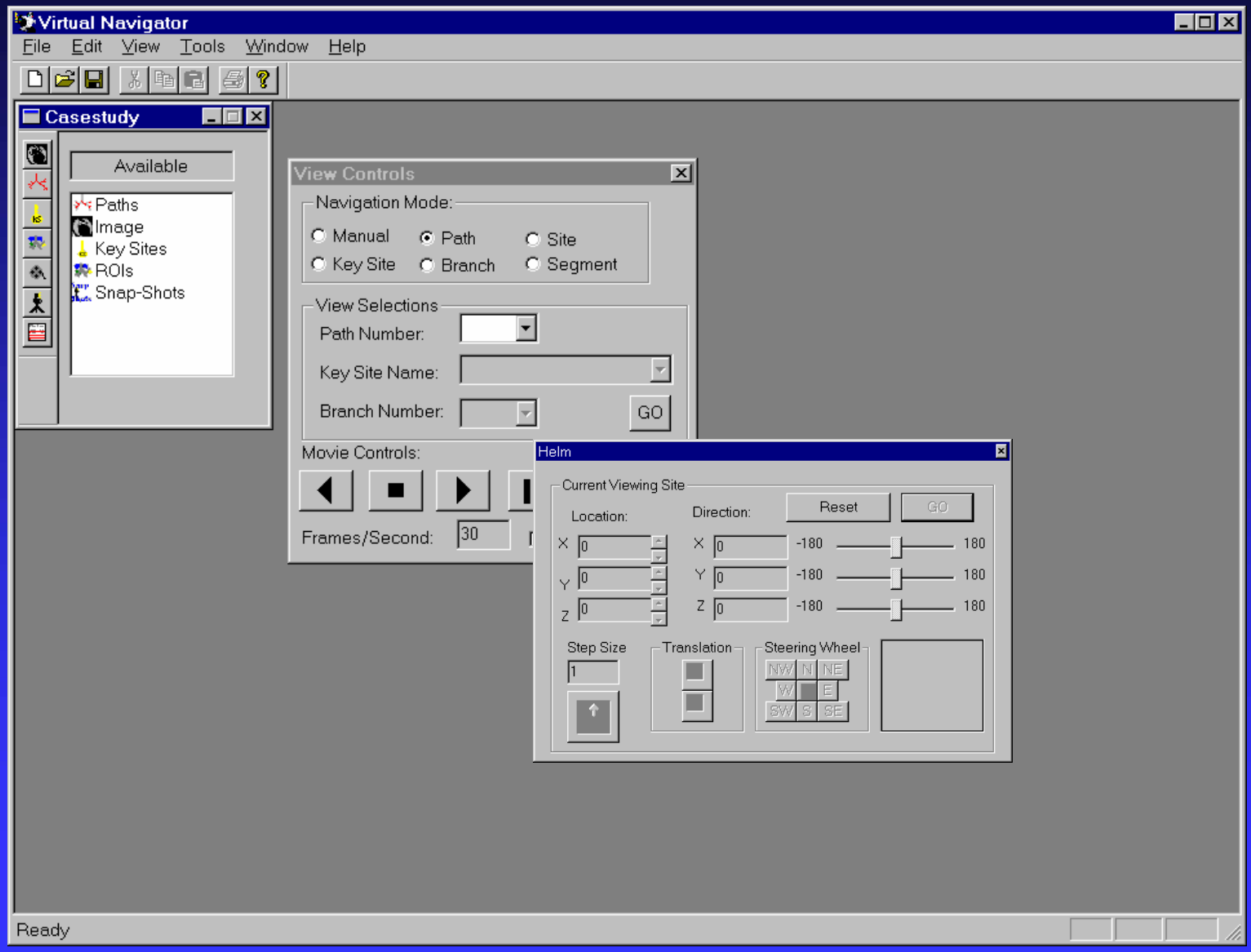
Oblique Cross-Section



Sagittal Slicer

Coronal Slicer

# Other Navigation Tools



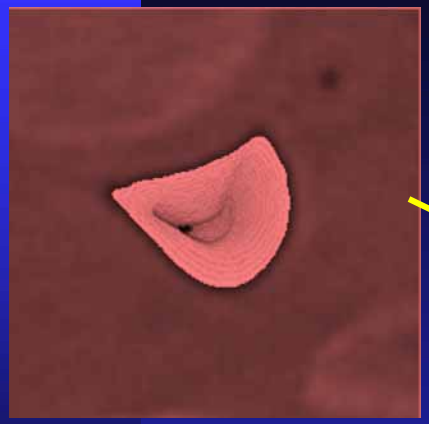
# Example 2: Pathology Case

- Patient suffering from tracheomalacia
- EBCT scan; 133 slices; 512x512 voxels/slice
- 1.5mm slice thickness
- 0.586mm axial-plane resolution

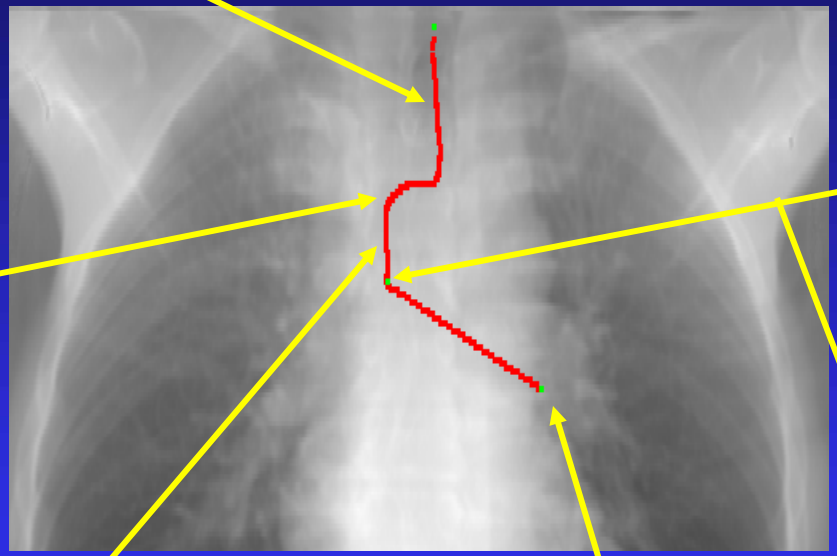
➢ Illustrates utility of a **Key Site**

# Ex #2: Coronal Weighted-Sum Projection showing computed path

Virtual endoscopic renderings shown for selected sites.



Site #20 approaching tracheal collapse

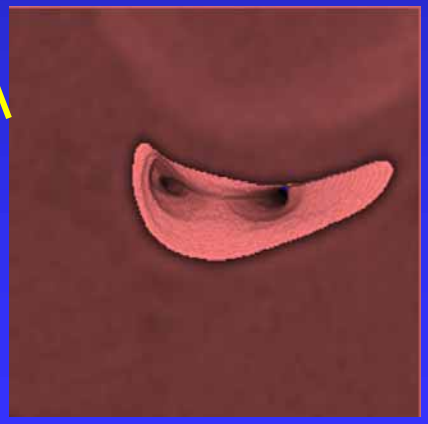


Looking back toward tracheal collapse from site #99

Site #56 within tracheal collapse

Site #86 leaving trachea

**Preselected *Key Site* used to initiate path.**

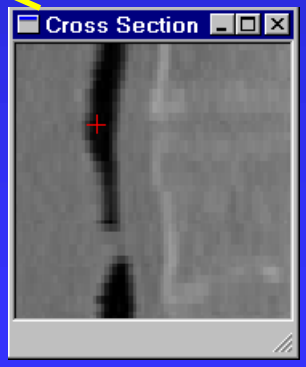


Site #99 near carina

# Example 2: Plot of Airway Cross-Sectional Area along Path


Oblique Cross-Section at site #18, near tracheal collapse.

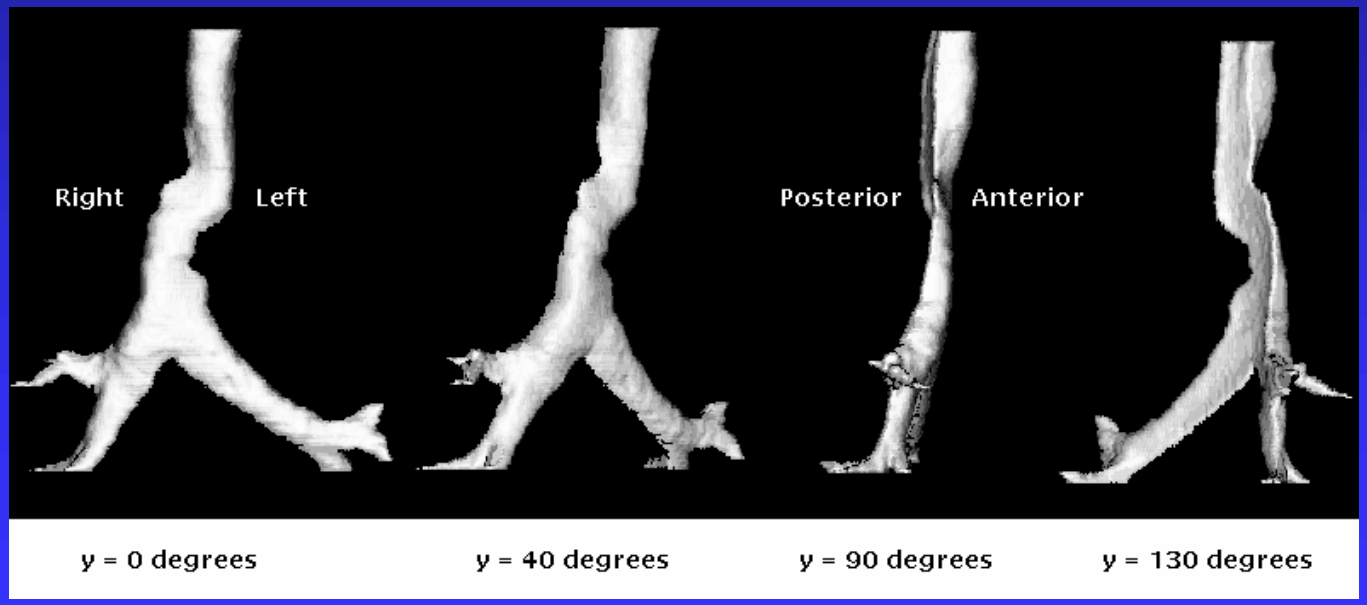

Oblique Cross-Section at site #48, within tracheal collapse.




***Plot clearly shows drop in cross-section where blockage occurs.***

# Example 2: Captured Snapshots of Pathology

Coronal Slicer snapshot clearly shows pathology.



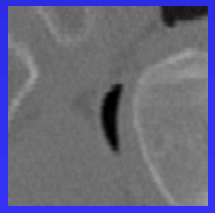

Renderings of Airway tree clearly show pathology.

## **Example 2:** ***Movie Sequences*** saved with Case Study

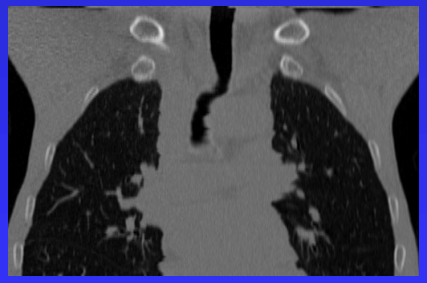
Vertically Oriented Cross-Section

Transverse STS-Max

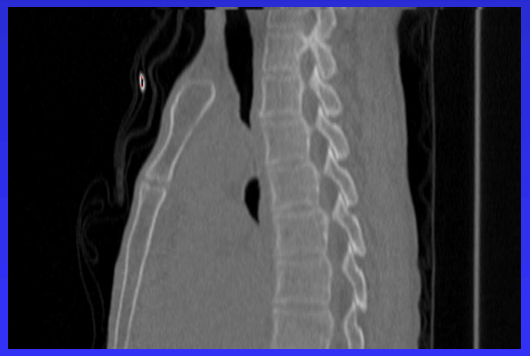
Virtualscope



Orthogonal Cross-Section



Coronal Slicer



Sagittal Slicer

# III. Complete CT-Video: progress

- **Virtually guided bronchoscopy**

1. **Overview**
2. **Mutual information algorithm**
3. **Test results: bronchoscopy training device**

# Application to TBNA (needle biopsy)

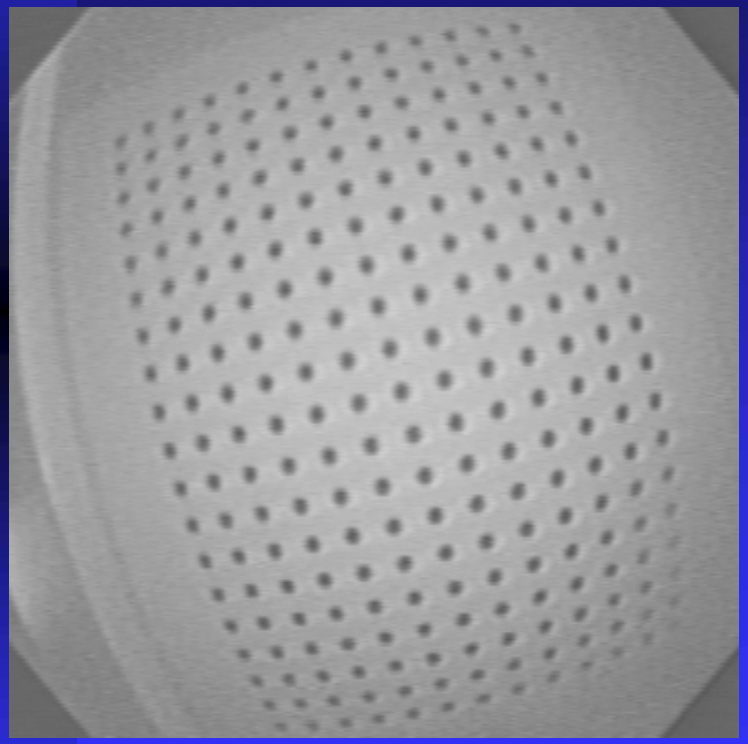
- TBNA -- blind procedure for sampling tissue
- Use VB-generated path:
  - »bronchoscopist sees more, maintains orientation
- Matched video with rendered 3D CT scan
  - »identify target areas for biopsy

# CT-Video Matching: mutual-information algorithm

- Match rendered endoluminal CT view to video.
- Normalized Mutual Information Criteria
  - Studholme, IEEE TMI, Jan 1999
- Rendered Images with Graphical Accelerator
  - Hata, Lect. Notes in Comp. Sci., vol. 1131
- Steepest decent optimization.

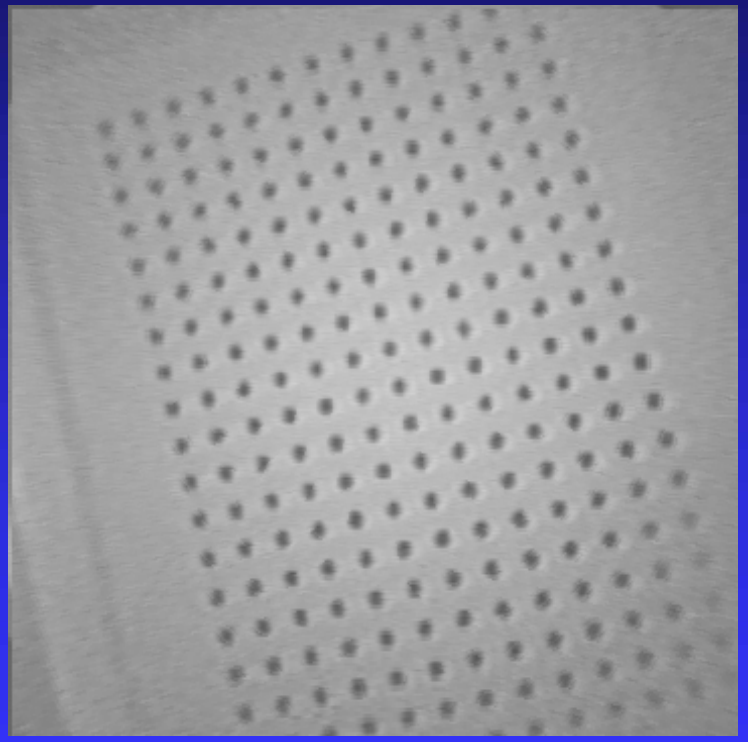
# Barrel-Distortion Correction of Bronchoscopic Video

Necessary for proper registration of video to rendered CT



Before correction

(video frame of a test pattern)



After correction

*See Zhang, ICIP2000

# Registration of Rendered 3D CT & Bronchoscopic Video

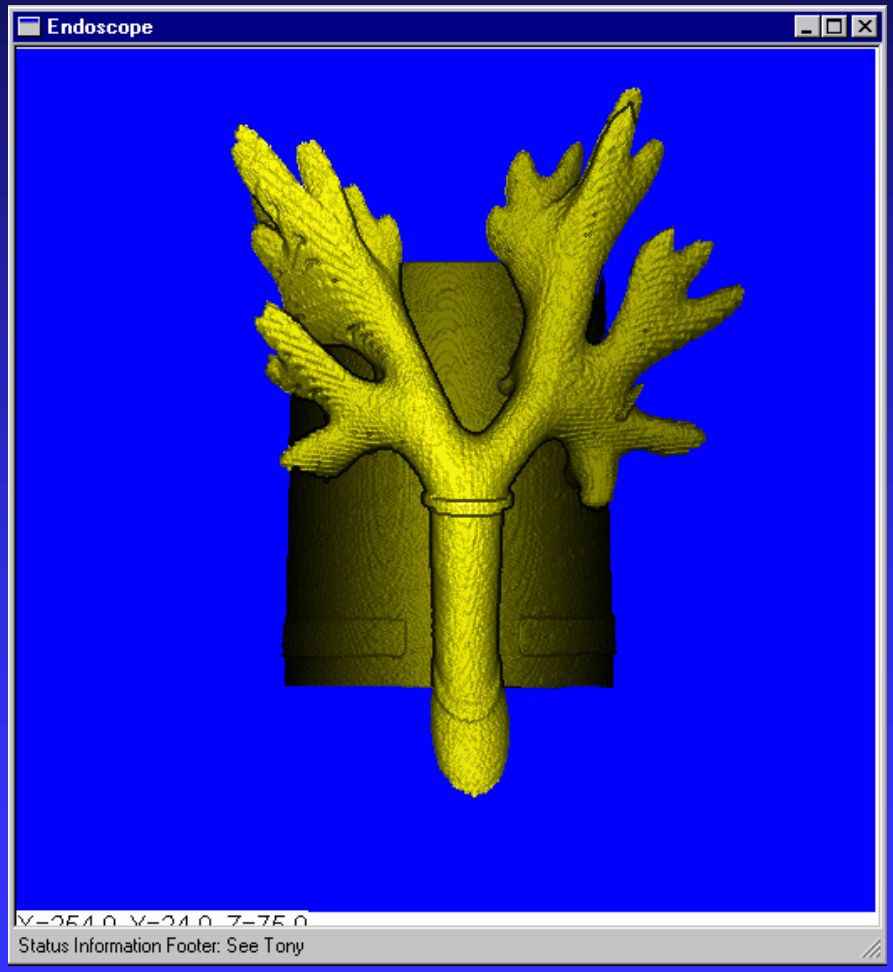
1. Use bronchoscopy training device.

2. Collect high-resolution EBCT scan.

3. “Perform” bronchoscopy on device

   → collect video

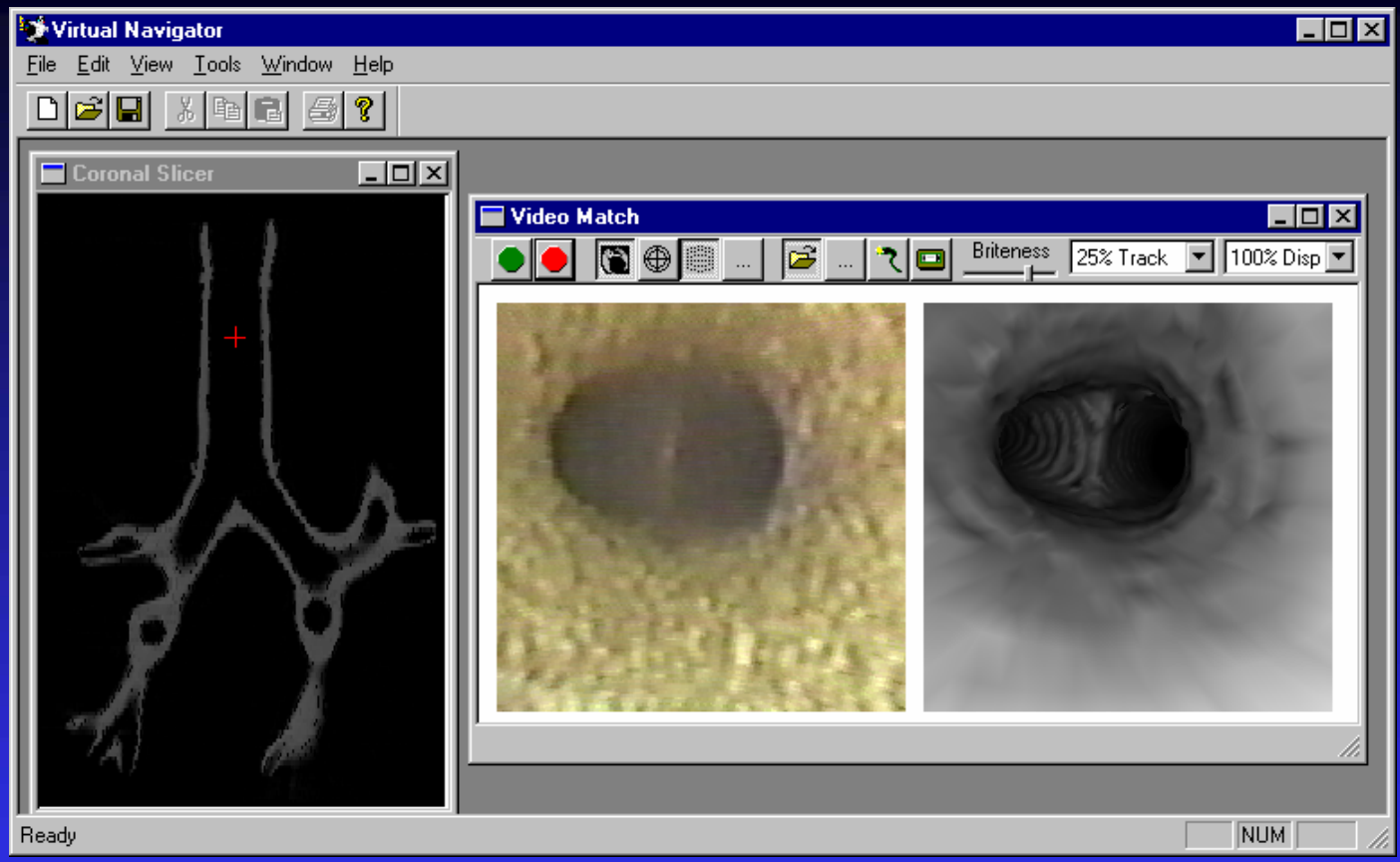
# Bronchoscopy Training Device




- *3D CT image rendered*

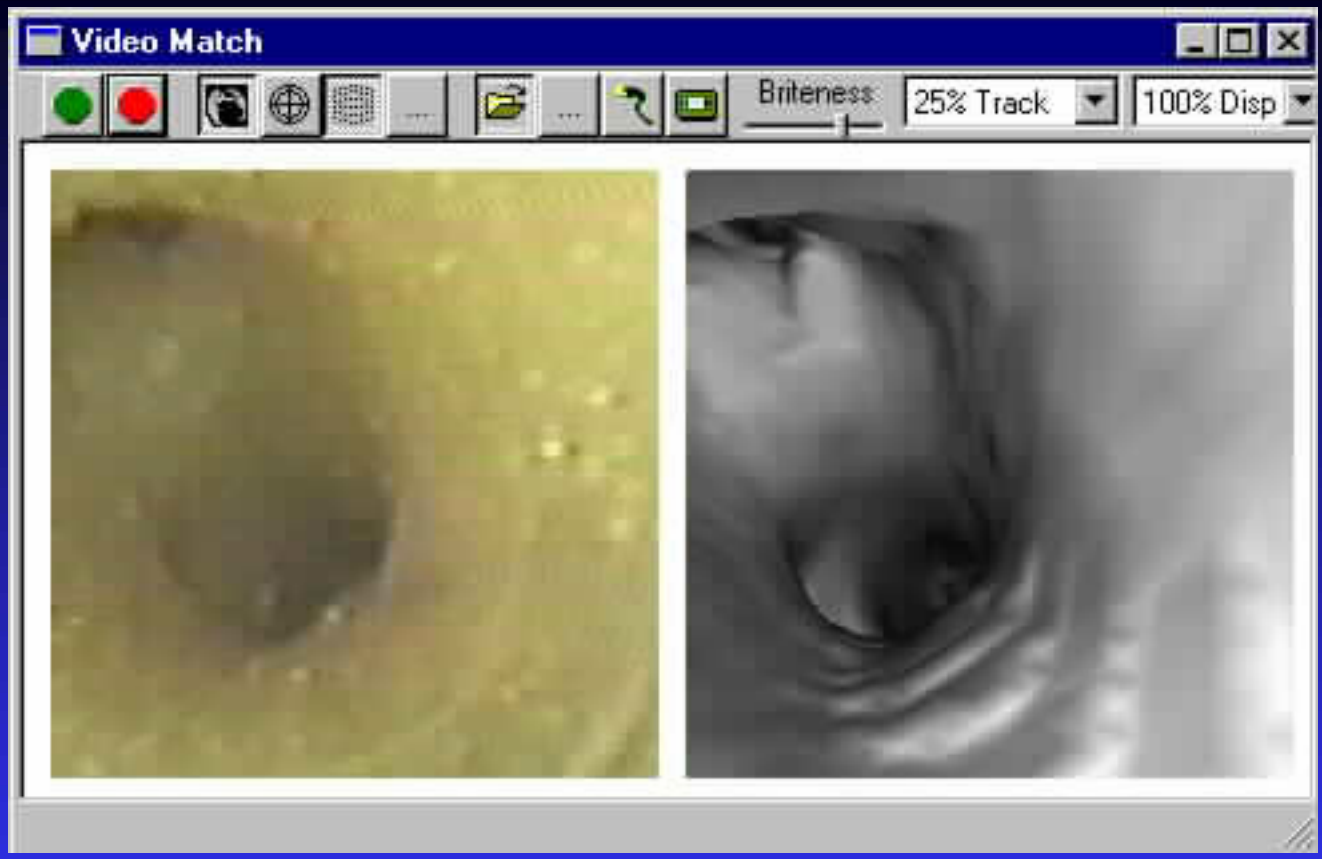
## *Initial Point:*

## *Registration near Carina*




- Initial point chosen in virtual 3D-CT world.
- Bronchoscope moved in “live” world to point.
- Optimal viewpoint calculated using mutual information.

# *Registration in Left Bronchus*




- *Bronch video frame*
- *Matching rendered CT view*

# Future Work

- Design specific VB-based protocols:
  lymph-node location, stent design

- Combine CT-based analysis with video during live bronchoscopic procedures.

# Other SPIE Talks

- 5:30 tonight -- California Room
  - "Place of Virtual Bronchoscopy in Clinical Practice:  Barriers and Solutions"
- 1:20 today -- *Image Display* conference
  - "New Techniques for Fast Sliding Thin-Slab Volume Visualization" by J. Turlington