



IBM Almaden Research Center

# miAnnotation: An Open Source Software Tool for Annotating Medical Images

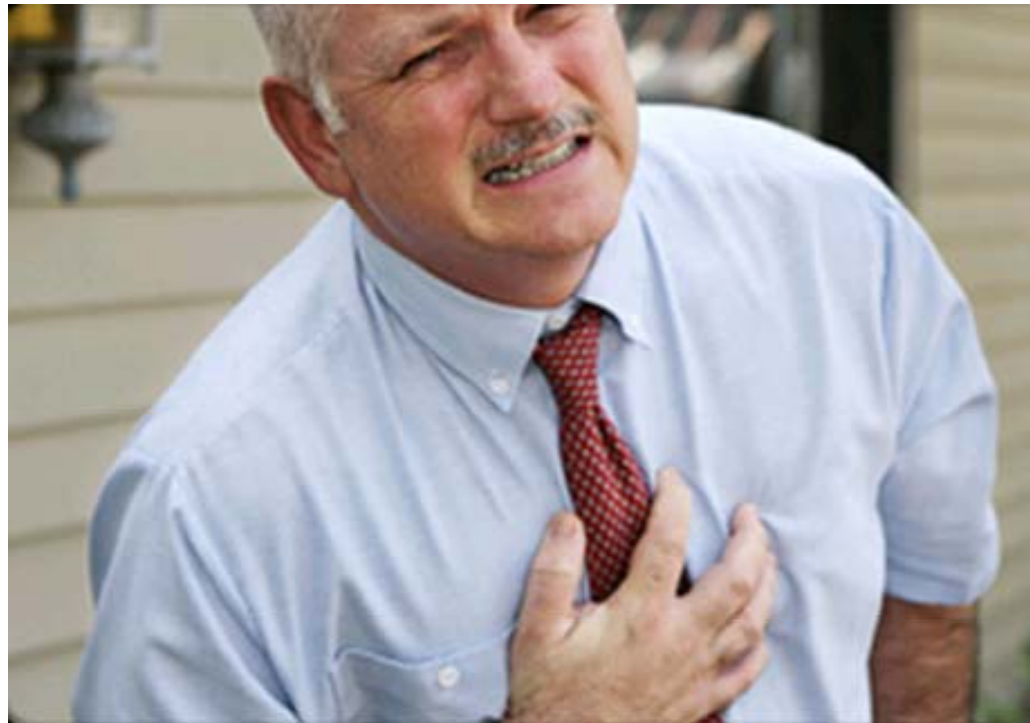
Kilian Pohl & Yong Zhang

May 2010





# Symptom



70 Years Old, Chest Pain

<http://www.medicinenet.com/>



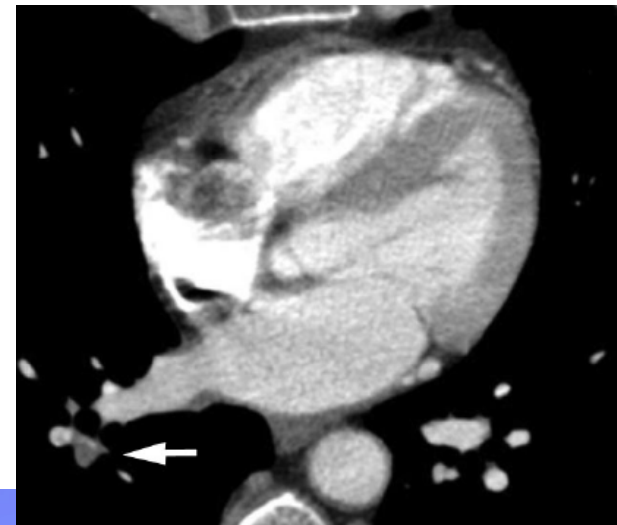
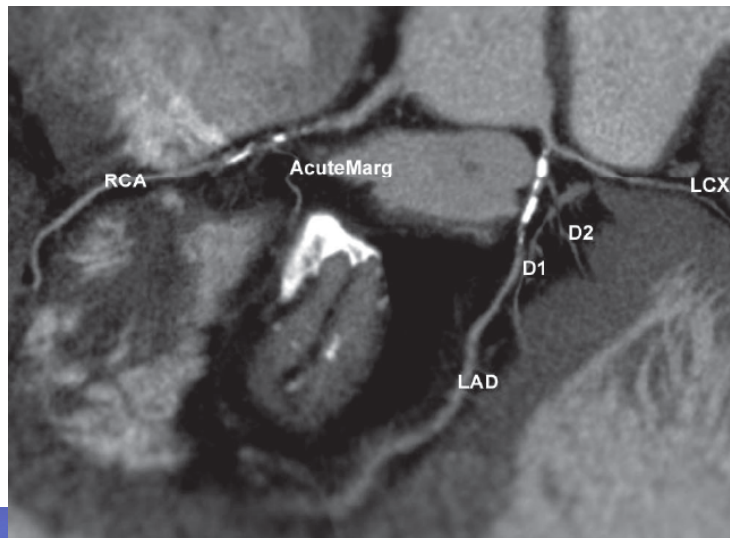
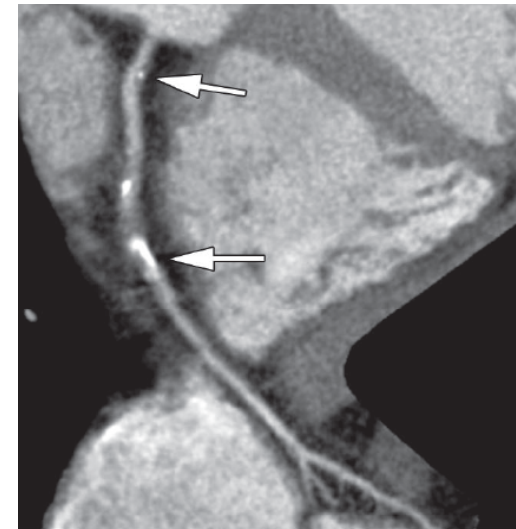
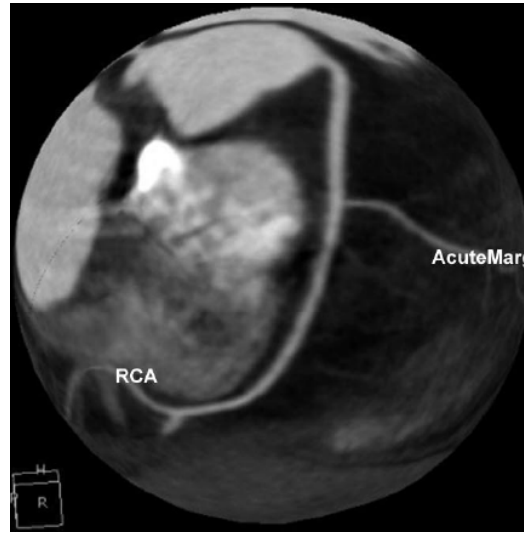
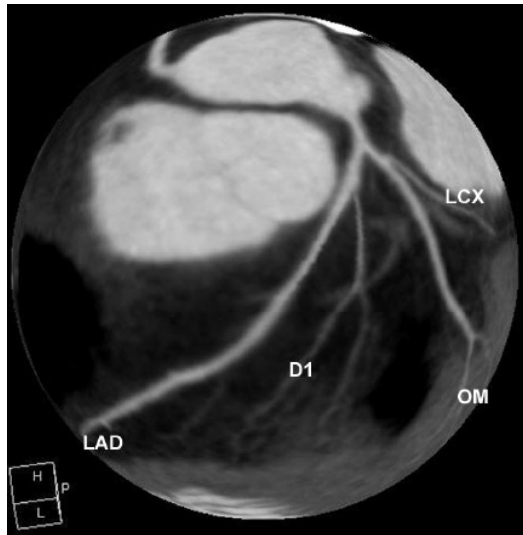
## Diagnosing Patients



<http://www.medicinenet.com/>



# CT Angiography Images





## Disease Detection

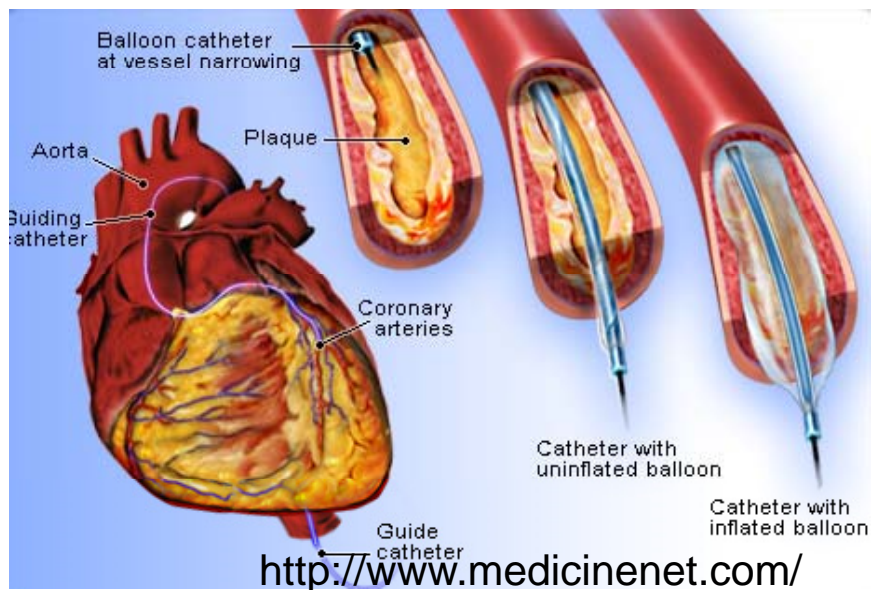
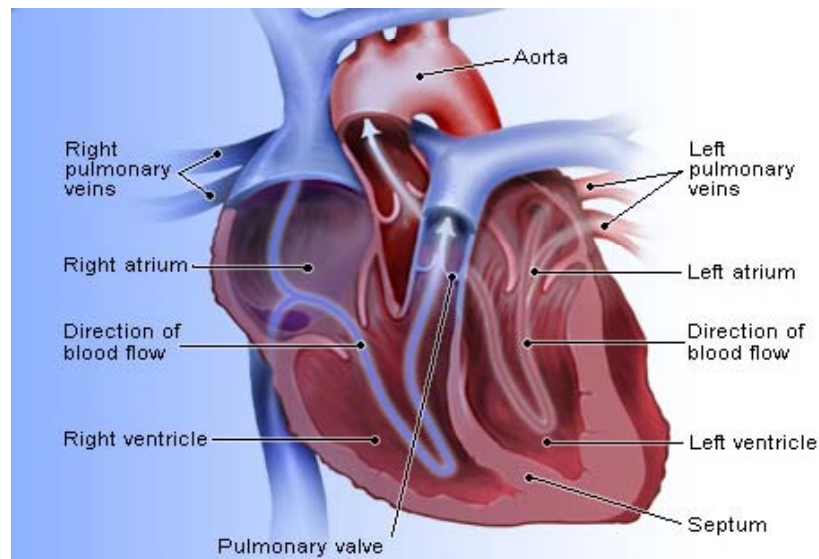


more objective and effective



## The Question

- To improve diagnosis and treatment, images need to be properly annotated and important features need to be measured.
- The question is: *what is the best way to do that?*





## Goal

Received a subcontract by Harvard Medical School funded through the NIH (ARRA Supplement to P41RR013218 ) to develop an annotation tool for medical images that is

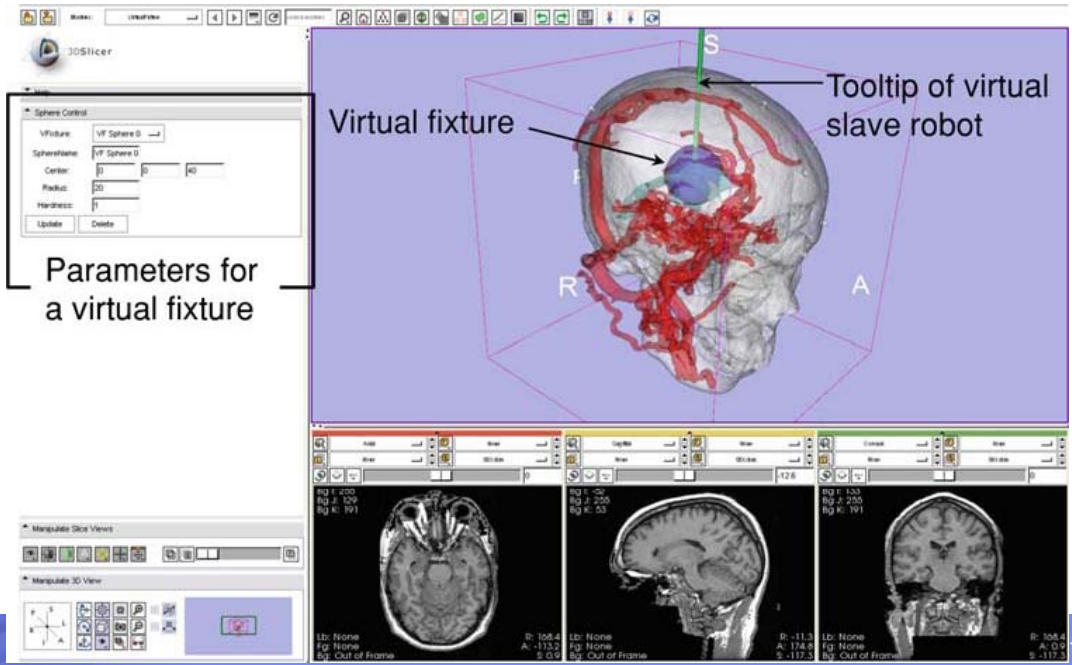
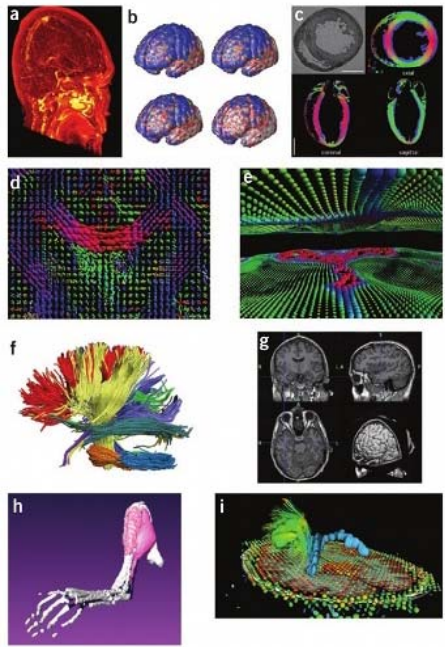
- Free open source
- Platform independent
- Functionality similar to commercial systems





# 3D Slicer

- a multi-platform, free open source software for exploring novel *image analysis* and *visualization* techniques.
- consists of more than over a million lines of code, mostly C++, 250 active developer, 5K downloads in 2009.
- has extensive *algorithmic* and visualization functionality.
- a research platform and NOT FDA approved.

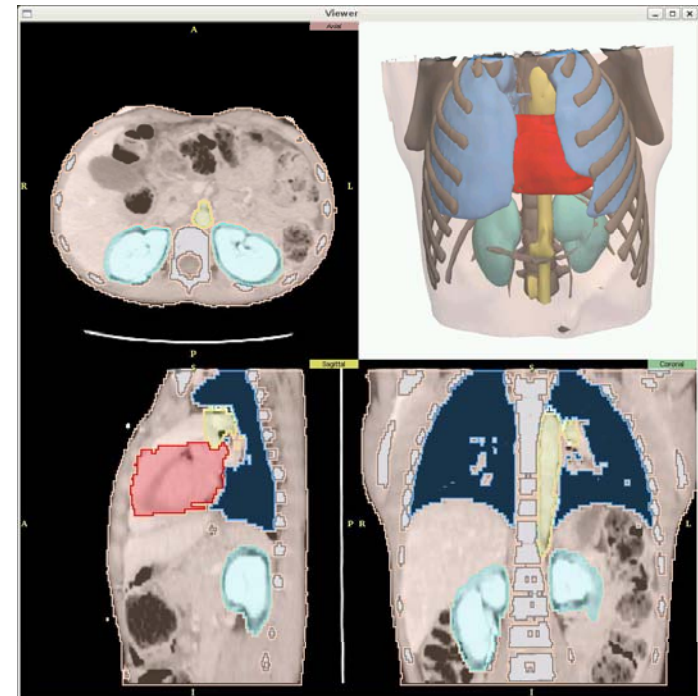






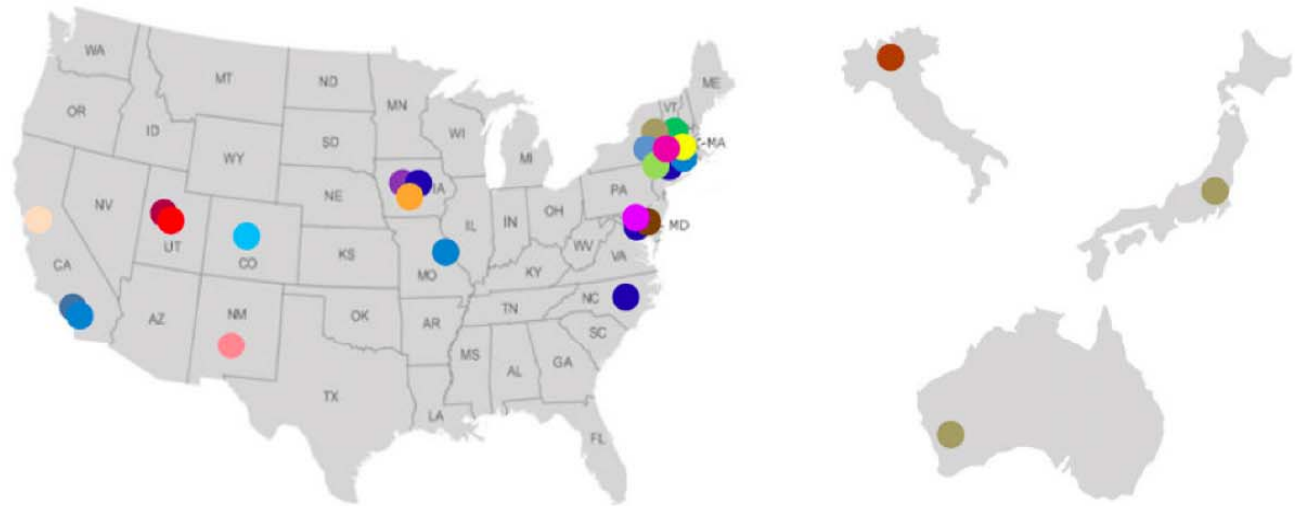
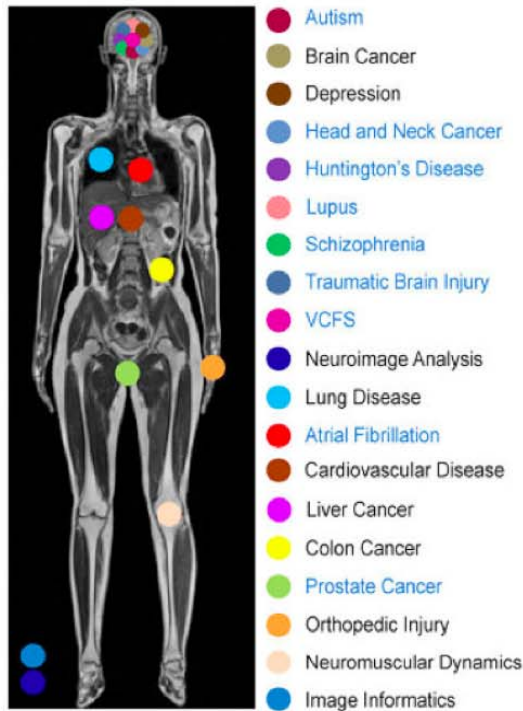
## Slicer Features

Visualization  
Filtering  
Registration  
Segmentation  
DTI  
Quantification  
Real-time Integration





# Core Slicer Contributors



## Active

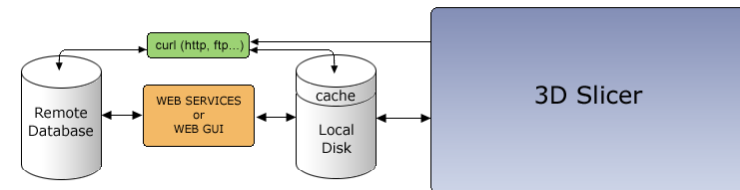
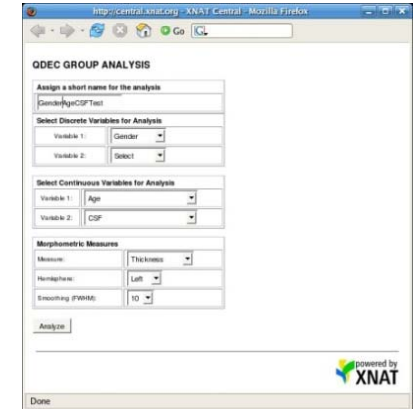
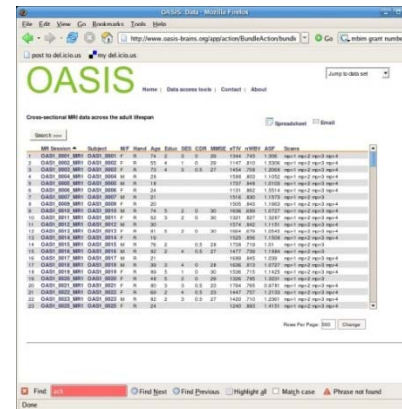
- |                                      |                                 |                                     |                                 |  |                                 |                                      |                                 |                                 |
|--------------------------------------|---------------------------------|-------------------------------------|---------------------------------|--|---------------------------------|--------------------------------------|---------------------------------|---------------------------------|
| ● R01MH084795 <a href="#">↗</a>      | ● U41RR019703 <a href="#">↗</a> | ● NSF CCF-0916526 <a href="#">↗</a> | ● R01EB008171 <a href="#">↗</a> | ● U01HL089897 <a href="#">↗</a>                  | ● R01CA124377 <a href="#">↗</a> | ● R01CA131718 <a href="#">↗</a>      | ● R01CA111288 <a href="#">↗</a> | ● R01EB005973 <a href="#">↗</a> |
| ● U54EB005149-05S2 <a href="#">↗</a> | ● U54GM072970 <a href="#">↗</a> | ● P41RR013218 <a href="#">↗</a>     | ● R01EB006733 <a href="#">↗</a> | ● R01NS050568 <a href="#">↗</a>                  | ● R01EB009900 <a href="#">↗</a> | ● U54EB005149-05S3 <a href="#">↗</a> | ● UL1RR025758 <a href="#">↗</a> | ● U54LM008748 <a href="#">↗</a> |
| ● U24RR025736 <a href="#">↗</a>      | ● U24RR021992 <a href="#">↗</a> | ● U24RR021382 <a href="#">↗</a>     | ● U24RR026057 <a href="#">↗</a> | ● Mario Negri Institute, Italy <a href="#">↗</a> | ● AIST, Japan <a href="#">↗</a> | ● UWA, Australia <a href="#">↗</a>   |                                 |                                 |





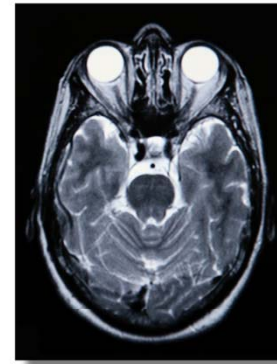
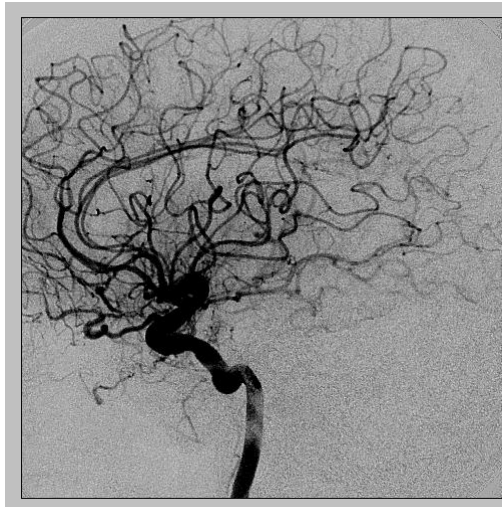
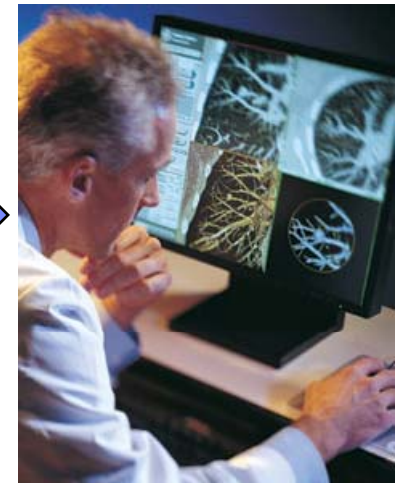
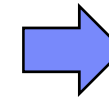
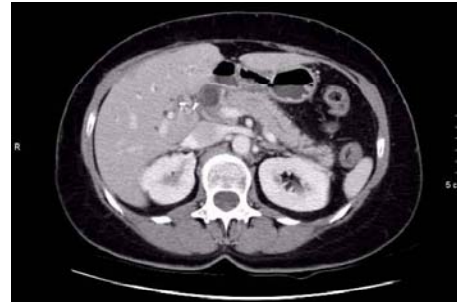
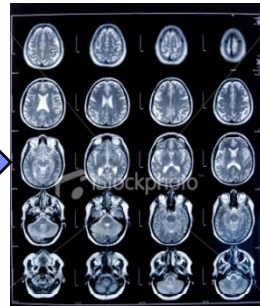
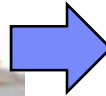
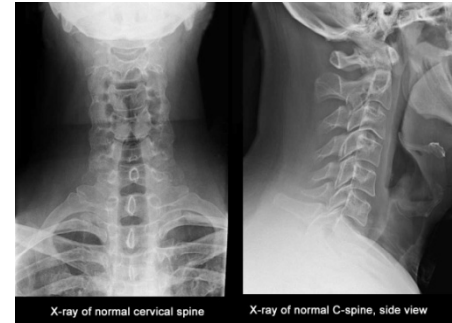
# Informatics Implementation

- Remote I/O in MRML Lib
  - All Data is Loadable from URL
    - Models, Volumes, Transforms...
    - Scenes
  - All Storable Data can be Pushed to Web Services
    - XNAT, HTTP...
- FetchMI Module
  - Tagging, Searching
  - XNAT Web Services
- Created Under mBIRN, Clinically Applied via Harvard Catalyst CTSC





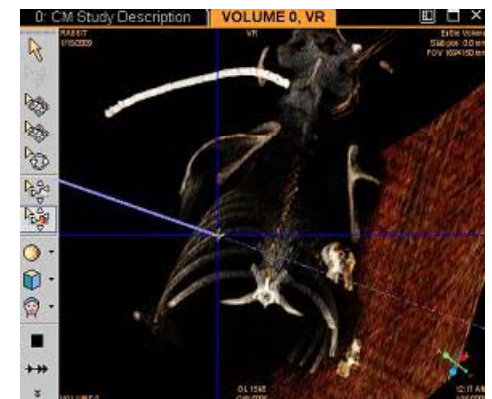
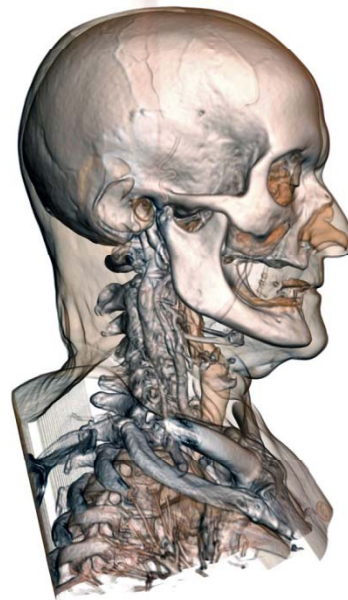
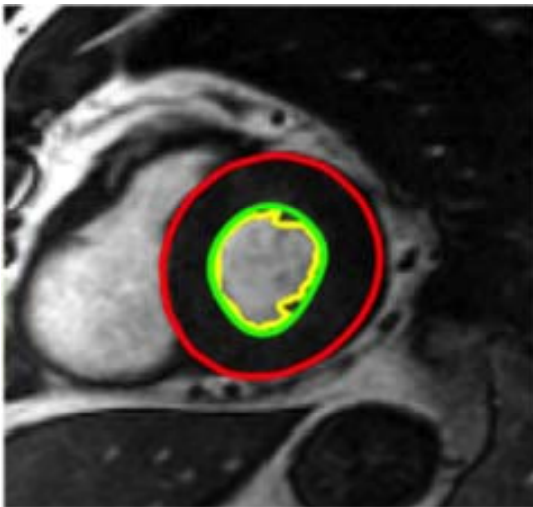
# Medical Images





## Medical Image Analysis - increase the efficiency and accuracy of radiologists and clinicians, thus improve healthcare

- Automated or Semi-automated analysis of n-dimensional medical images.
- Visualization, *annotation*, and interaction with n-dimensional medical images.
- Image Guided Diagnosis and Therapy.

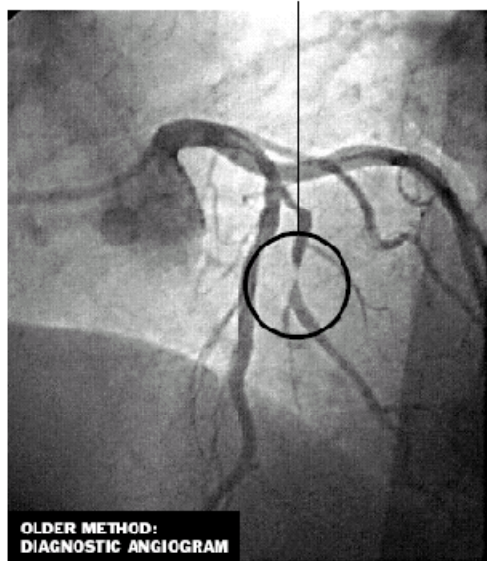




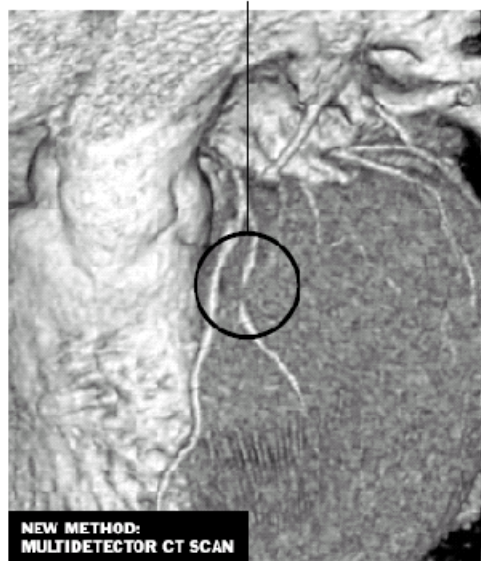
# Medical Image Annotation - Daily Clinical Practice

- to capture information latent in the scans.
- to support efficient storage in modern databases.
- to enhance communication between experts.

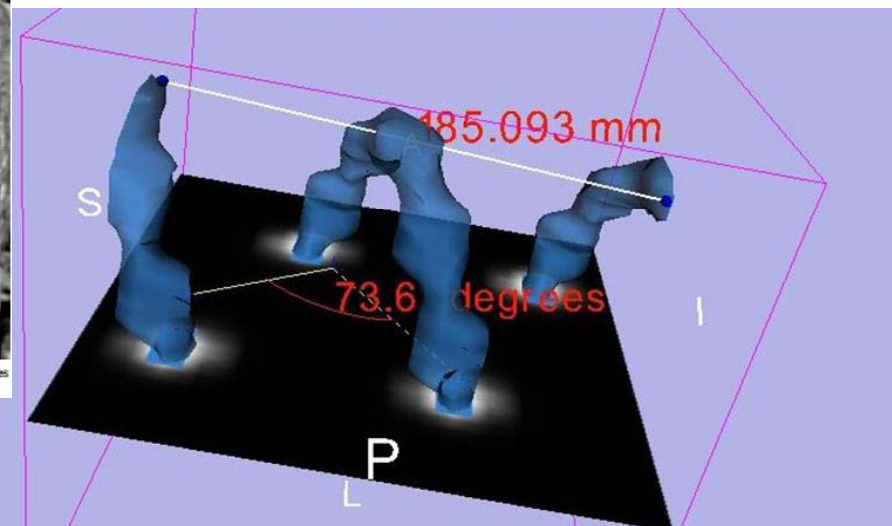
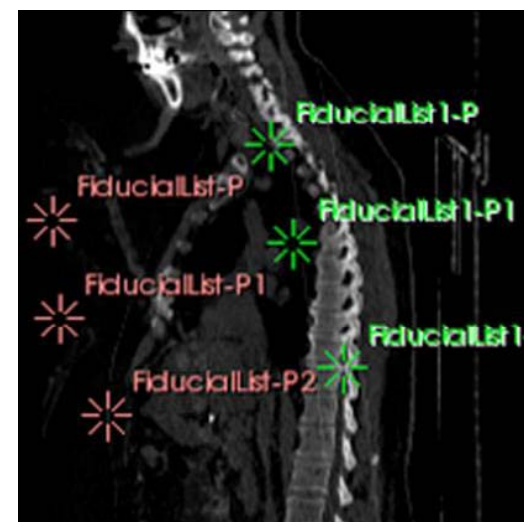
A stenosis, or mostly blocked coronary artery, from images taken of the same patient.



Source: Dr. Mario J. Garcia, Cleveland Clinic



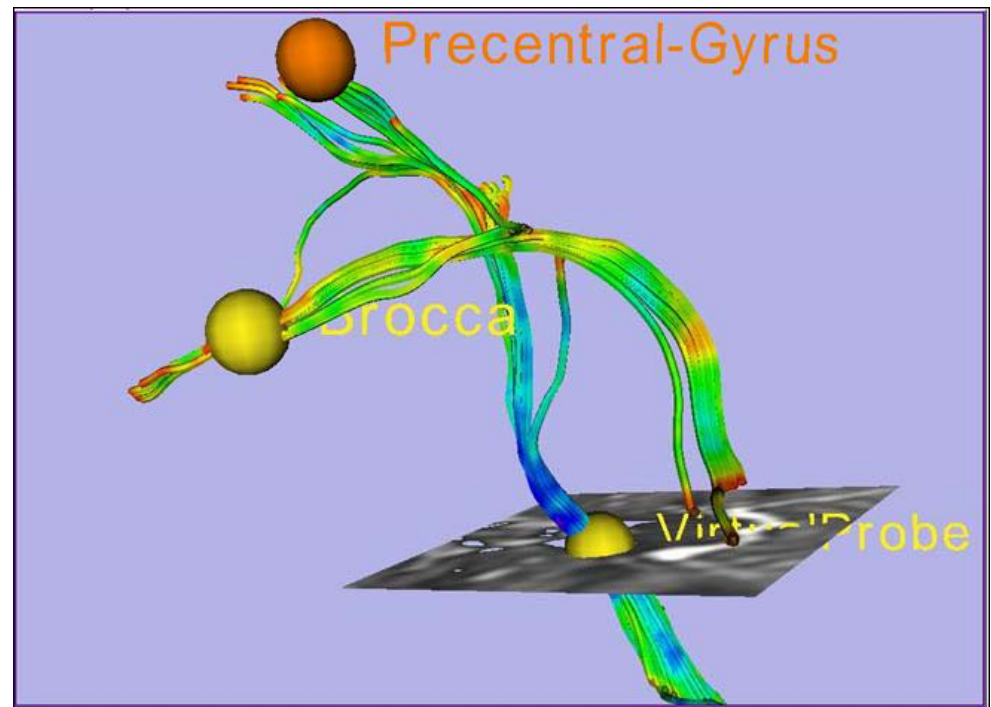
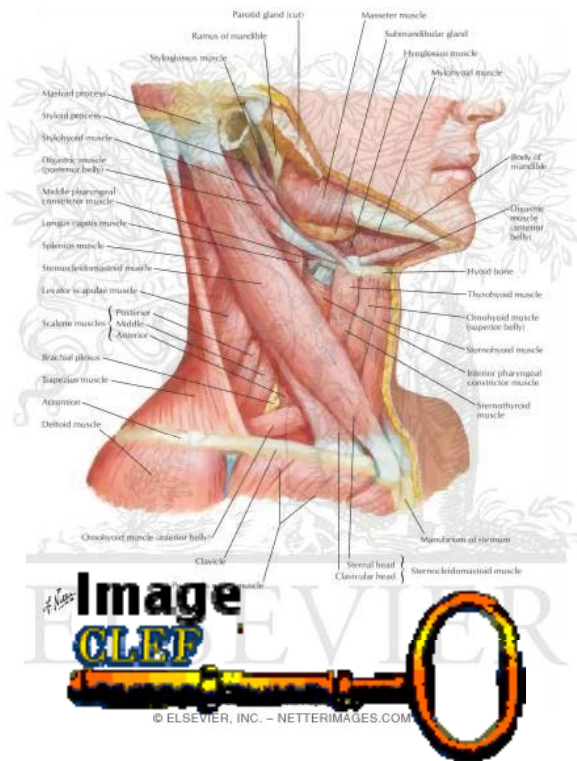
The New York Times





# Medical Image Annotation - Biomedical Research

- to design ontology and semantic-based annotation techniques for information retrieval.
- To reduce the wealth of information latent in the scans to more explicit features useful in clinical decision-making.







## Current Annotation Tools – Vendors Medical Scanners

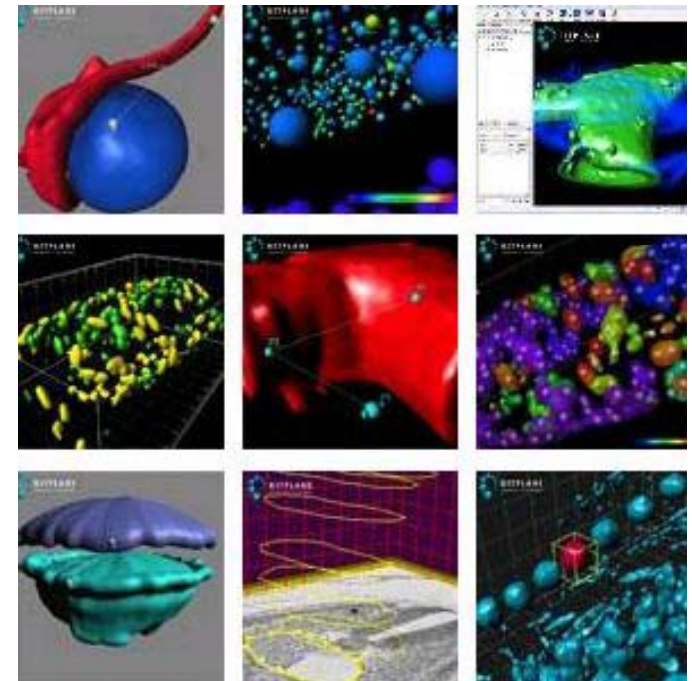
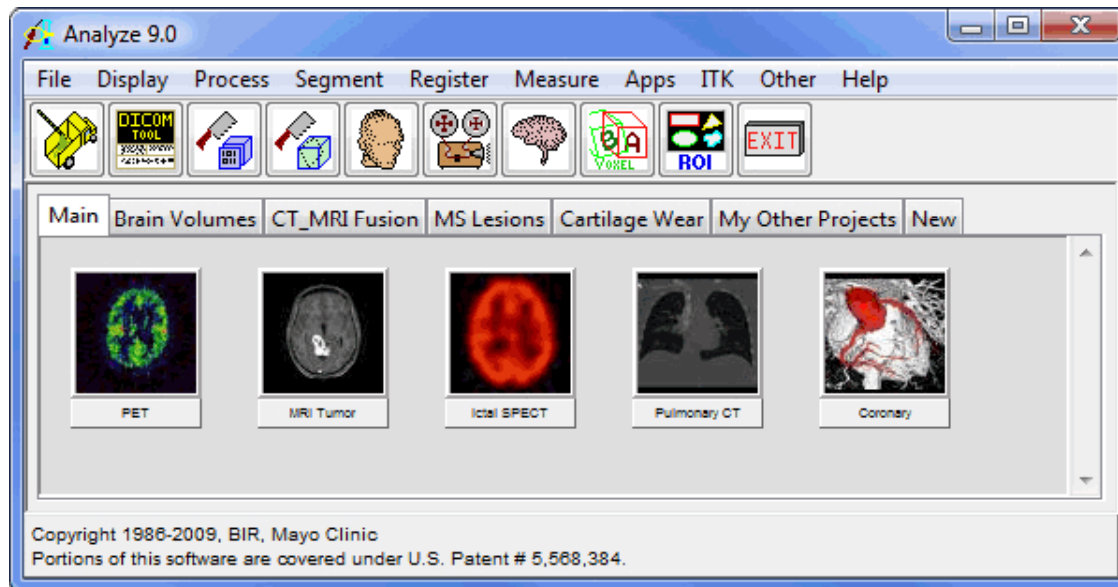
- Only tuned to the specific medical imaging workstations.
- Not trivial to compare annotation by different workstations.
- Not simple to share the annotation.





## Current Annotation Tools – Non Vendors Software

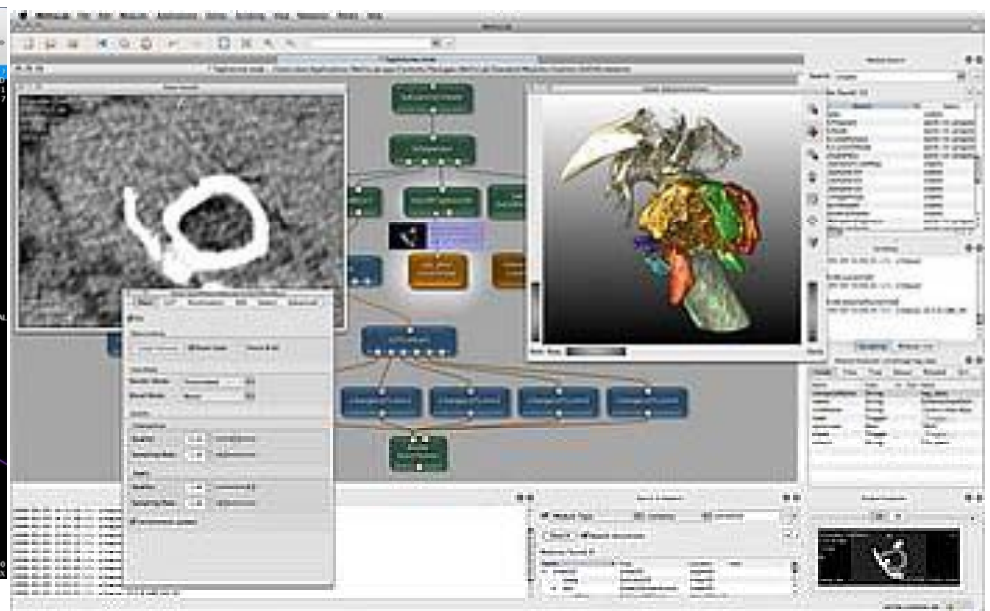
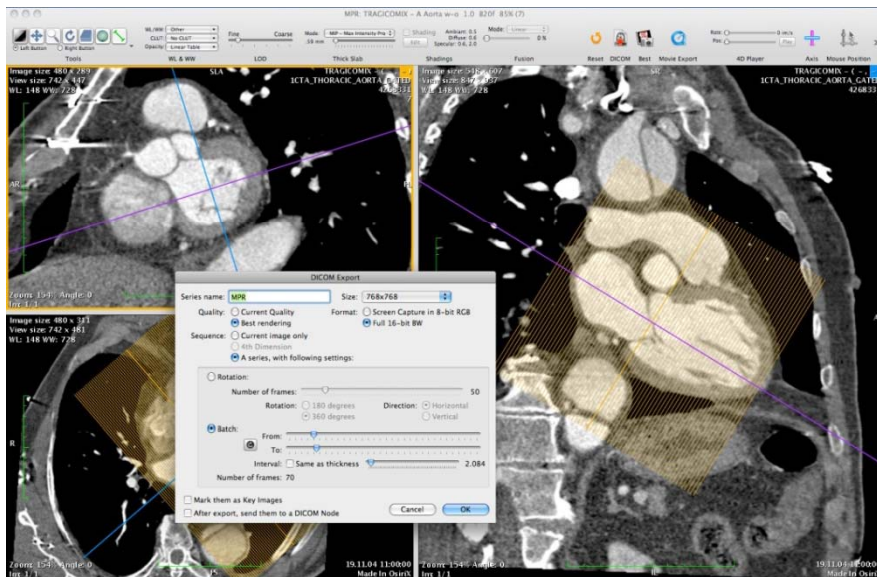
- provide more flexibility.
- the source code is not publicly available.





# Current Annotation Tools – Open Source Software

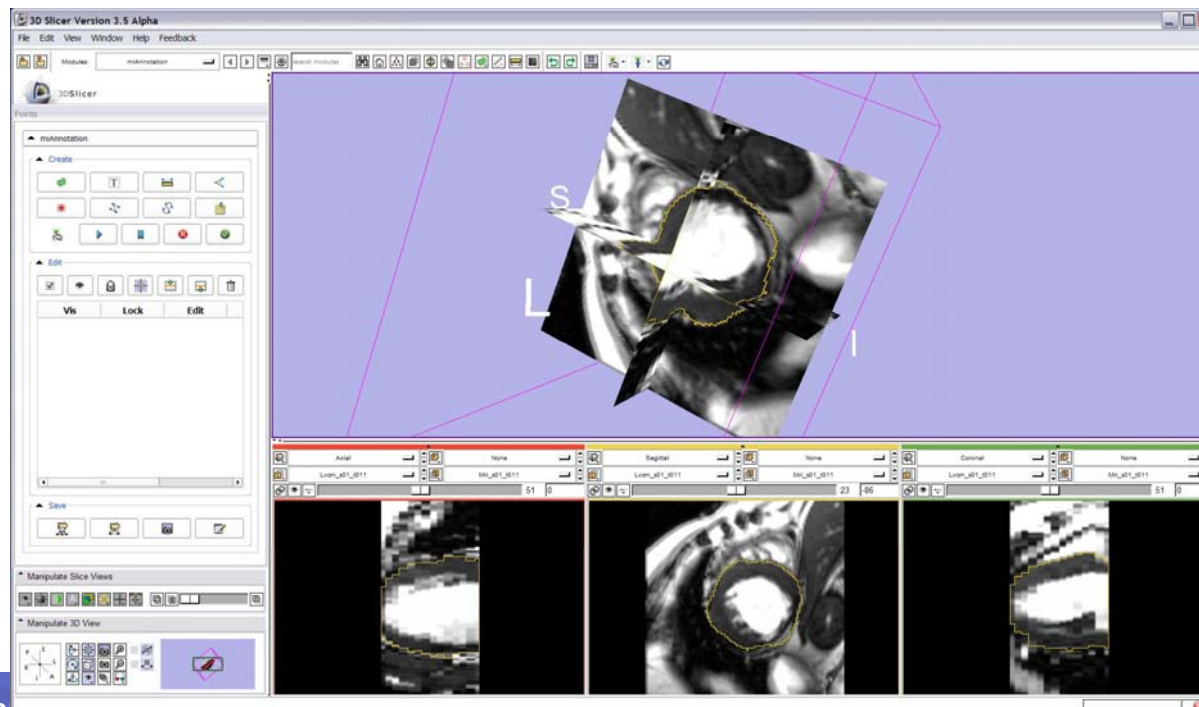
- Limited to certain operation systems.
- Missing features often found in other commercial products.





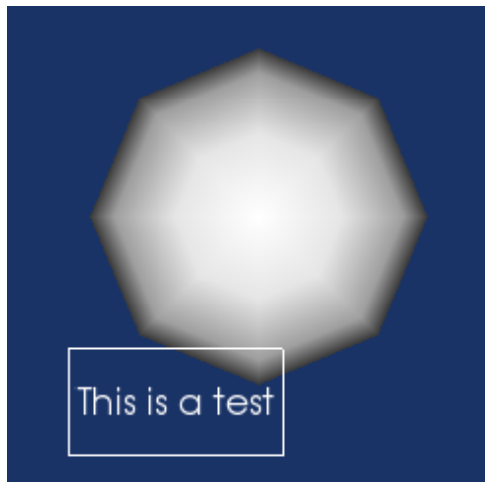
## Our Solution – miAnnotation Open Source Tool

- Is open source
- Supports multiple operating systems
- Has similar annotation functionalities to commercial systems
- Is integrated into 3D Slicer
- Is easy to be customized





## Annotation Types



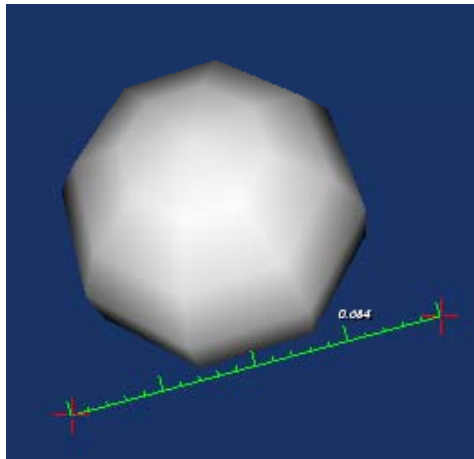
Overlay Text Annotations

Sticky Note

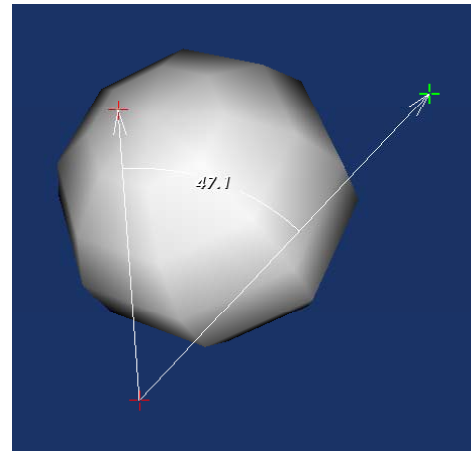




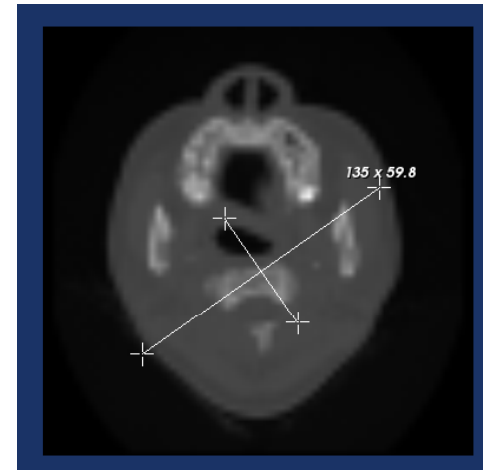
# Measurement Annotations



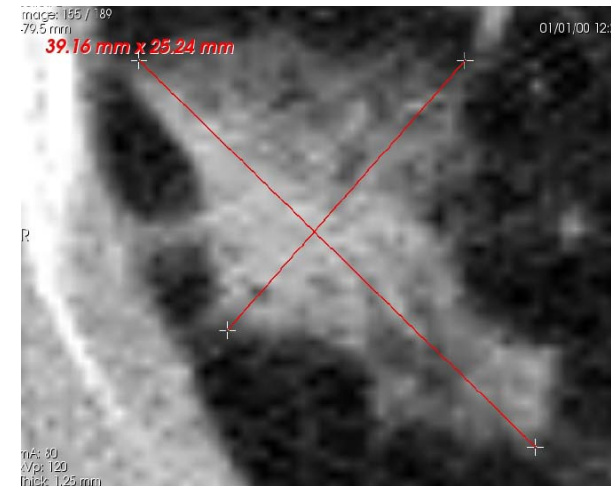
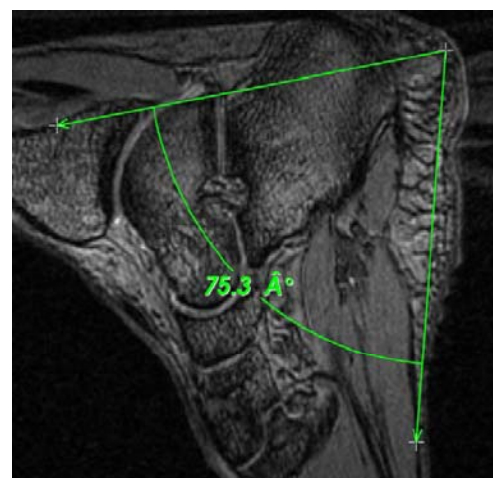
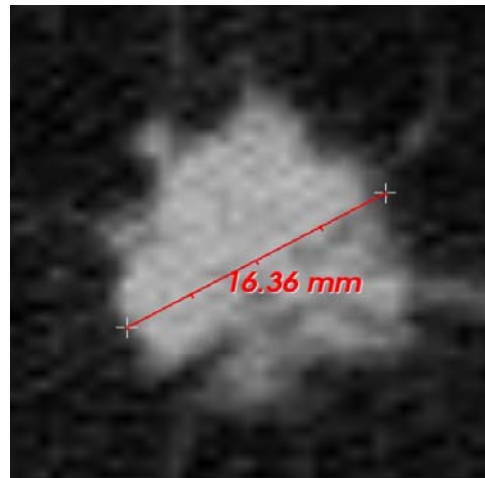
Ruler



Angle

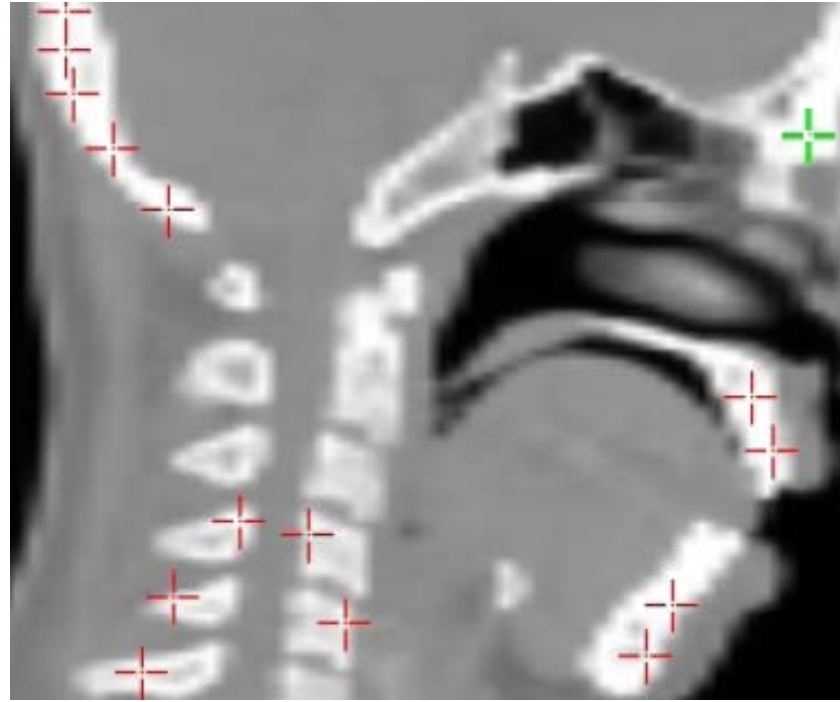
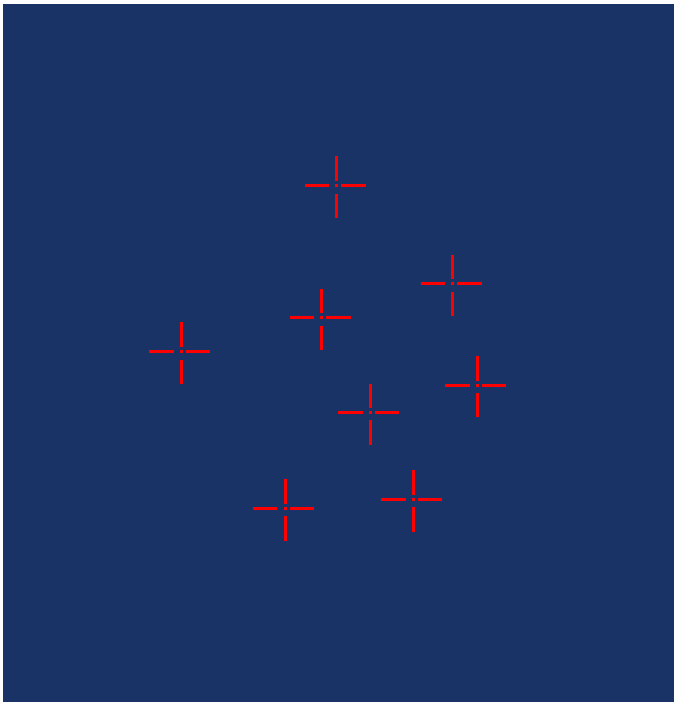


BiDimensional



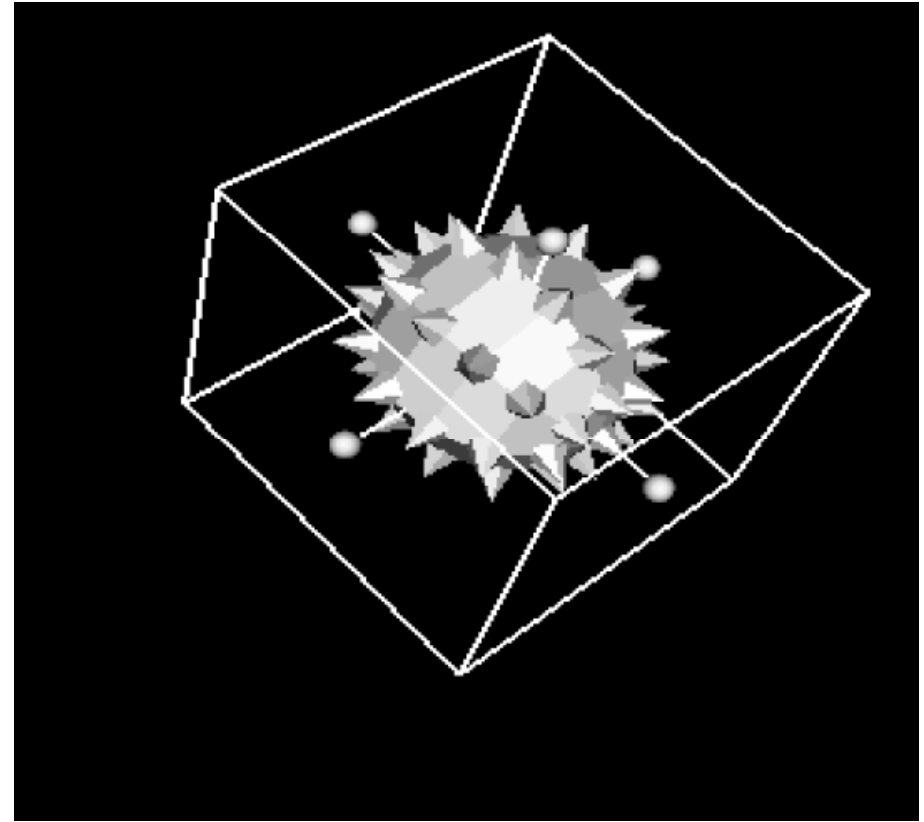
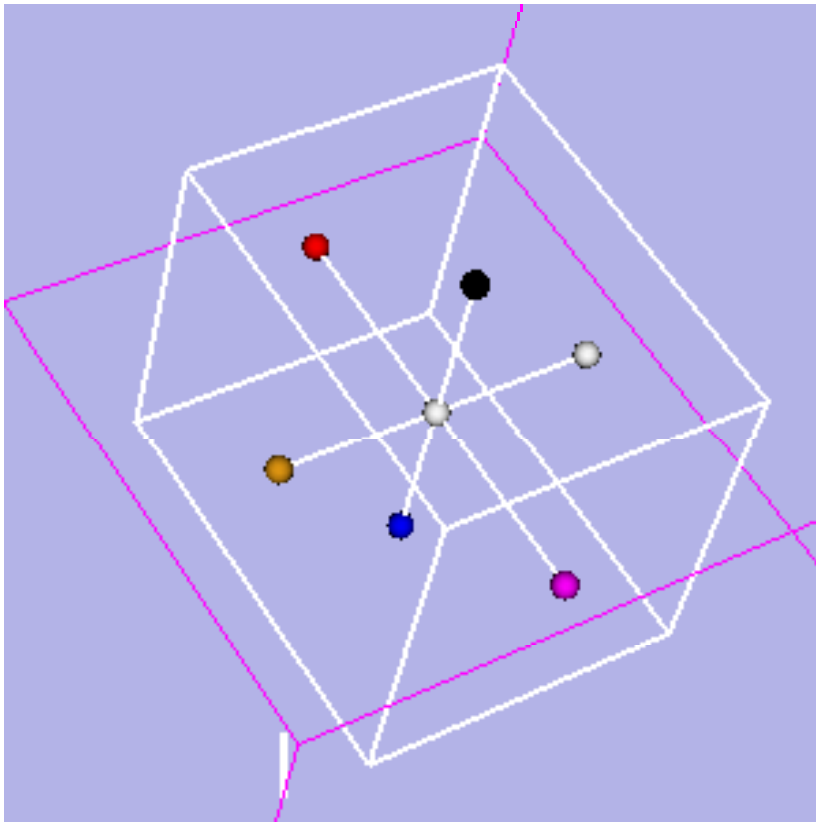


## Fiducials (Seeds)





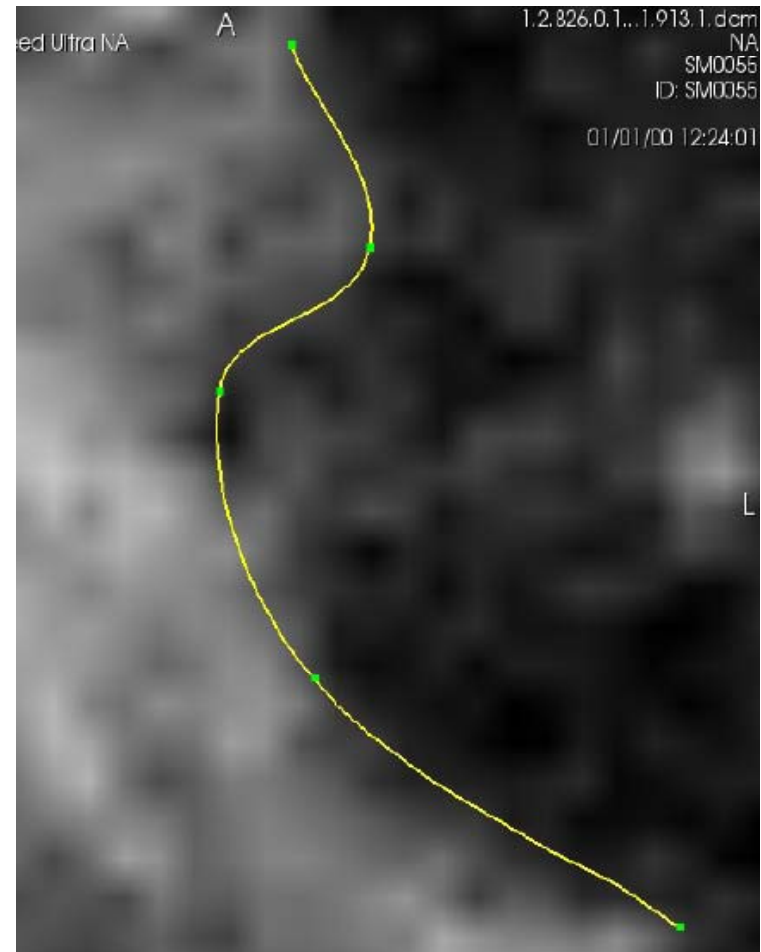
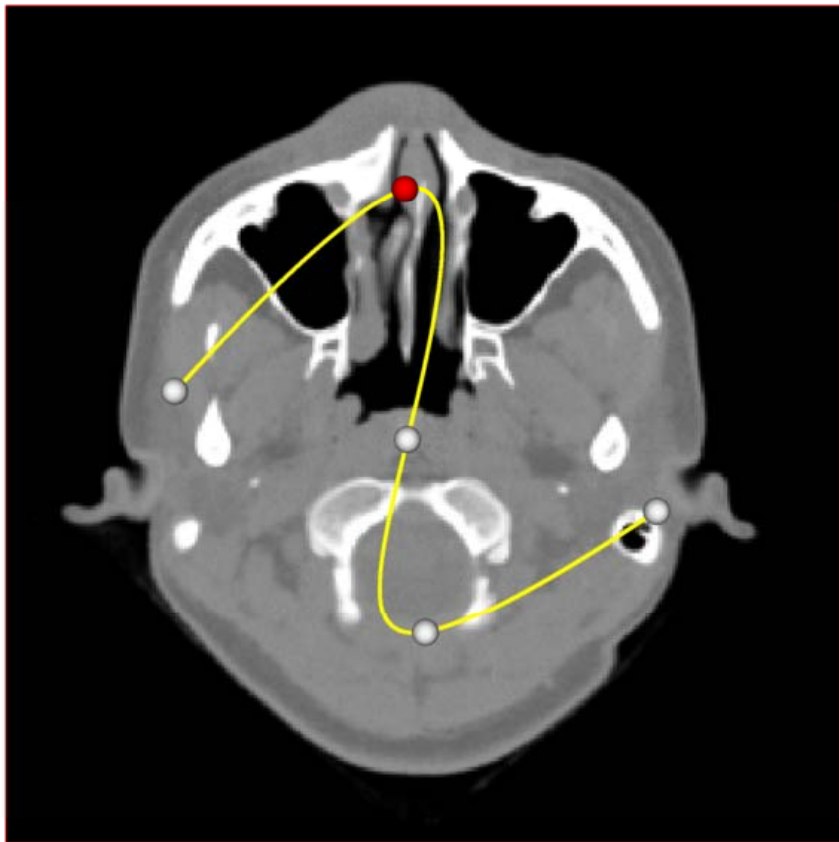
## Region Of Interests (ROI) or Box Annotation







## Spline Interpolator (Contour Annotation)





# miAnnotation – Kits



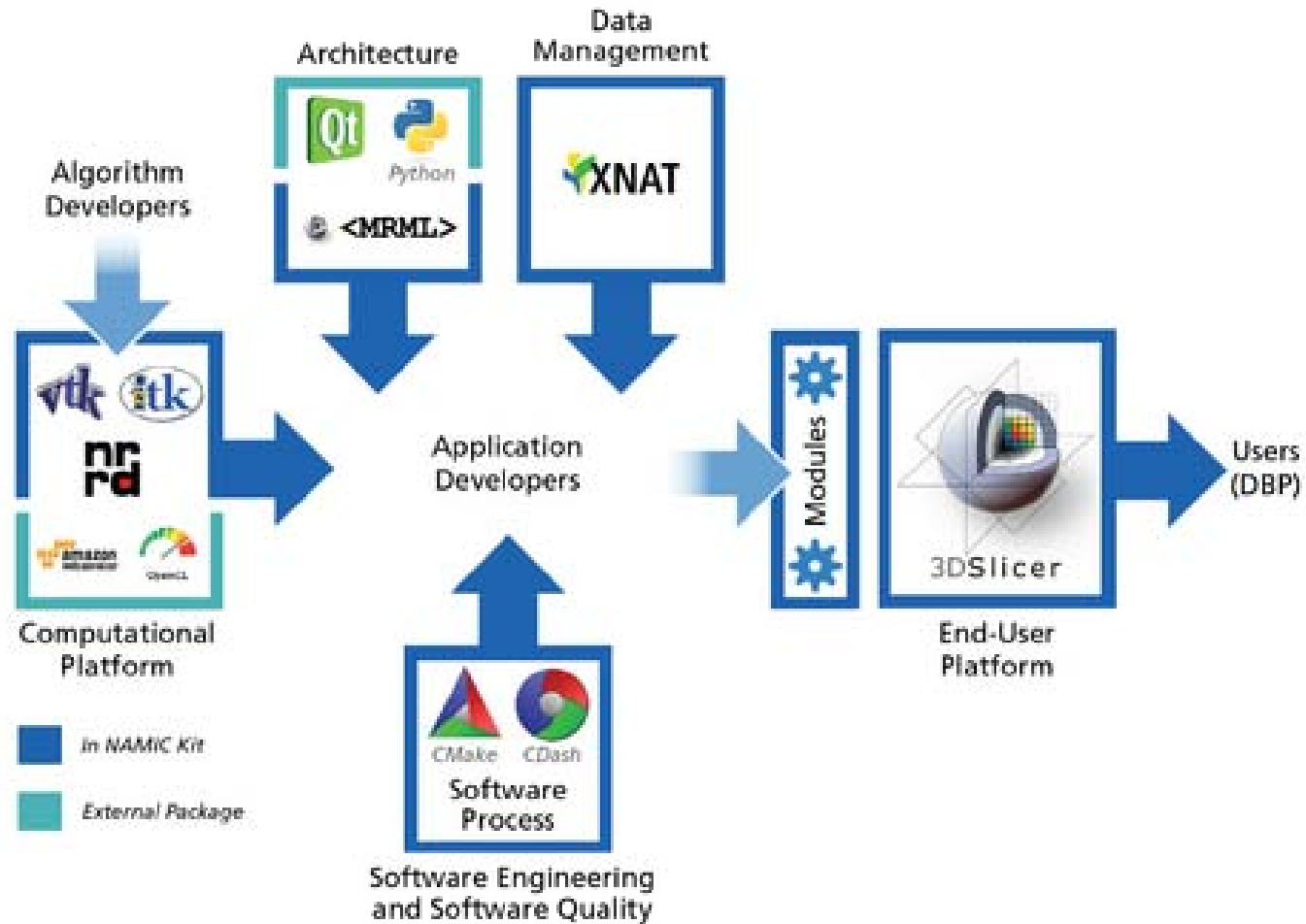
3DSlicer



| Package               | Lines of code    | Person years | Price tag at 100k per person year |
|-----------------------|------------------|--------------|-----------------------------------|
| Slicer                | 1,270,816        | 361          | \$36,122,644                      |
| KWW                   | 207,208          | 54           | \$ 5,406,516                      |
| VTK                   | 1,853,529        | 538          | \$53,808,076                      |
| ITK                   | 848,383          | 237          | \$23,719,173                      |
| CMake / CTest / CPack | 323,454          | 86           | \$8,590,888                       |
| CDash                 | 78,226           | 19           | \$1,897,060                       |
| XNat                  | 200,985          | 51           | \$5,149,987                       |
| <b>Total</b>          | <b>4,782,601</b> | <b>1346</b>  | <b>\$134,694,344</b>              |

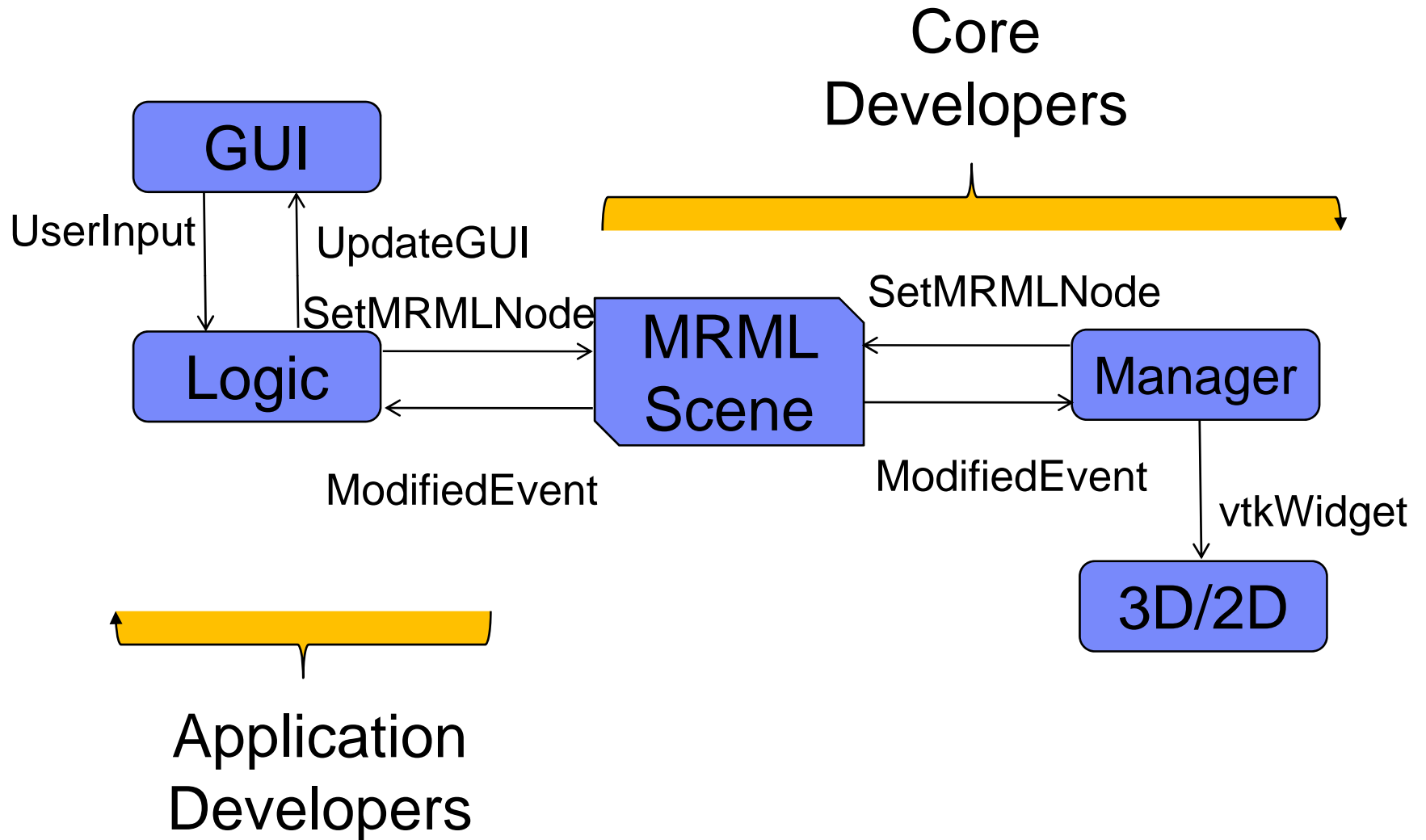


# miAnnotation – Software Development



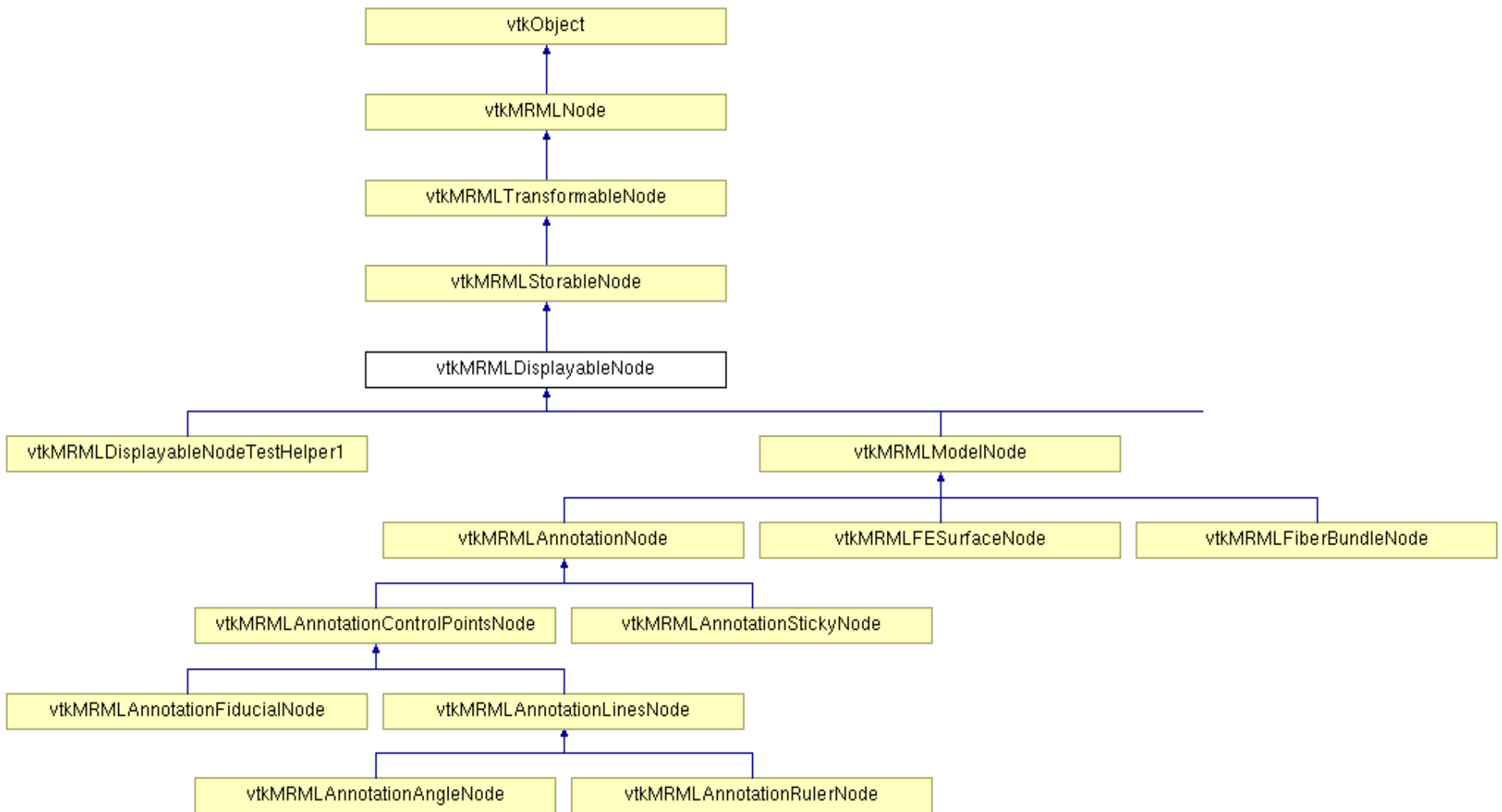


# miAnnotation – Design

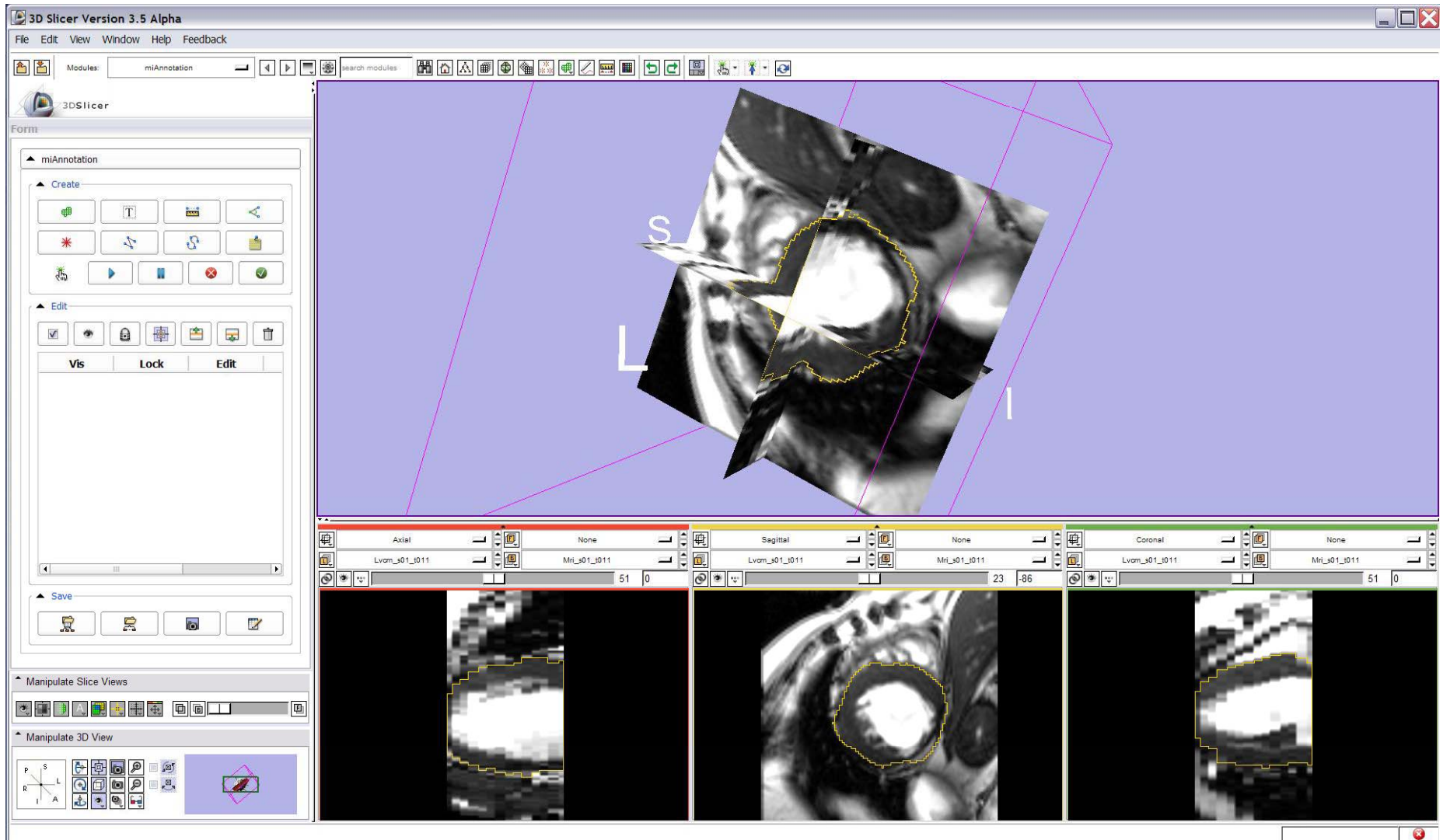




## miAnnotation – Design (MRML Structures)



# miAnnotation – The User Interface





# miAnnotation – Left Panel

- Upper Panel – **Create**
  - 8 different annotation types
  - Controls for mouse mode
  
- Middle Panel – **Edit**
  - A table contains all annotations
  - Edit annotation properties
  - Edit annotation table
  
- Lower Panel - **Save**
  - Save as text format
  - Save screen shot
  - Save entire MRML structure
  - Save report as HTML format

**miAnnotation**

**Create**

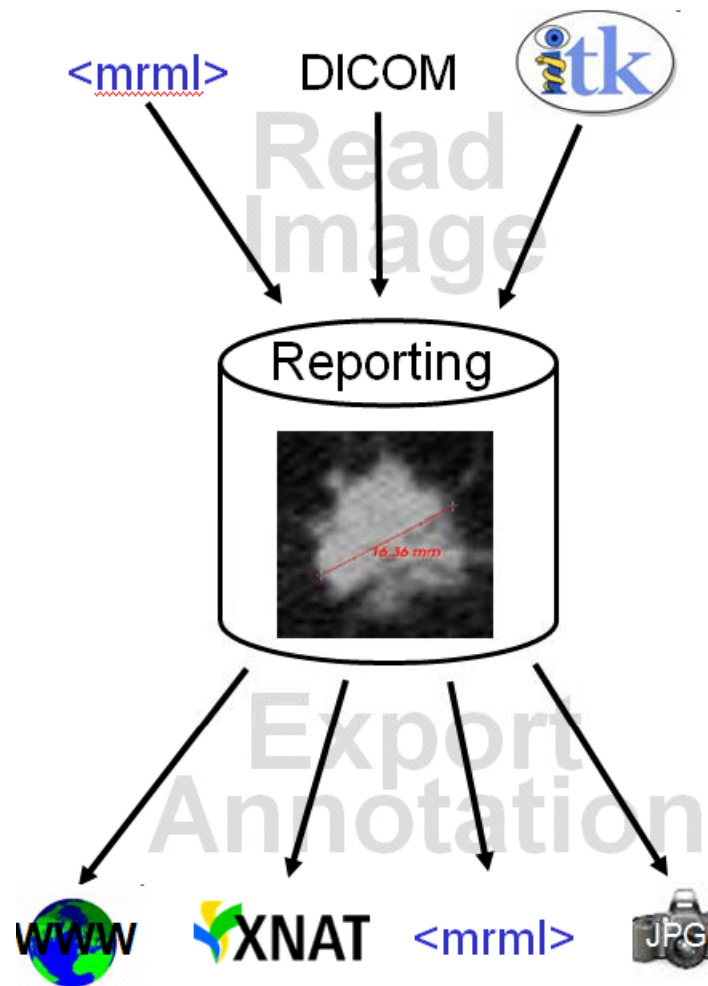
**Edit**

|   | Vis | Lock | Edit | Value  | Text                |
|---|-----|------|------|--------|---------------------|
| 1 |     |      |      |        |                     |
| 2 |     |      |      |        | This is a Text Node |
| 3 |     |      |      | 500 mm |                     |
| 4 |     |      |      | 67.1   |                     |
| 5 |     |      |      |        |                     |
| 6 |     |      |      |        |                     |
| 7 |     |      |      |        |                     |
| 8 |     |      |      |        |                     |

**Save**



## miAnnotation – Input/Output







## Output – MRML Scene

**Save Scene and Unsaved Data**

Save Scene & Data Options

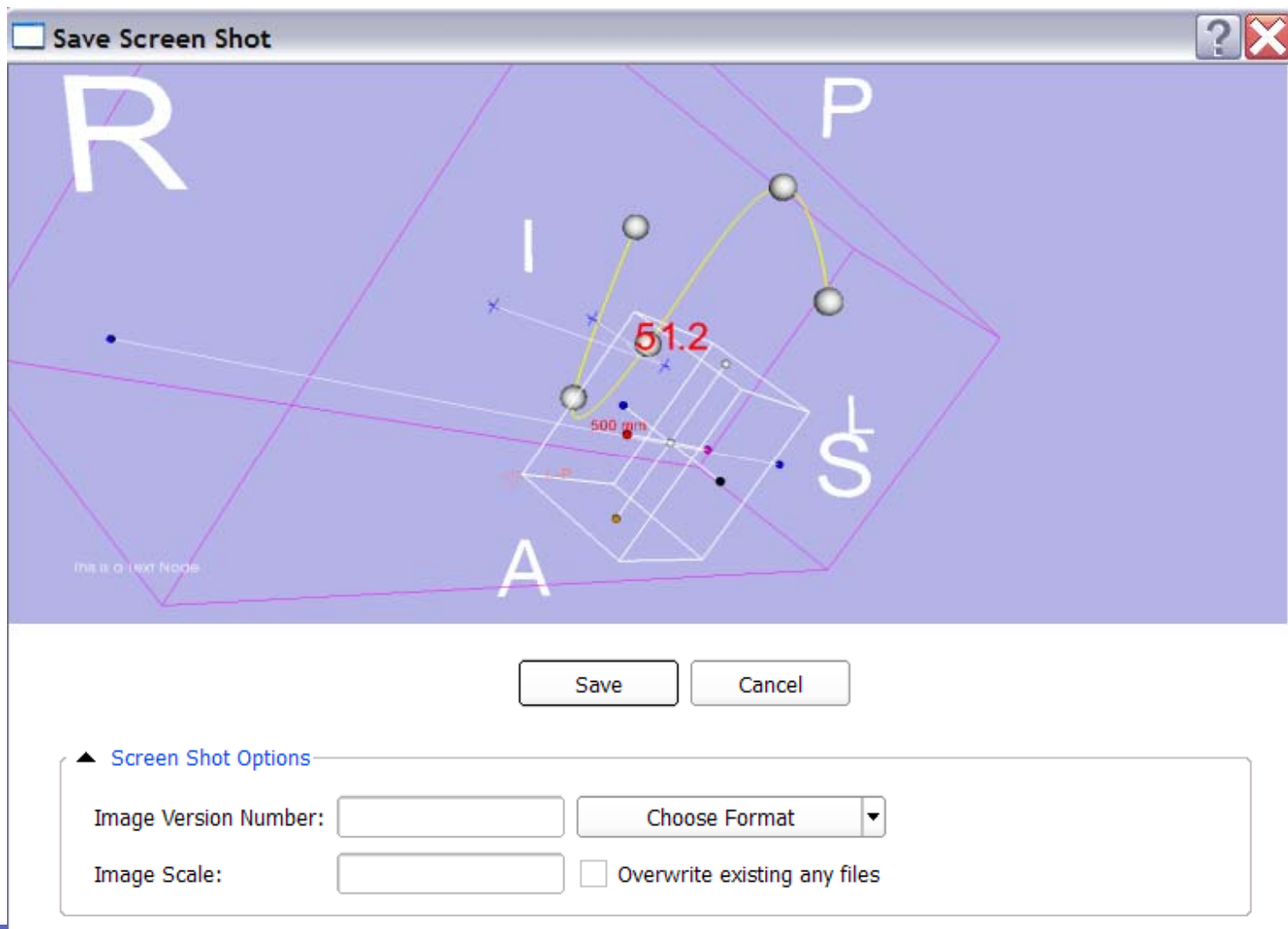
Change Destination for All Selected:

| Select                              | Node Name       | Node Type       | Node Status  | File Format                 | File Name                | Data Directory   |
|-------------------------------------|-----------------|-----------------|--------------|-----------------------------|--------------------------|--|
| <input checked="" type="checkbox"/> | (Scene Des...   | (SCENE)         | Modified     | MRML (.mrm)                 | SlicerScene1             | C:/cygwin/home/latest/Slicer3-build/QTModules/miAnnotation |
| <input checked="" type="checkbox"/> | AnnotationT...  | AnnotationT...  | Modified     | Annotation List CSV (.acsv) | AnnotationTextNode...    | C:/cygwin/home/latest/Slicer3-build/QTModules/miAnnotation |
| <input checked="" type="checkbox"/> | AnnotationR...  | AnnotationR...  | Modified     | Annotation List CSV (.acsv) | AnnotationRuler.acsv     | C:/cygwin/home/latest/Slicer3-build/QTModules/miAnnotation |
| <input checked="" type="checkbox"/> | AnnotationA...  | AnnotationA...  | Modified     | Annotation List CSV (.acsv) | AnnotationAngle.acsv     | C:/cygwin/home/latest/Slicer3-build/QTModules/miAnnotation |
| <input checked="" type="checkbox"/> | AnnotationFi... | AnnotationFi... | Modified     | Annotation List CSV (.acsv) | AnnotationFiducial.ac... | C:/cygwin/home/latest/Slicer3-build/QTModules/miAnnotation |
| <input checked="" type="checkbox"/> | L               | FiducialList    | Modified     | Fiducial List CSV (.fcsv)   | L.fcsv                   | C:/cygwin/home/latest/Slicer3-build/QTModules/miAnnotation |
| <input type="checkbox"/>            | AnnotationP...  | BSplineTran...  | Not Modified | Transform (.tfm)            | AnnotationPolylineNo...  | C:/cygwin/home/latest/Slicer3-build/QTModules/miAnnotation |
| <input checked="" type="checkbox"/> | AnnotationSt... | AnnotationSt... | Modified     | Annotation List CSV (.acsv) | AnnotationStickyNod...   | C:/cygwin/home/latest/Slicer3-build/QTModules/miAnnotation |

Save Selected    Cancel



## Output – Screen Shot





# Output – Report in HTML

Report

### 3D Slicer Report

| Type | Value  | Text                |
|------|--------|---------------------|
|      |        | This is a Text Node |
|      | 500 mm |                     |
|      | 51.2   |                     |
|      |        |                     |
|      |        |                     |

Save Cancel

NA-MIC-Kit - NAMIC 3D Slicer Report

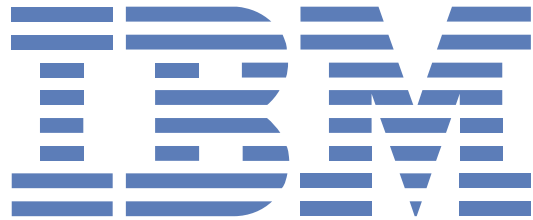
### 3D Slicer Report

| Type | Value  | Text |
|------|--------|------|
|      | 506 mm |      |
|      | 21.3   |      |
|      |        |      |

### Screen Shots



Thank You



Software Demo...