

MIPAV



MEDICAL IMAGE PROCESSING AND VISUALIZATION

<http://mipav.cit.nih.gov>





Getting Started with Medical Image Processing, Analysis & Visualization (MIPAV)

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MIPAV Team

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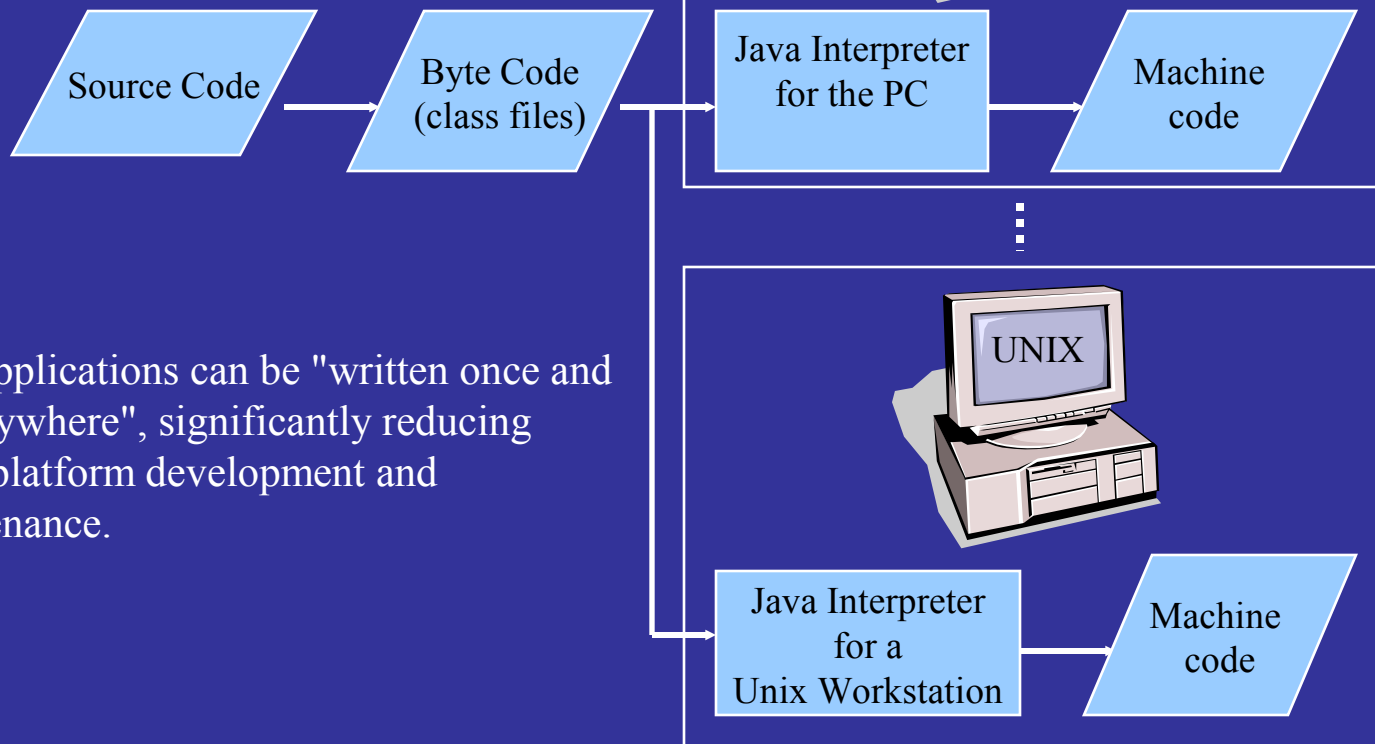
Requirements for an Image Quantification and Visualization Application

- **Portability**
 - cross-platform or platform-independent execution
- **Data format independence**
 - access to images: DICOM 3.0 files/server, Analyze, TIFF, Raw, ...
- **Extensibility**
 - plugins and/or scripts
- **Scalability**
 - foundation to support the growth to larger and more intricate data structures
- **Usability**
 - coherent graphical user interface (GUI)



Portability

Java Primer



Java applications can be "written once and run anywhere", significantly reducing cross-platform development and maintenance.

Data Independence

- DICOM file reader/ writer
- DICOM Query/Retrieve and “Catcher”
- Comprehensive file format support/conversion
 - <http://mipav.cit.nih.gov/about/fileformat.html>
- MIPAV file format based on XML and is extensible



Extensibility

Plugins and Scripts

- **Plugin**
 - Function written in Java using the MIPAV API.
- **Script**
 - Use MIPAV to record and save function(s) applied to image dataset(s)
 - Apply the script to any number of image datasets using the script wizard.



Scalability

- **Model Image is an n-dimensional structure.**
- **Algorithms typically support 4D datasets (7D if you count, red, green, and blue channels as separate dimensions). Not all algorithms support 4D operations, they are added as required.**
- **Most viewers support 4D dataset with fusion**

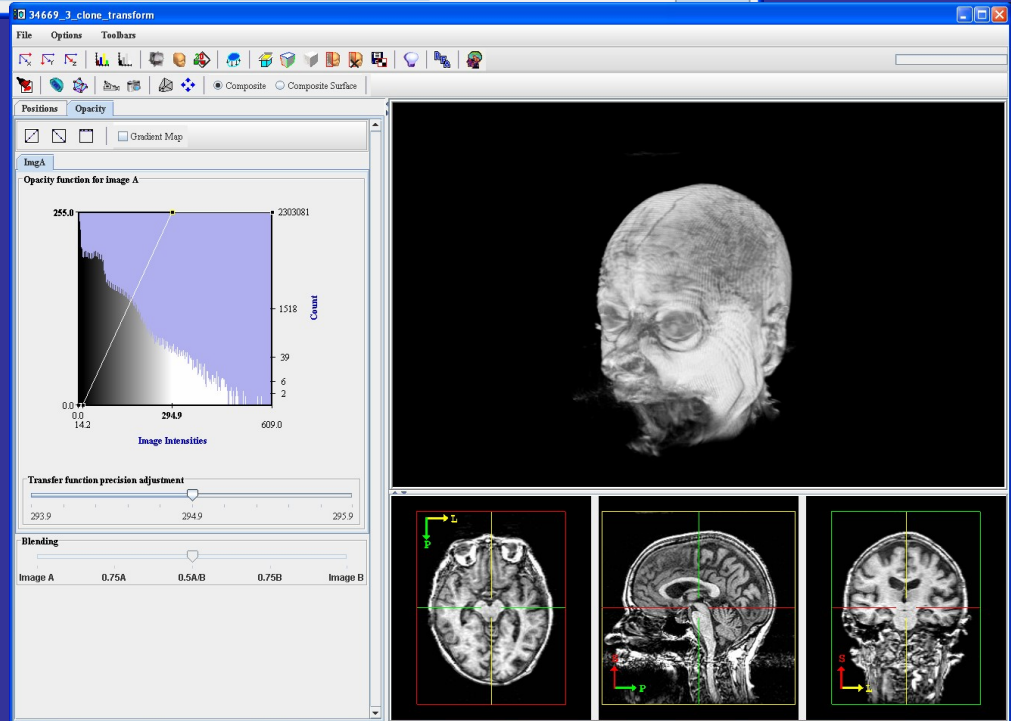
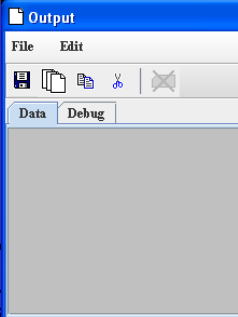
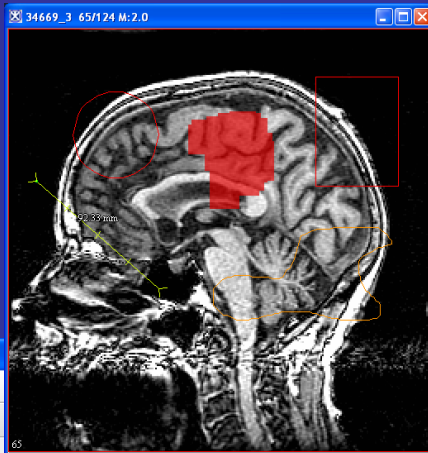
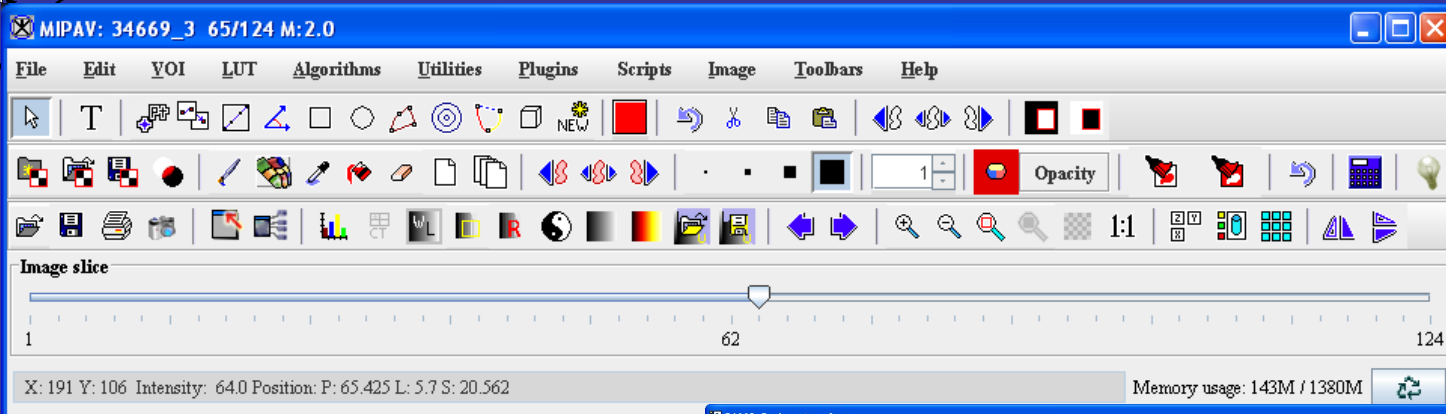




Usability

- **Most NIH intramural researchers not interested in software / development, they require a GUI.**
 - MIPAV provides a GUI driven application to support user-interactive functions.
 - Supports scripts and plugins for automated and repetitive functions.
 - We are adding – calling MIPAV functions or scripts from the command line.





Functional Overview

GUI

Views – with data fusion

2D planar,
 “Lightbox”,
 Cine (movie),
 Multi-planar,
 3D tri-planar,
 Surface render, (supports 3D texture
 mapped volume rendering)
 Volume render

VOIs

32K
 Manual and
 automated
 contouring

Algorithms

Filtering
 Segmentation/classification
 Measurement/quantification
 Registration/fusion
 Insight Toolkit (ITK) interface
 Plugins

S
c
r
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t
i
n
g

Data (Image) types: n-dimensional structure

(boolean, byte, unsigned byte, short,
 unsigned short, int, long, float, double, Complex, ARGB)

PACS

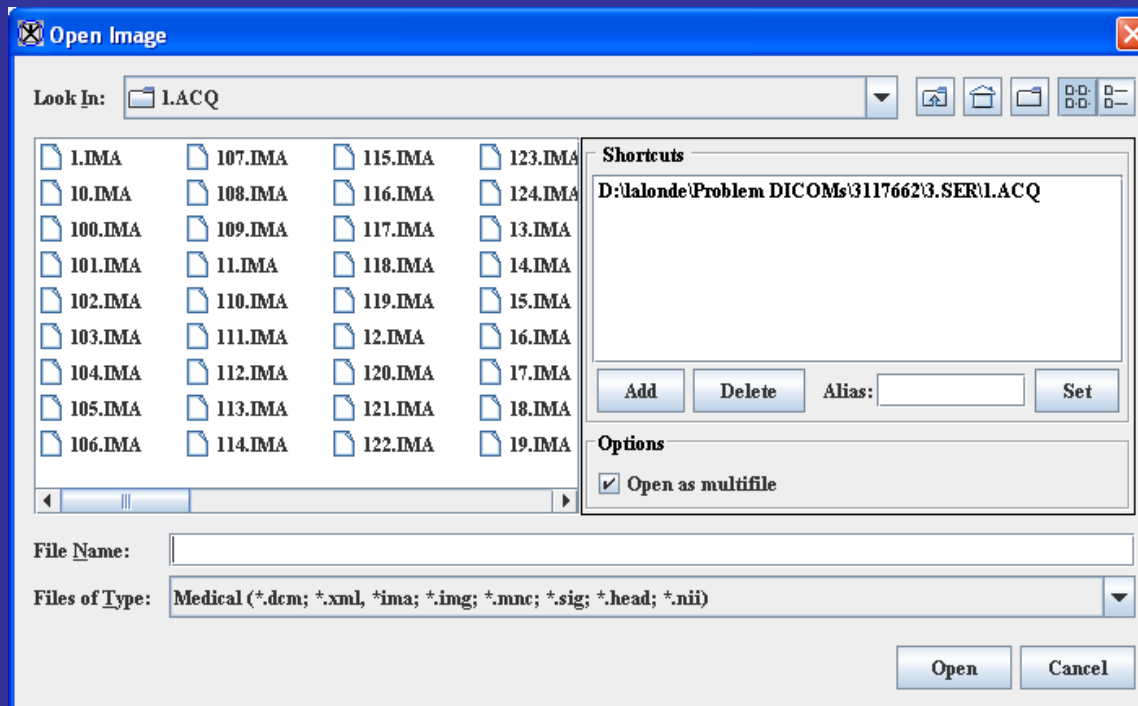
DICOM 3.0:
 Query/Retrieve, Catcher

File types

(Raw, Analyze, DICOM 3.0, GE, Siemens, Bruker, Interfile,
 Micro cat, MINC, MRC, FITS, Cheshire, AFNI, TIFF, JPEG, GIF,
 BMP, AVI, QuickTime, Biorad, Ziess LSM510, **XML**, and more)



Opening Images



Opening Images

Open image sequence

Browse: D:\costes\Cell2_0_3D002.tif

File list

- Cell2_0_3D000.tif
- Cell2_0_3D001.tif
- Cell2_0_3D002.tif
- Cell2_0_3D003.tif
- Cell2_0_3D004.tif
- Cell2_0_3D005.tif
- Cell2_0_3D006.tif
- Cell2_0_3D007.tif
- Cell2_0_3D008.tif
- Cell2_0_3D009.tif**
- Cell2_0_3D010.tif
- Cell2_0_3D011.tif
- Cell2_0_3D012.tif
- Cell2_0_3D013.tif
- Cell2_0_3D014.tif
- Cell2_0_3D015.tif
- Cell2_0_3D016.tif
- Cell2_0_3D017.tif
- Cell2_0_3D018.tif
- Cell2_0_3D019.tif

Dimensions

5 Slices (Z)
1 Channels (C)
4 Time points (T)


Sequences

Z-C-T Z-T-C
 C-Z-T C-T-Z
 T-Z-C T-C-Z

Subsampling

Enable
Width:
Height:
 Force 8-bit

Apply >>


Image dimensions: 171x144

Window

0.1 1 10

Level

-255 0 255

Channel	Time point 1	Time point 2	Time point 3	Time point 4
1	Cell2_0_3D000.tif	Cell2_0_3D005.tif	Cell2_0_3D010.tif	Cell2_0_3D015.tif
	Cell2_0_3D001.tif	Cell2_0_3D006.tif	Cell2_0_3D011.tif	Cell2_0_3D016.tif
	Cell2_0_3D002.tif	Cell2_0_3D007.tif	Cell2_0_3D012.tif	Cell2_0_3D017.tif
	Cell2_0_3D003.tif	Cell2_0_3D008.tif	Cell2_0_3D013.tif	Cell2_0_3D018.tif
	Cell2_0_3D004.tif	Cell2_0_3D009.tif	Cell2_0_3D014.tif	Cell2_0_3D019.tif

Crop **Remove**

Open **Close**

Image Browser

Tree of images in selected directory

File

D:\alonde\Problem DICOMs

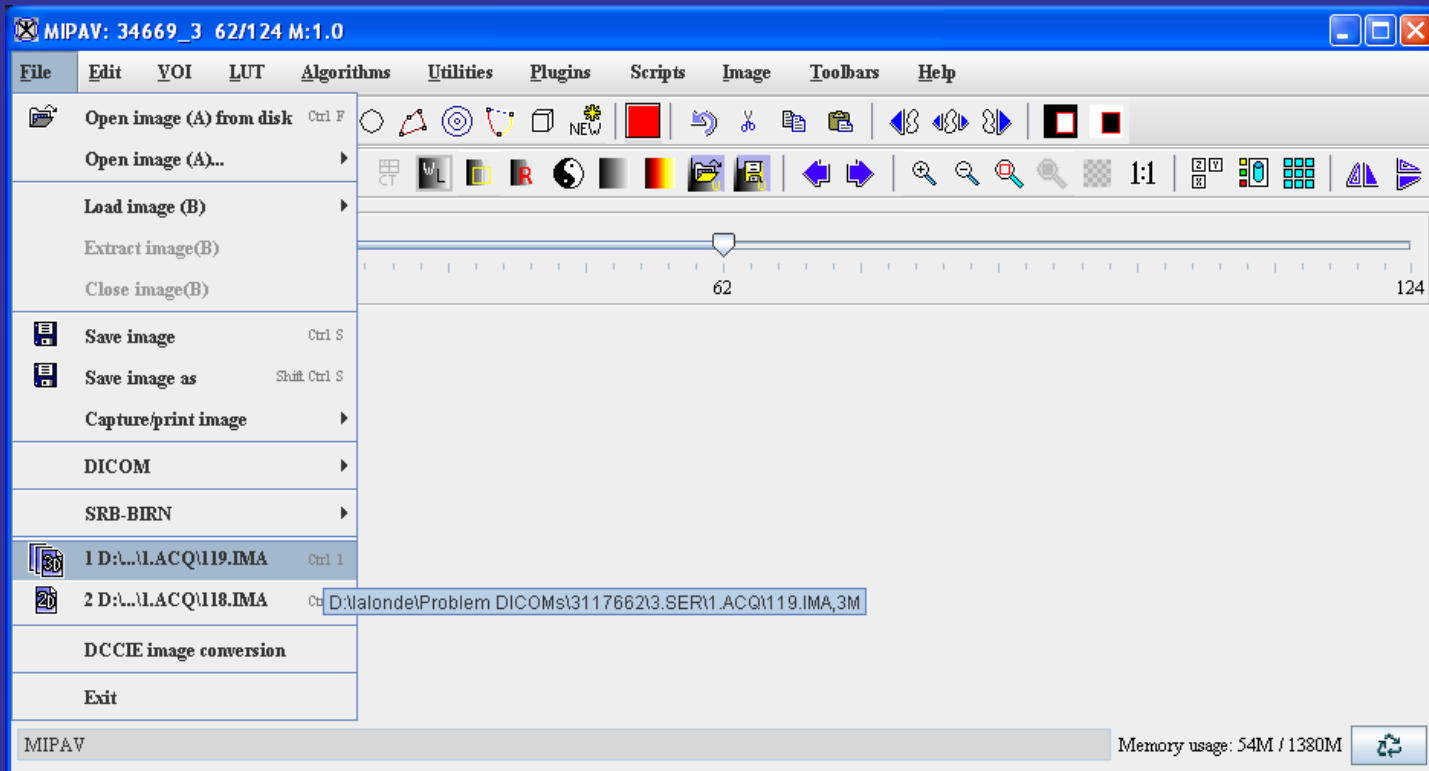
- 3086665
- 3117862
 - 3.SER
 - 1.ACQ
 - 1.IMA
 - 10.IMA
 - 100.IMA
 - 101.IMA
 - 102.IMA
 - 103.IMA
 - 104.IMA
 - 105.IMA
 - 106.IMA
 - 107.IMA
 - 108.IMA
 - 109.IMA
 - 11.IMA
 - 110.IMA
 - 111.IMA
 - 112.IMA
 - 113.IMA
 - 114.IMA
 - 115.IMA
 - 116.IMA
 - 117.IMA
 - 118.IMA
 - 119.IMA
 - 12.IMA
 - 120.IMA
 - 121.IMA
 - 122.IMA
 - 123.IMA
 - 124.IMA
 - 13.IMA
 - 14.IMA

Window: 0.1 1 10

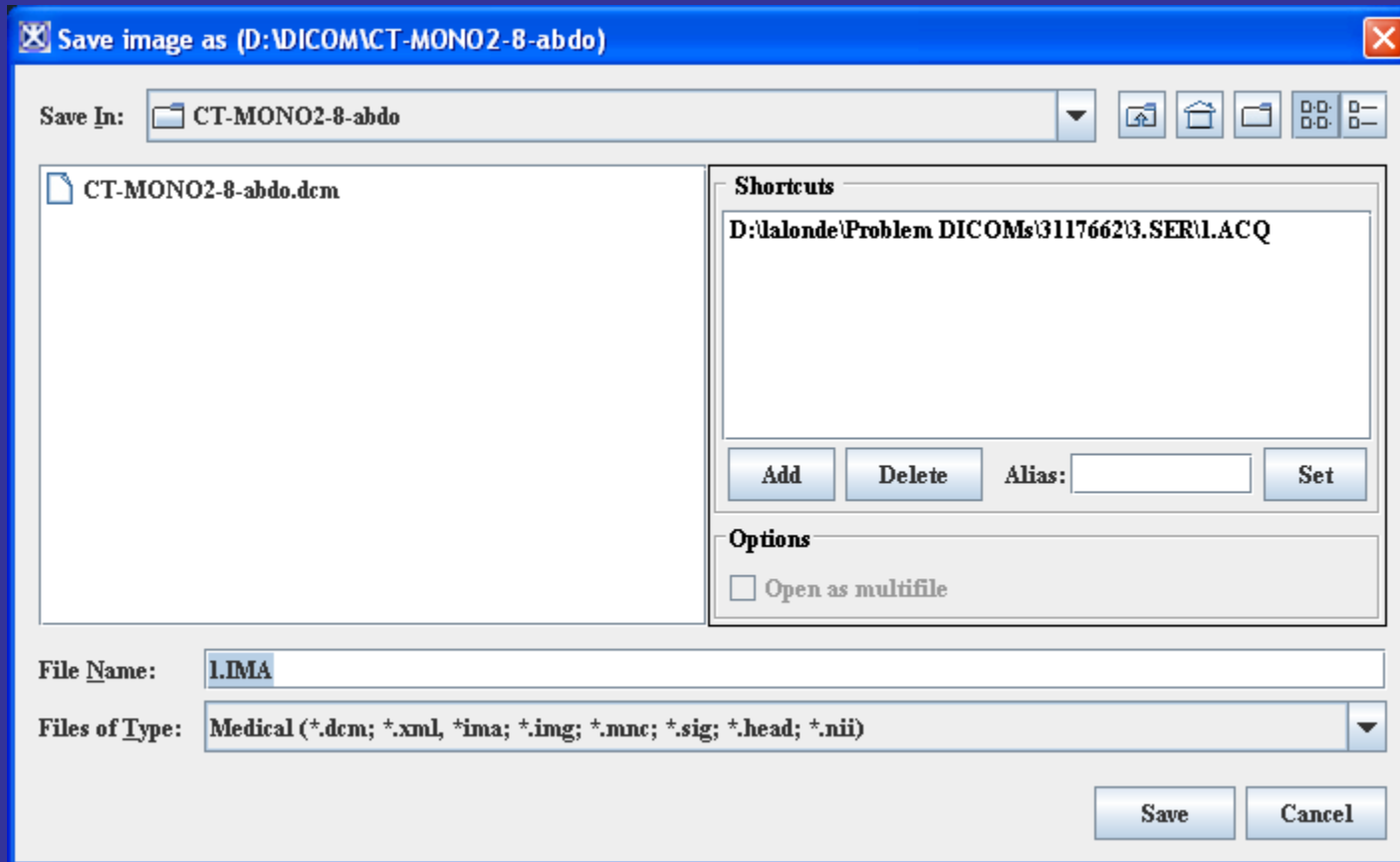
Level: -255 0 255

Image Information		
Dimension 0	256	
Dimension 1	256	
Type	Short	
Max	279.0	
Min	0.0	
Modality	Magnetic Resonance	
Orientation	Sagittal	
Pixel resolution 0	0.9375 Millimeters	
Pixel resolution 1	0.9375 Millimeters	
Other Information		
(0002,0000)	File Meta Information Group Length	192
(0002,0001)	File Meta Information Version	256

Opening Images



Saving Image As (use suffix)



Code Snapshot



```
int destExtents[] = new int[2];
destExtents[0] = image.getExtents()[0]; // X dim
destExtents[1] = image.getExtents()[1]; // Y dim

// Make a result image of Unsigned byte type
resultImage = new ModelImage(ModelStorageBase.UBYTE, destExtents, "Result Image", null);

int length = destExtents[0] * destExtents[1];
for (int i = 0; i < length; i++){
    destImage.set(i, i%256);
}

ViewJFrameImage imageFrame;
ModelLUT LUTa = new ModelLUT(ModelLUT.COOLHOT, 256, dimExtentsLUT);
imageFrame = new ViewJFrameImage(resultImage, LUTa, new Dimension(610,200), userInterface);
```

Major Algorithms Supported

- **Algorithms**

- Filters: Gaussian blurring, gradient magnitude, Laplacian, curvature, other higher order derivatives, median, anisotropic diffusion, coherence-enhance diffusion, isotropic diffusion, wavelet, unsharp masking, etc.
- Image Calculator (add, subtract, multiply, divide, AND, OR, XOR)
- Registration
 - Landmark – least squares, thin-plate splines for both 2D and 3D datasets
 - AIR 5.07 and AFNI
 - Automatic 2D/2.5D/3D registration intra/inter patient, intra/intra modality
 - multi-resolution, user selectable DOF, user selectable cost function (correlation ratio, normalized cross correlation, least squares, mutual information).
- Image transformations or resample with nearest neighbor, tri-linear, 3rd, 4th bSpline, Sinc, 3rd, 5th, 7th order Lagrangian, etc.
- Surface extraction with decimation
 - Adaptive skeleton climbing
 - Marching cubes
 - Marching tetrahedrons
- Skull striping
- Classification – Fuzzy c-means
- Watershed
- Morphological filters (open, close, erode, dilate, etc)
- Active contour methods (GVF etc.)



Download and Setup

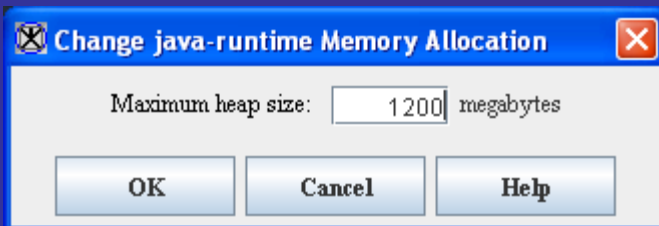
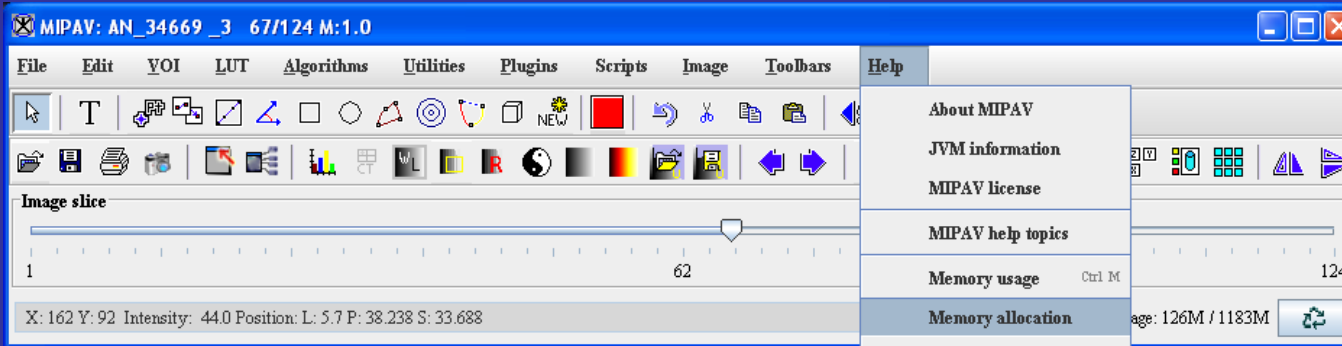
1. <http://mipav.cit.nih.gov/download>
2. Fill in form
3. Install (e.g. installMIPAV.exe)

** Nightly download - latest changes but might have bugs.

The screenshot shows a Netscape browser window titled "Download MIPAV - Netscape" with the address bar displaying "http://mipav.cit.nih.gov/download/". The page content includes a navigation menu on the left with links like Home, Download, About MIPAV, Documentation, Related Studies, Contact Information, Sister Sites, taso, EFAST, DCB Links, Scientific Resources, Research Studies, Publications, News, and Journals. The main content area features a registration form with fields for Name (required), Email (required), and Address, and a dropdown menu for "Institute or Center" set to "Not at the National Institutes of Health, Maryland, USA". Below the form is a "Platform" section with "Installation Instructions" for Windows, Linux, Solaris, and Macintosh. The Windows instructions include turning off virus scanners and double-clicking installMIPAV.exe. The Linux instructions include opening a shell and running ./installMIPAV.bin. The Solaris instructions are similar to Linux. The Macintosh instructions note that the version is currently being tested and may not be completely functional. At the bottom, there are general requirements for Java 1.4 or higher and Java WebServices, and a list of steps for downloading and installing Java 3D and JAI.



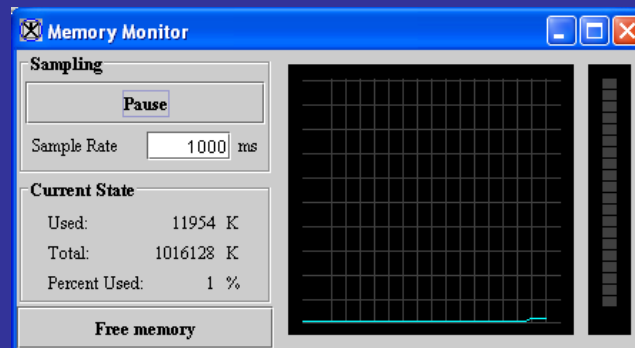
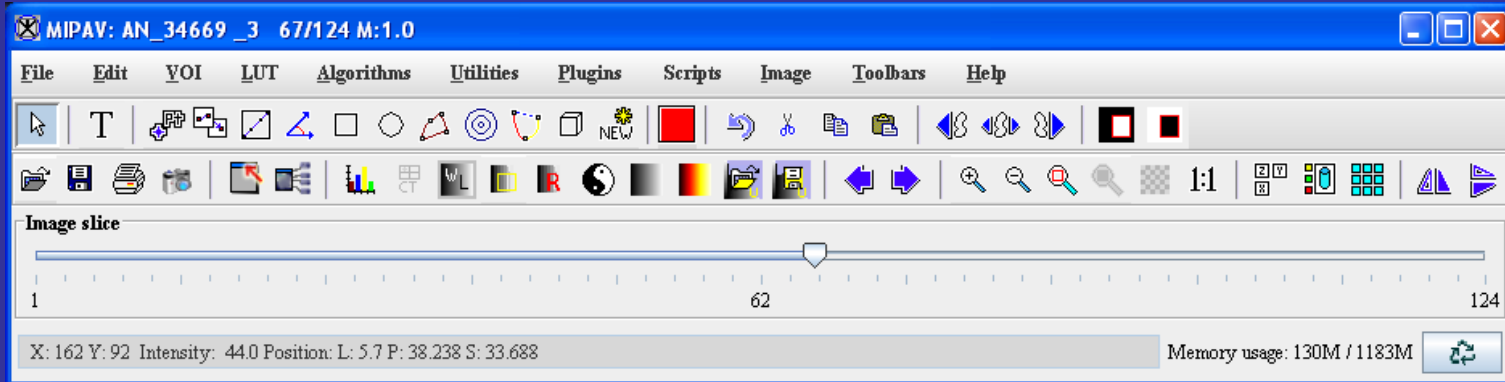
Memory Allocation



General Rules

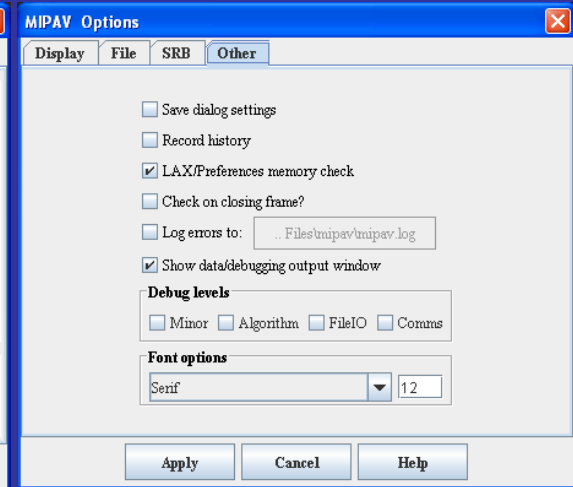
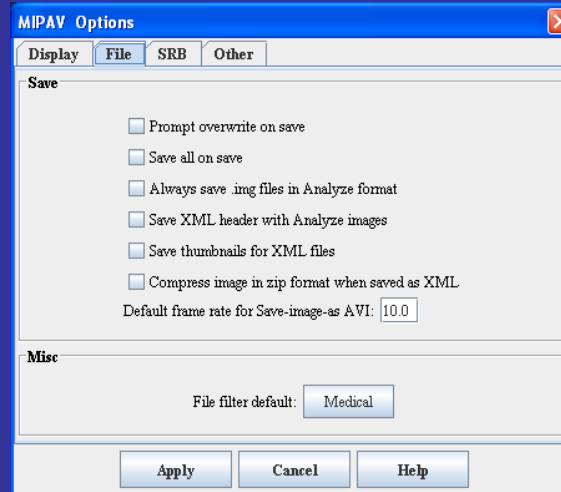
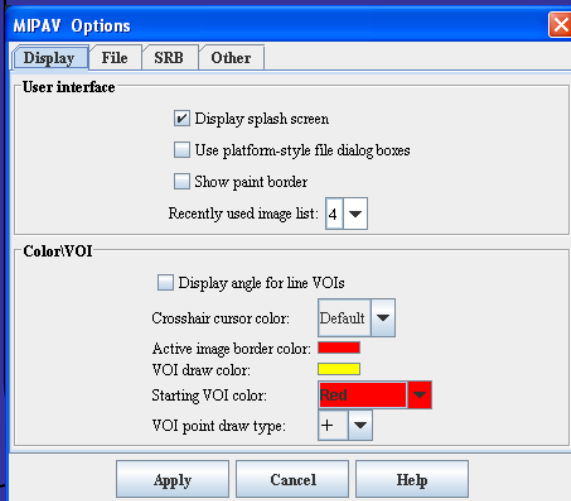
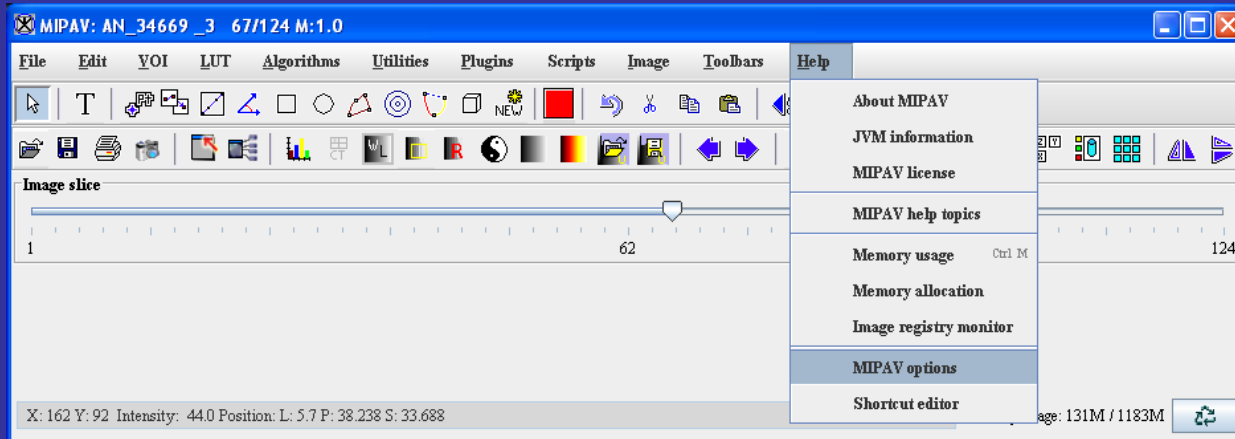
- Do not exceed the computer's physical RAM. For example if the computer has 1GB do not exceed approx 800MB.
- For Windows OS do not exceed 1,400MB

Memory Usage



Press to recover memory

MIPAV Program Options



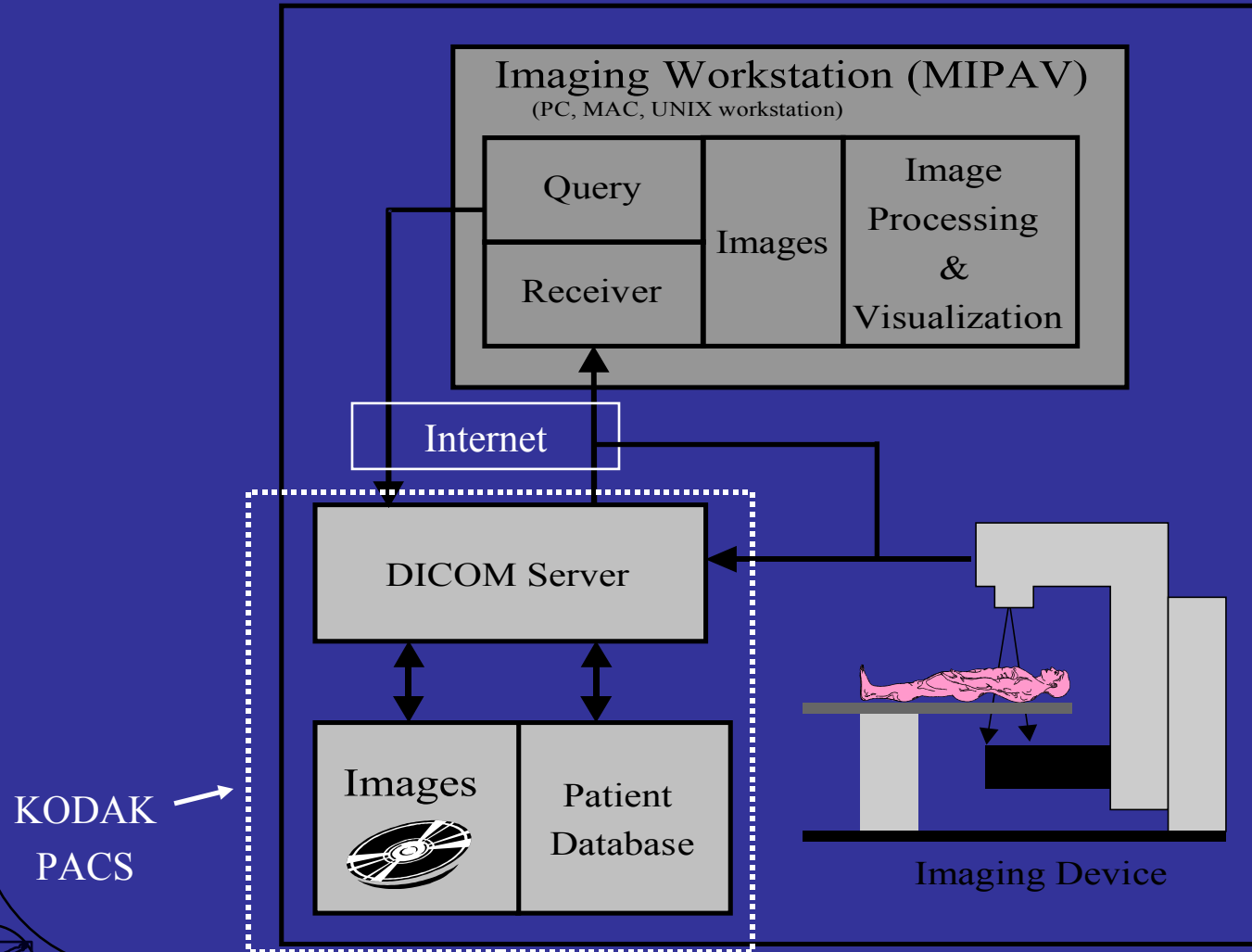
Digital Image Communication in Medicine (DICOM).

With the advent of magnetic resonance imaging (MRI), computed tomography (CT), other diagnostic imaging modalities and the exponential growth of computers, the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) formed a joint committee in 1983 to develop a standard in Digital Image Communication in Medicine (DICOM). This DICOM standards committee meets regularly to:

2. Promote communication of digital image information, regardless of device manufacturer
4. Facilitate the development and expansion of picture archiving and communication systems (PACS) that can also interface with other systems of hospital information
6. Allow the creation of diagnostic information databases that can be interrogated by a wide variety of devices distributed geographically.



DICOM Model



DICOM Query Panel - IP address = 165.112.92.95

QR Client Hosts Help

Patient Query Information

Patient Name:
Patient ID:
Study Number:
Physician:

Study Duration

Today One Week One Month
 Three Month Six Month One Year

Start Date: Apr 26 1999
End Date: Jul 26 1999

Today's Date: Jul-26-1999

Query Result

Query Level: Patient

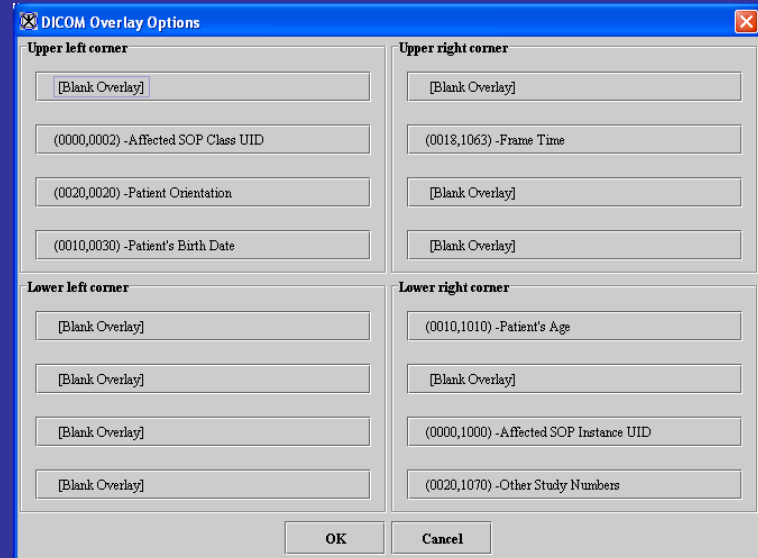
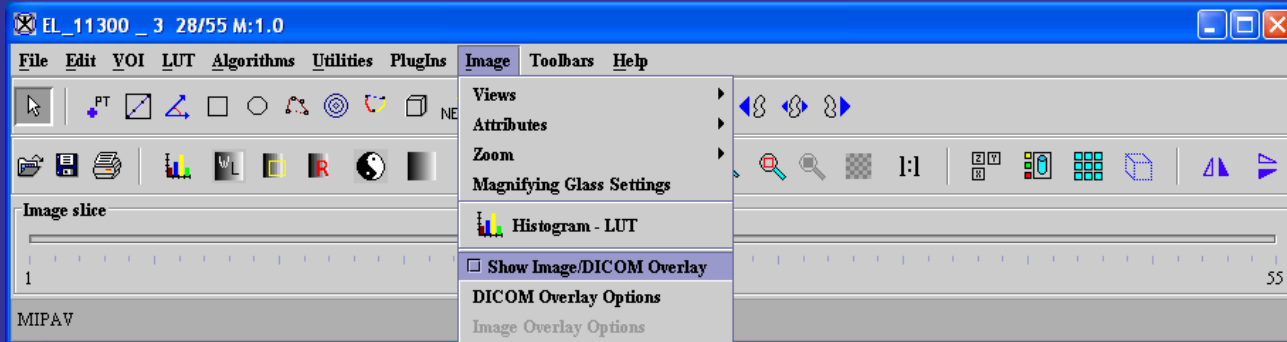
Pat. Name	Pat. ID	Referring Physician
-----------	---------	---------------------

Query Retrieval Information

Status	#	Source	Destination	Error
--------	---	--------	-------------	-------

MIPAV's DICOM Interface

DICOM



DICOM

Access to image header information

	Value
	0.703125
	0.703125
	5.0
	Millimeters per pixel
	1.0000 0.0000 0.0000 0.0000
	0.0000 1.0000 0.0000 0.0000
	0.0000 0.0000 1.0000 0.0000
	0.0000 0.0000 0.0000 1.0000
	Other Image Information
(0002,0000)	Meta Element Group Length 158
(0002,0001)	File Meta Information Version 1
(0002,0002)	Media Storage SOP Class UID 1.2.840.10008.5.1.4.1.1.2
(0002,0003)	Media Storage SOP Instance UID 1.2.840.113619.2.1.1.2702805020.277.8979...
(0002,0010)	Transfer Syntax UID 1.2.840.10008.1.2
(0002,0012)	Implementation Class UID 2.16.840.1.113664.1.1
(0008,0000)	Group Length 464
(0008,0008)	Image Type ORIGINALPRIMARYAXIAL
(0008,0016)	SOP Class UID 1.2.840.10008.5.1.4.1.1.2
(0008,0018)	SOP Instance UID 1.2.840.113619.2.1.1.2702805020.277.8979...
(0008,0020)	Study Date 06/16/1998
(0008,0021)	Series Date 06/16/1998
(0008,0022)	Acquisition Date 12/23/2004
(0008,0023)	Image Date 06/16/1998
(0008,0030)	Study Time 13:00:11
(0008,0031)	Series Time 13:16:36
(0008,0032)	Acquisition Time 13:08:09
(0008,0033)	Image Time 13:16:40
(0008,0050)	Accession Number 111-0098
(0008,0060)	Modality COMPUTED_TOMOGRAPHY
(0008,0070)	Manufacturer GE MEDICAL SYSTEMS
(0008,0080)	Institution Name C. C. N.I.H. BETHESDA, MD-A
(0008,0090)	Referring Physician's Name WALTHER, M
(0008,1010)	Station Name CT01OC0



DICOM Anonymization

MIPAV: AN_34669_3 67/124 M:1.0

File Edit VOI LUT Algorithms Utilities Plugins Scripts Image Toolbars Help

Open image (A) from disk Ctrl F
Open image (A)...
Load image (B)
Close image(B)
Save image Ctrl S
Save image as Shift Ctrl S
Capture/print image
DICOM
SRB-BIRN
1 D:\...\LACQ\119.IMA Ctrl 1
2 D:\...\LACQ\118.IMA Ctrl 2
DCCIE image conversion
Exit

Anonymize DICOM directory

File Dialog Entries

Directory Tag Options Logging

Image Source Directory

C:\users\matt\personal\focus\mipav\PPT\Images

Image Destination Directory
C:\Documents and Settings\mcmatt Browse

Translation/Key File Destination Directory
C:\Documents and Settings\mcmatt Browse

Naming Options

Recursive Anonymization

Randomize Directory Level

Randomize Selected Directory
 Randomize Child Directory

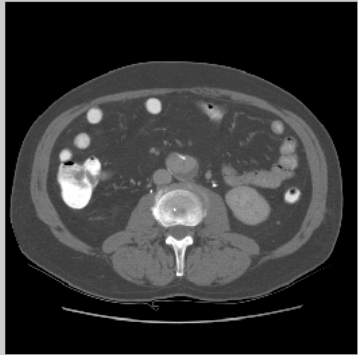
Run Close

DICOM File Browser

DICOM browser

ers\kidney\dicom259

Patient Smith



Window: 0.1 4.842 10

Level: -255 -208 255

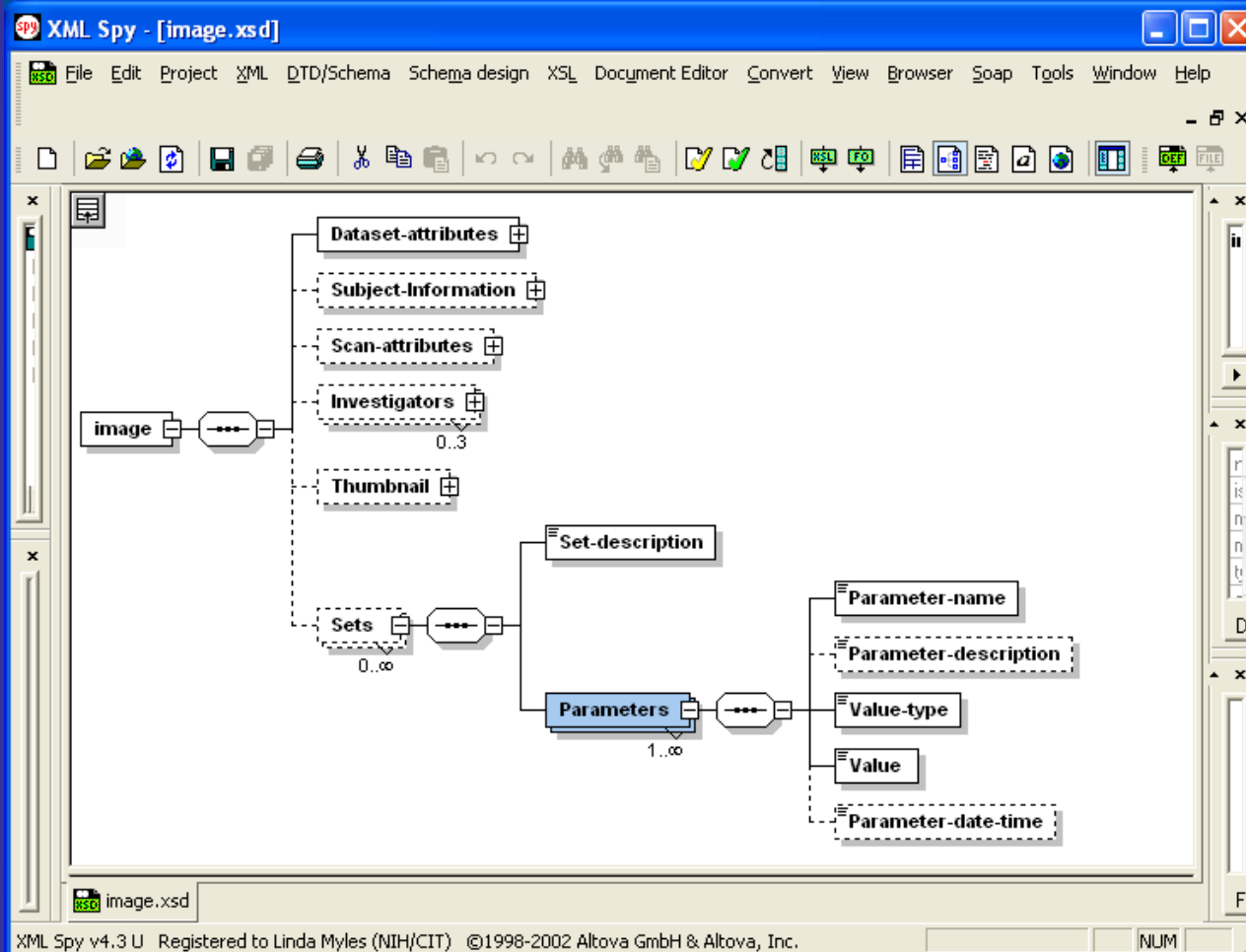
Patient Name	Patient ID	Study ID	Study Date	Description
			06/16/1998	

Series	Type	# Images	Time	Mod	Description
3		55	13:16:36	CT	

Image	Time	Echo	X-pos	Y-pos	Z-pos
1	13:16:43		-171.5	-180.0	-315.0
2	13:16:43		-171.5	-180.0	-305.0
3	13:16:43		-171.5	-180.0	-295.0
4	13:16:43		-171.5	-180.0	-285.0
5	13:16:42		-171.5	-180.0	-280.0
6	13:16:42		-171.5	-180.0	-275.0
7	13:16:42		-171.5	-180.0	-270.0
8	13:16:42		-171.5	-180.0	-265.0
9	13:16:42		-171.5	-180.0	-260.0
10	13:16:42		-171.5	-180.0	-255.0
11	13:16:42		-171.5	-180.0	-250.0
12	13:16:41		-171.5	-180.0	-245.0
13	13:16:41		-171.5	-180.0	-240.0
14	13:16:41		-171.5	-180.0	-235.0



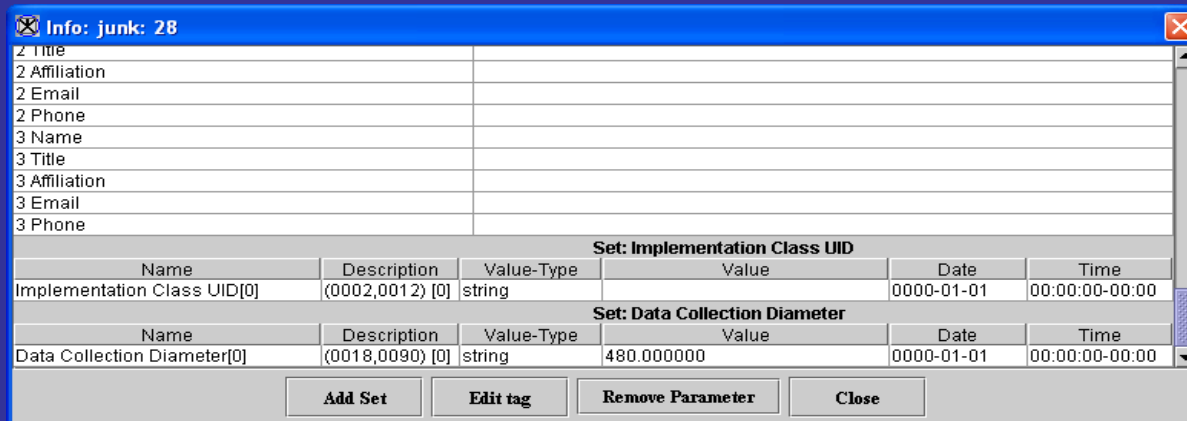
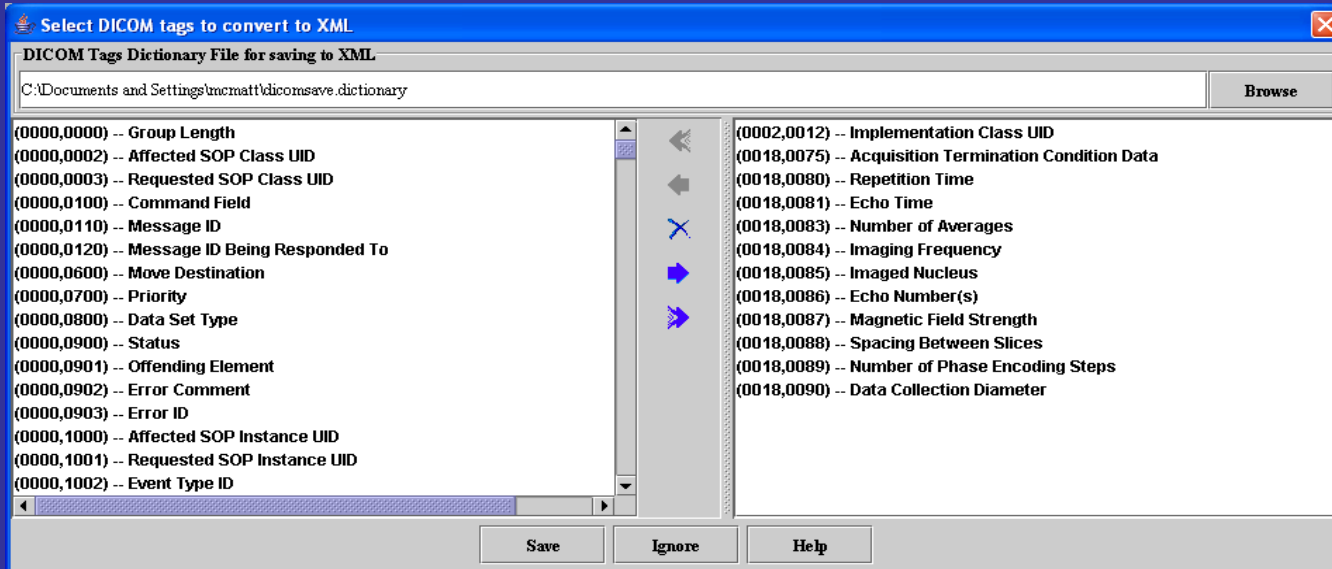
XML Schema File Format



XML Spy v4.3 U Registered to Linda Myles (NIH/CIT) ©1998-2002 Altova GmbH & Altova, Inc.



XML Schema File Format

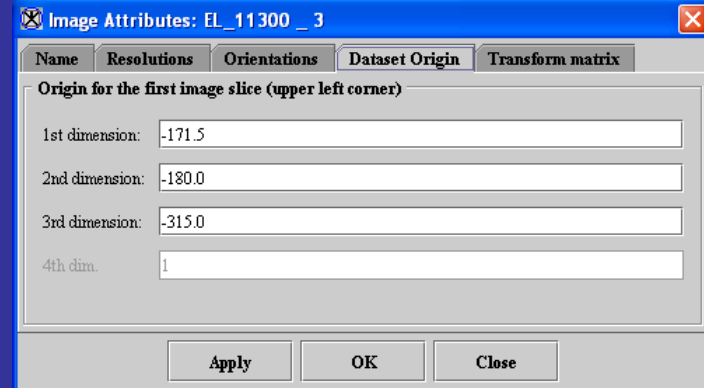
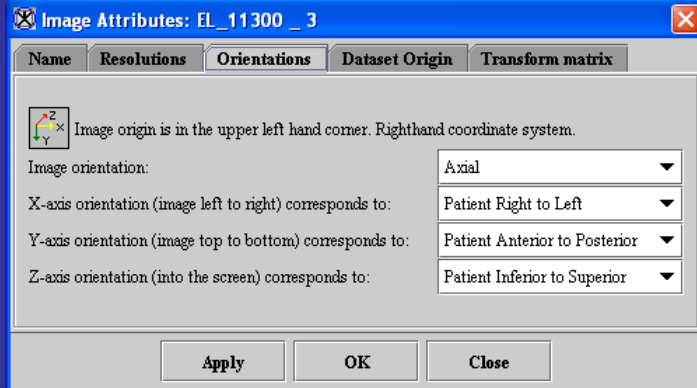
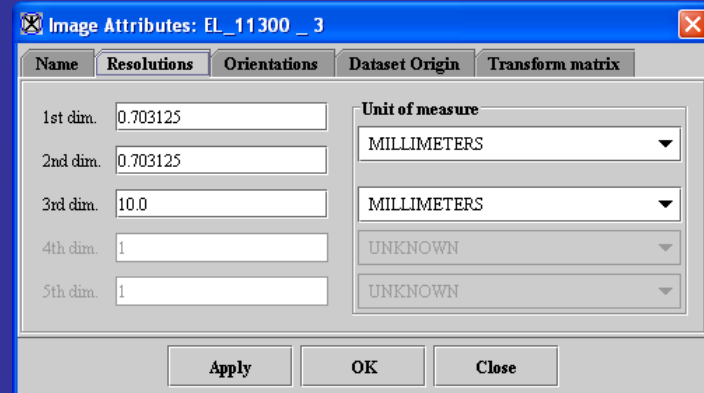
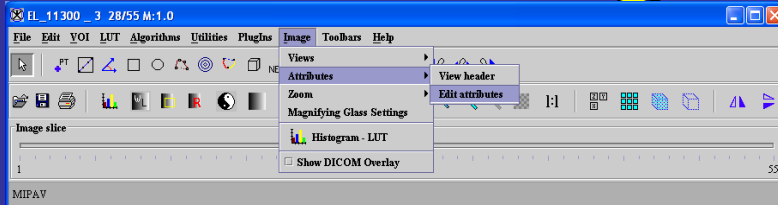


XML Schema File Format

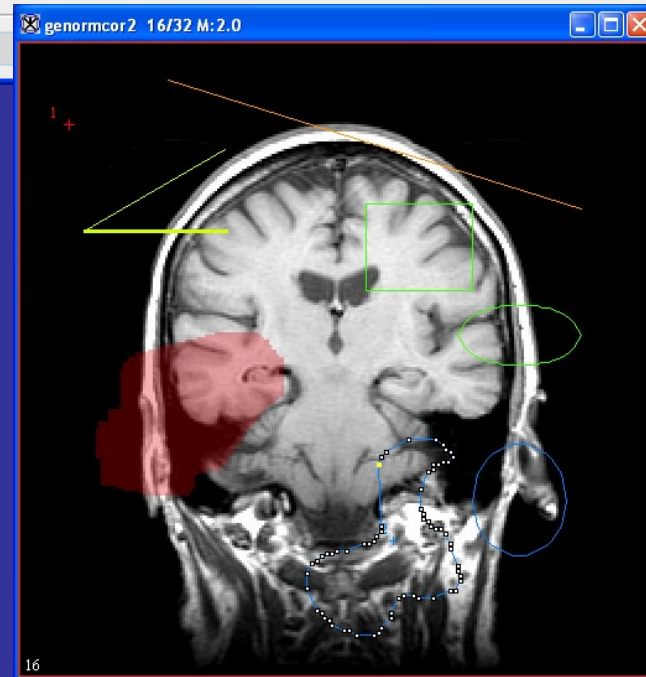
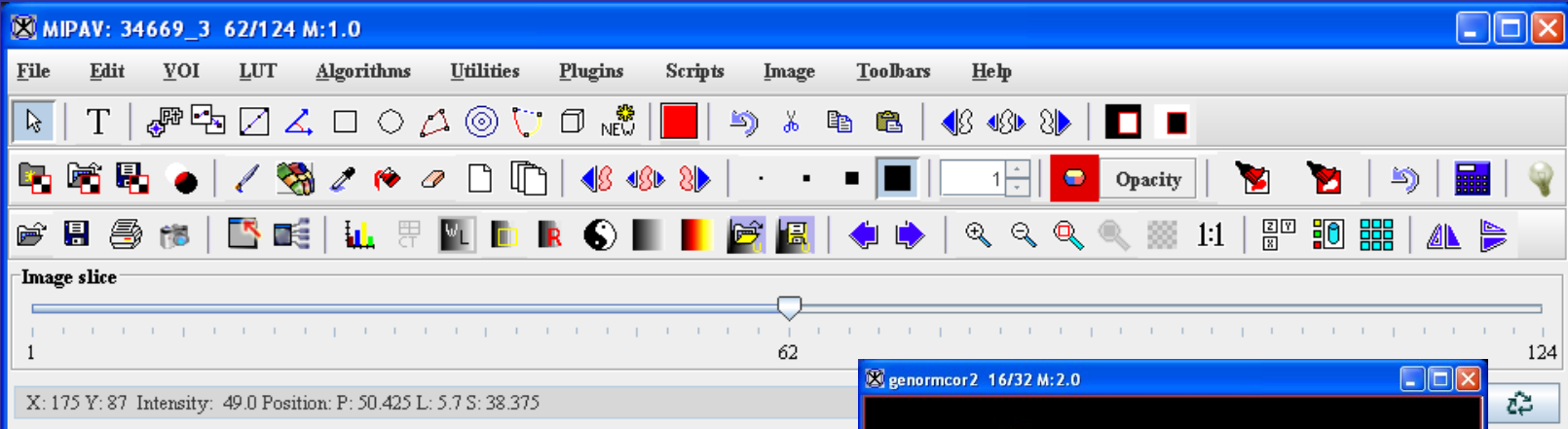
```
<?xml version="1.0" encoding="UTF-8" ?>
<!-- MIPAV header file -->
- <image xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  filename="junk.raw" nDimensions="3">
- <Dataset-attributes>
  <Image-offset>0</Image-offset>
  <Data-type>Short</Data-type>
  <Endianness>Little</Endianness>
  <Extents>512</Extents>
  <Extents>512</Extents>
  <Extents>55</Extents>
  <Resolutions>0.703125</Resolutions>
  <Resolutions>0.703125</Resolutions>
  <Resolutions>10.0</Resolutions>
  <Slice-spacing>0.0</Slice-spacing>
  <Units>Millimeters</Units>
  <Units>Millimeters</Units>
  <Units>Millimeters</Units>
  <Compression>zipped</Compression>
  <Orientation>Axial</Orientation>
  <Subject-axis-orientation>Right to Left</Subject-axis-orientation>
  <Subject-axis-orientation>Anterior to Posterior</Subject-axis-orientation>
  <Subject-axis-orientation>Inferior to Superior</Subject-axis-orientation>
  <Origin>-171.5</Origin>
  <Origin>-180.0</Origin>
  <Origin>-315.0</Origin>
  <Modality>Computed Tomography</Modality>
```



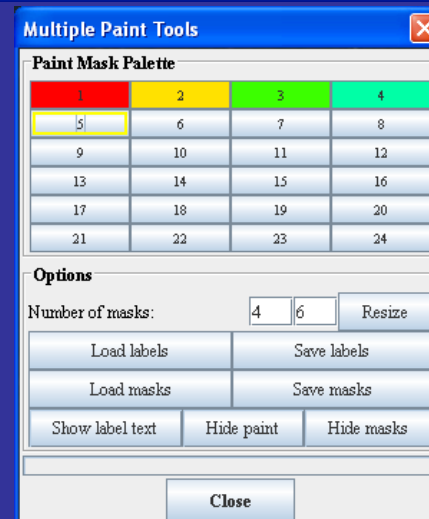
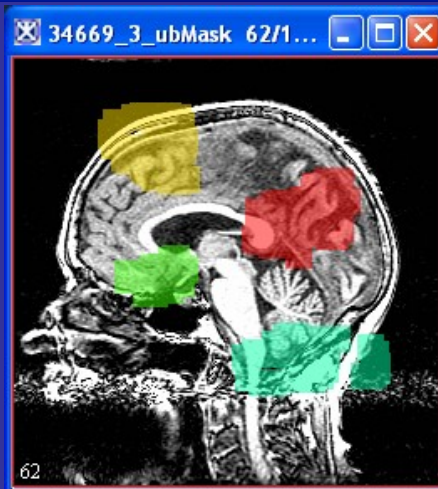
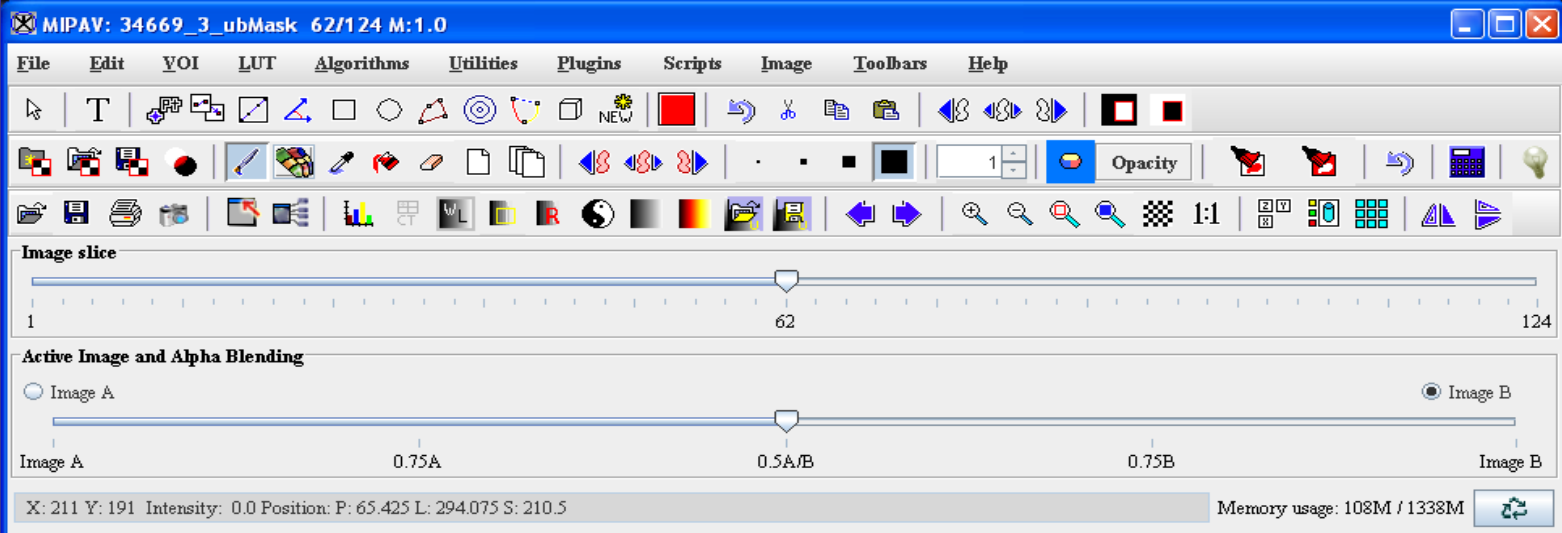
Image Attributes



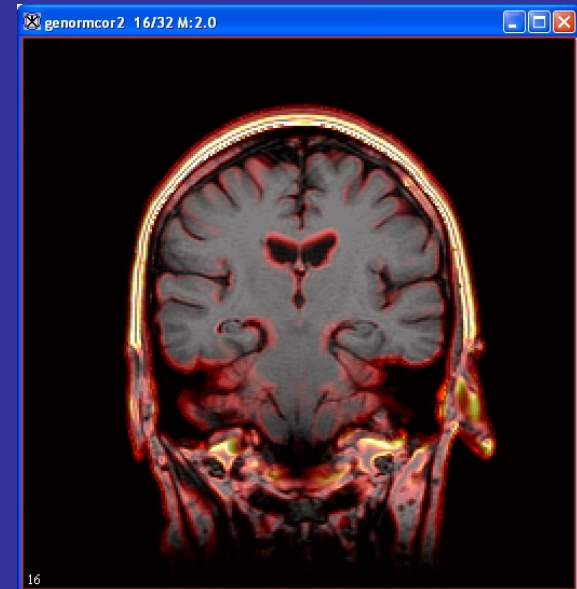
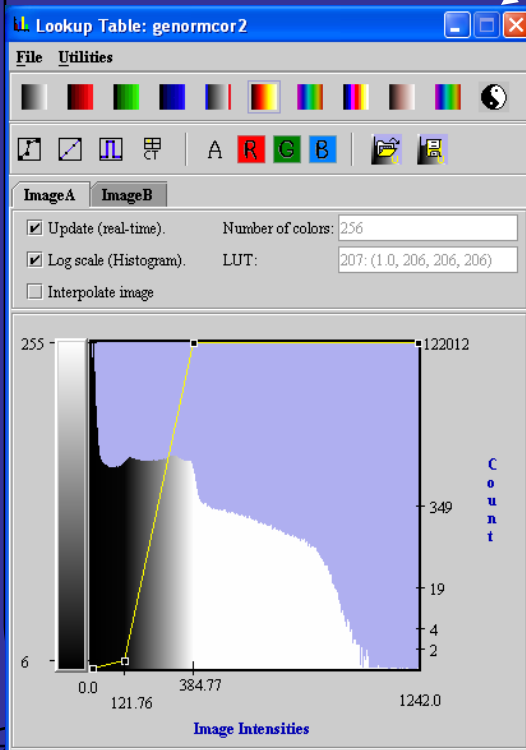
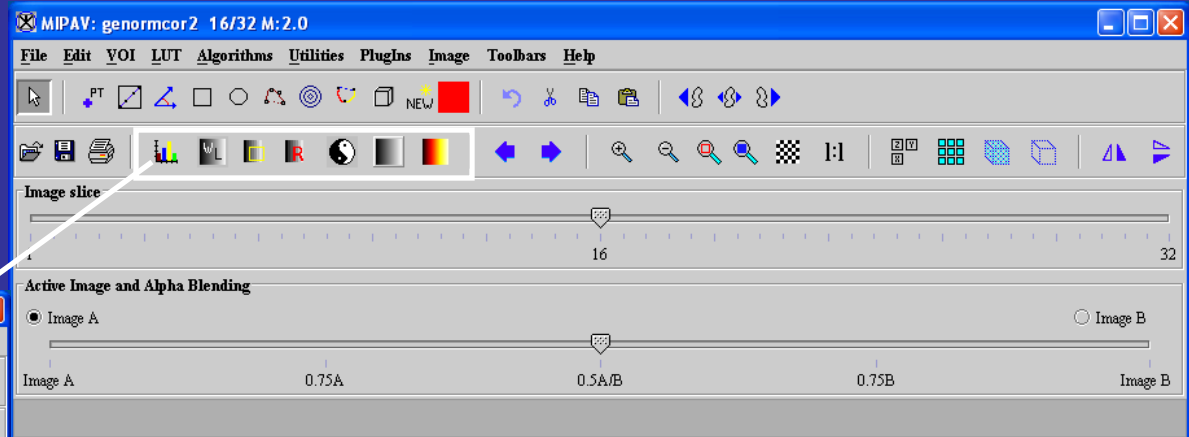
VOIs & Demo



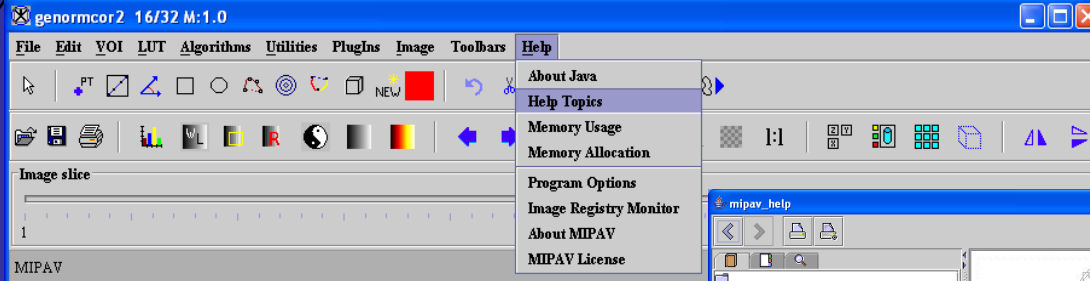
VOIs & Demo



LUTs- Demo



Help & Demo



Multi-planar and Lightbox

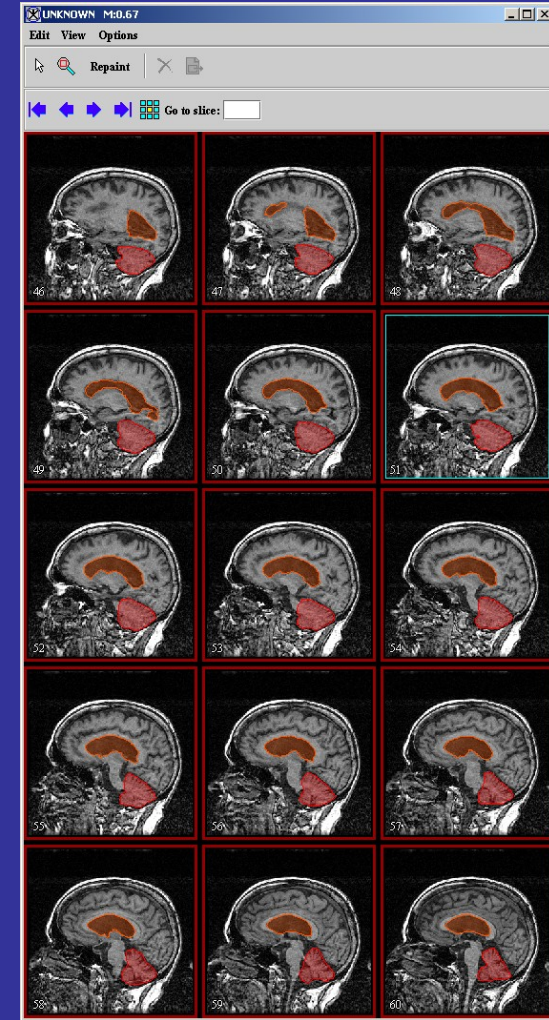
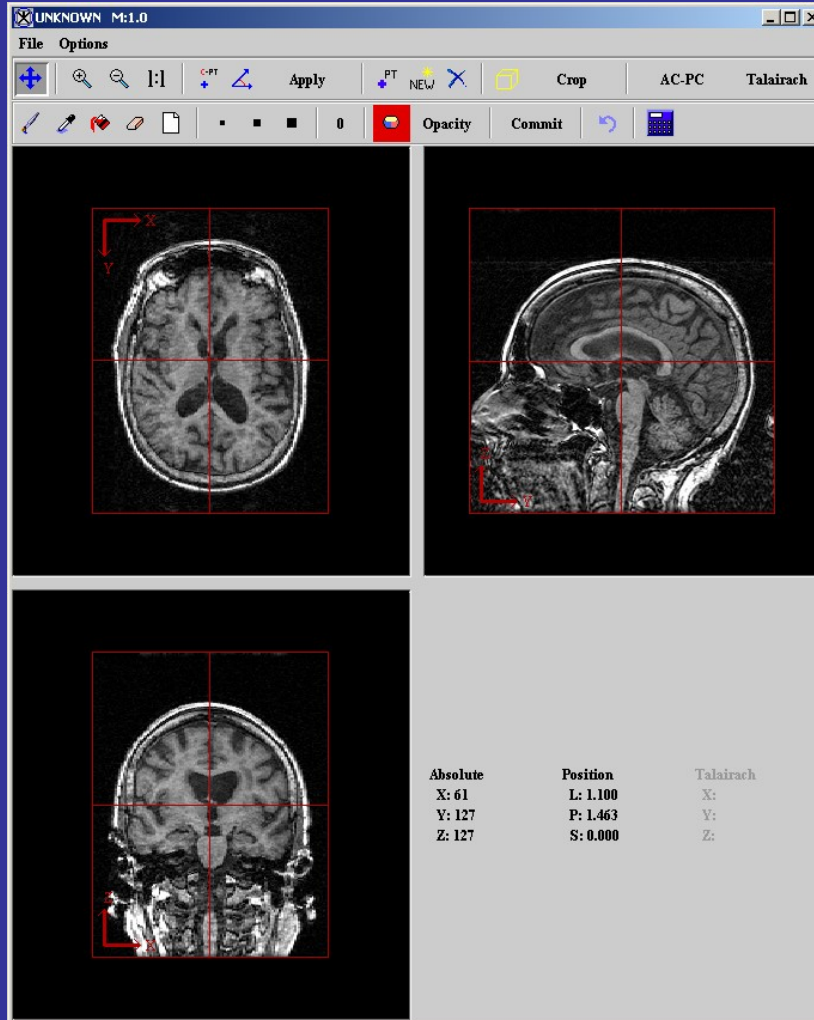
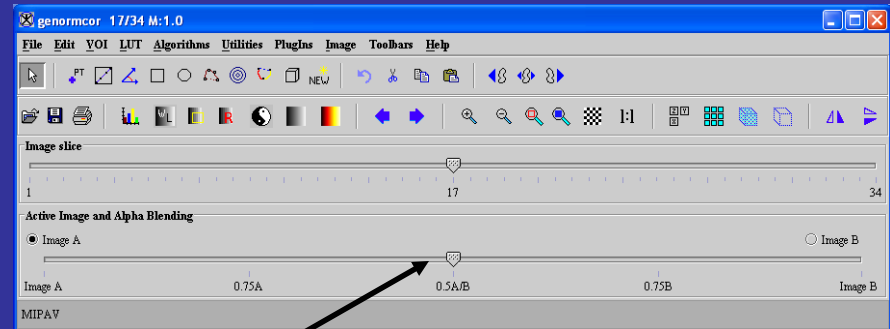
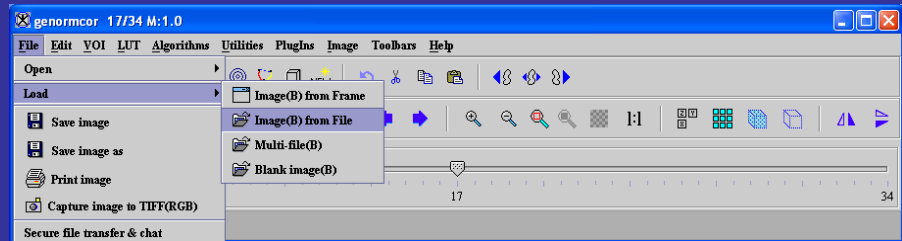
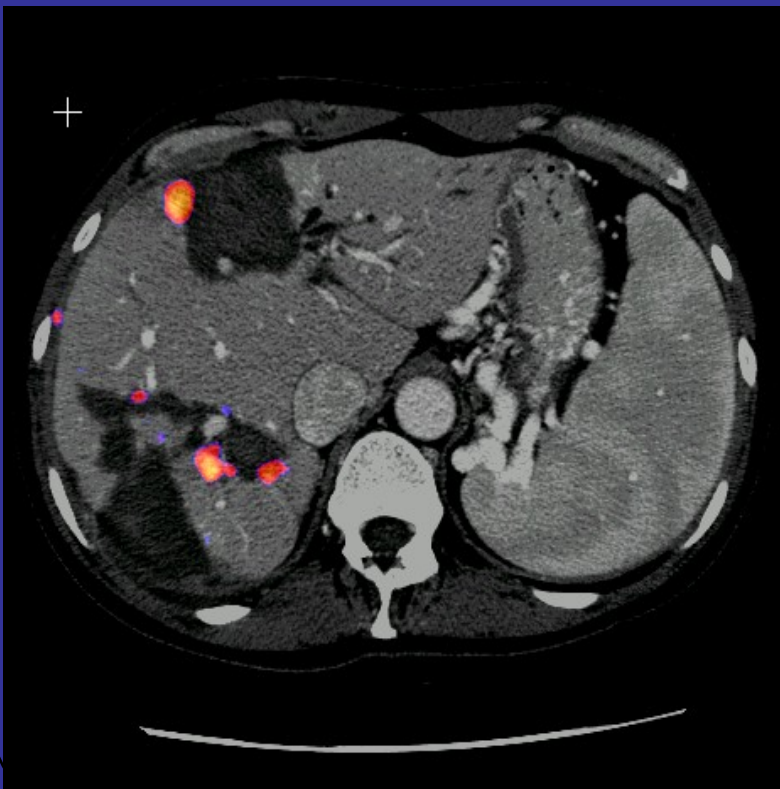


Image Fusion

The **loading** of two images into the same frame

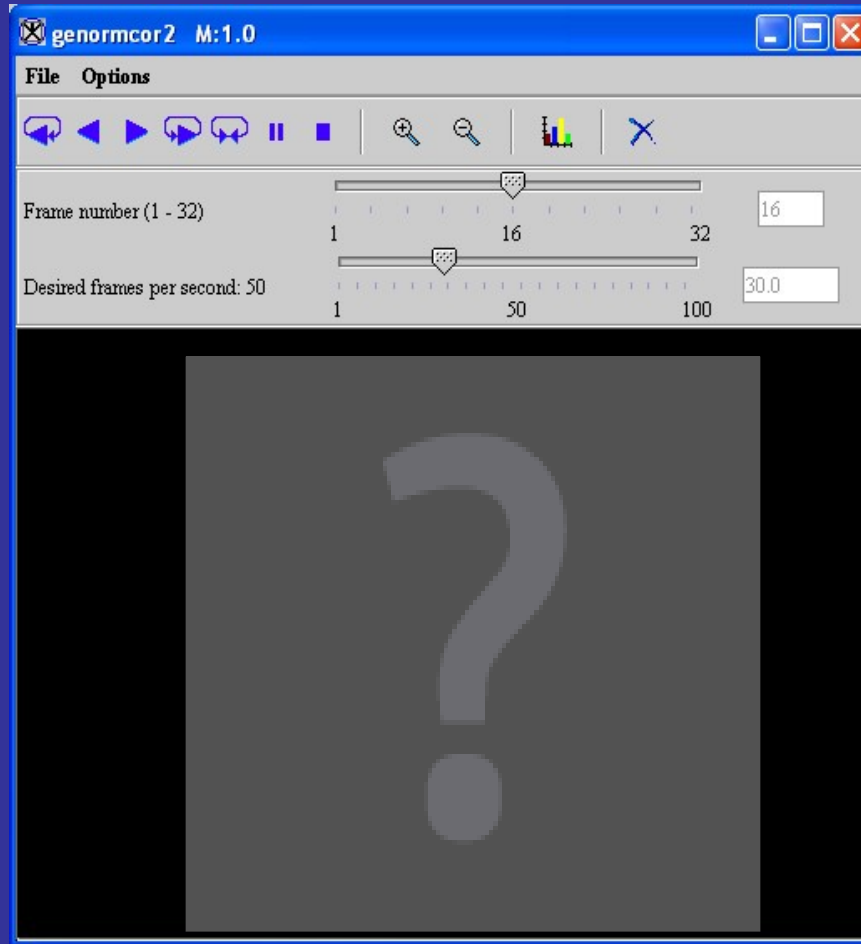


Controls blending between the two images

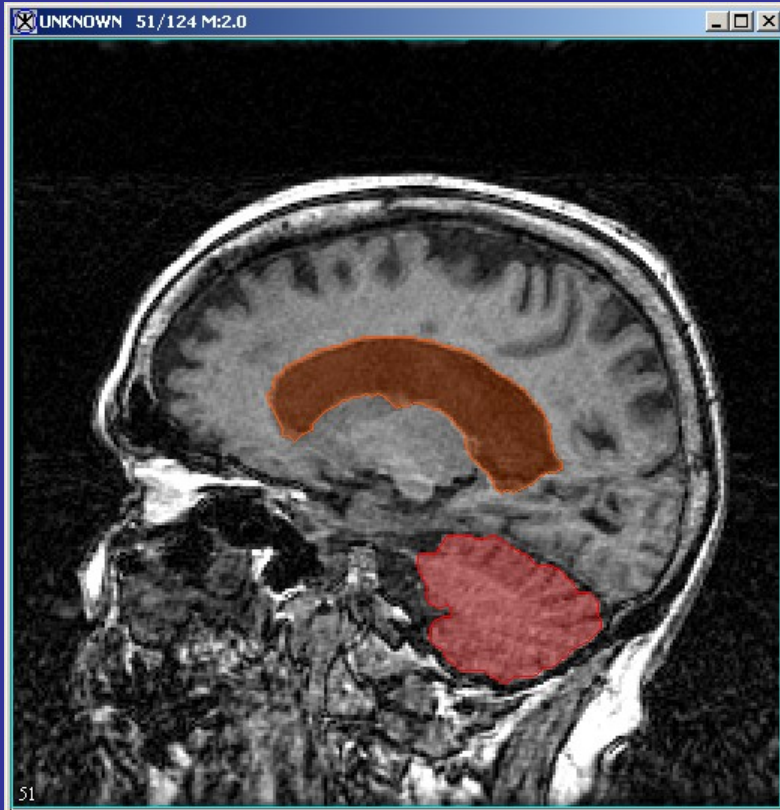
Structural MRI and Functional MRI



Animation Tool



Surface



MRA MIP





Scripting Demo



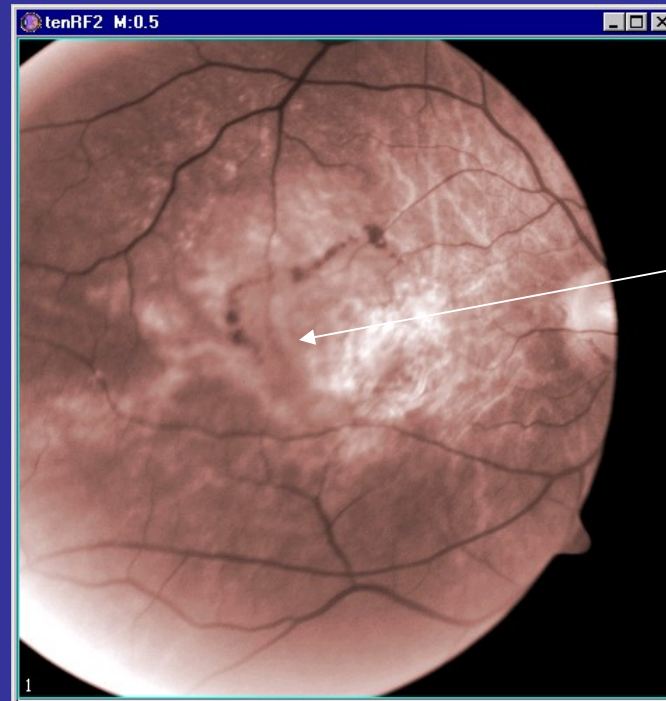


Application example
Age-related macular degeneration
(AMD)



Background

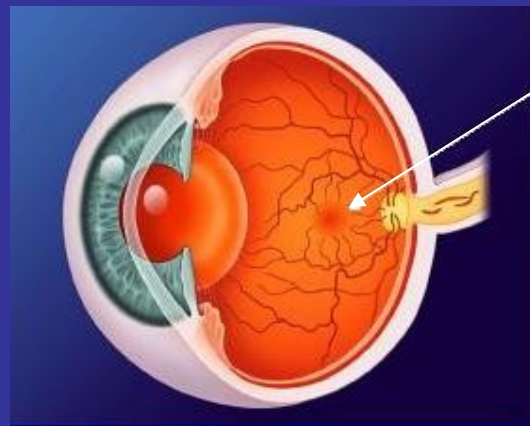
Fluorescein Angiography (FA) Imaging shows retinal vessels and can be seen in the visible light spectrum



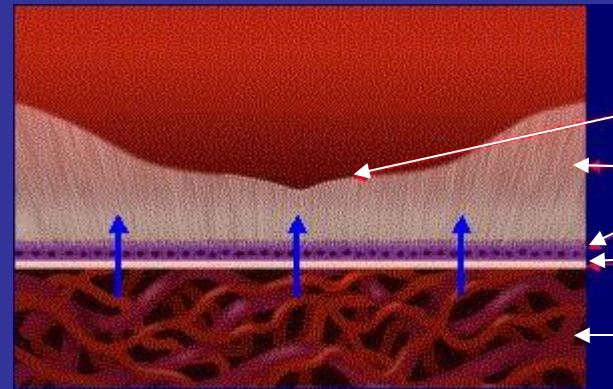
But a lesion obscures the feeder vessel

Background

High-speed Indocyanine Green (ICG) imaging shows the vessels of the choroid behind the retina and can only be captured in the infra-red (IR) spectrum.



Macula



Healthy Fovea

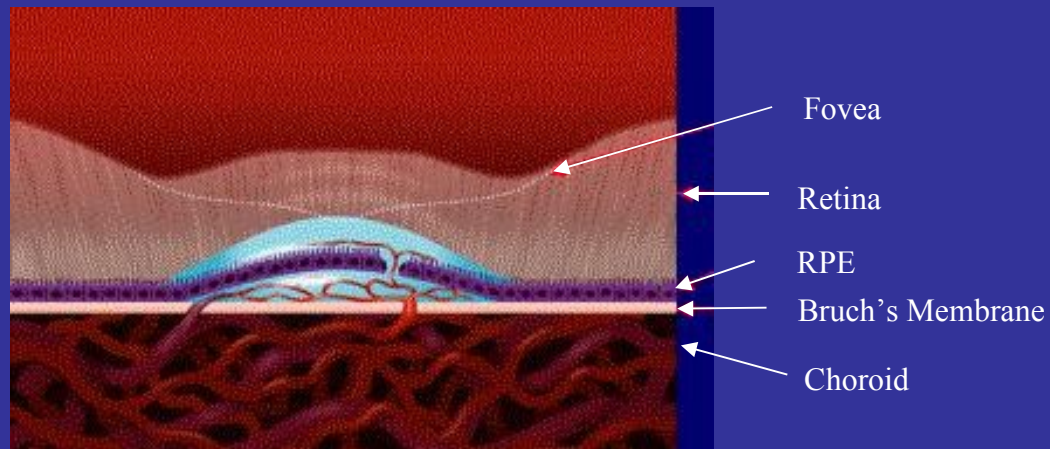
Retina

RPE

Bruch's Membrane

Choroid

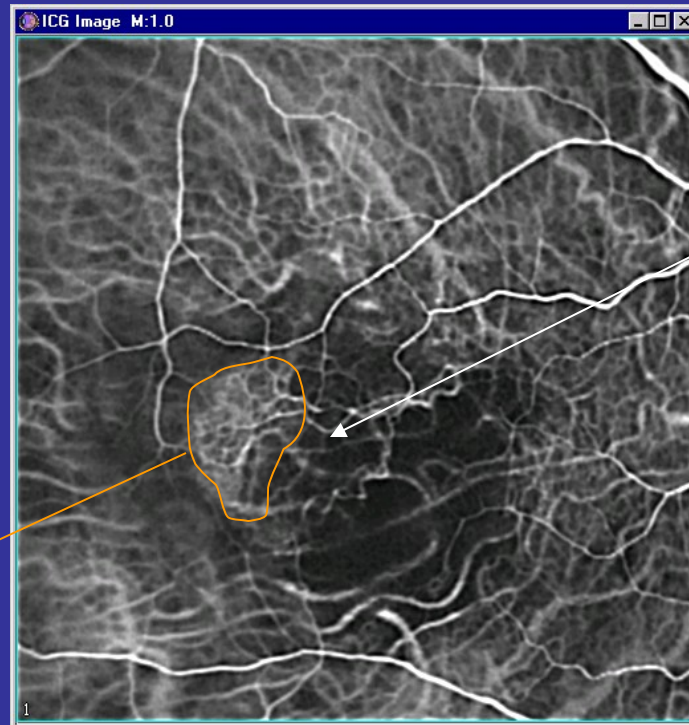
Wet Age Related Macular Degeneration (AMD)



Background

ICG Images show choroidal vessels. The feeder vessel can be readily identified in the IR spectrum.

area of neo-vascularization



feeder vessel

Problem

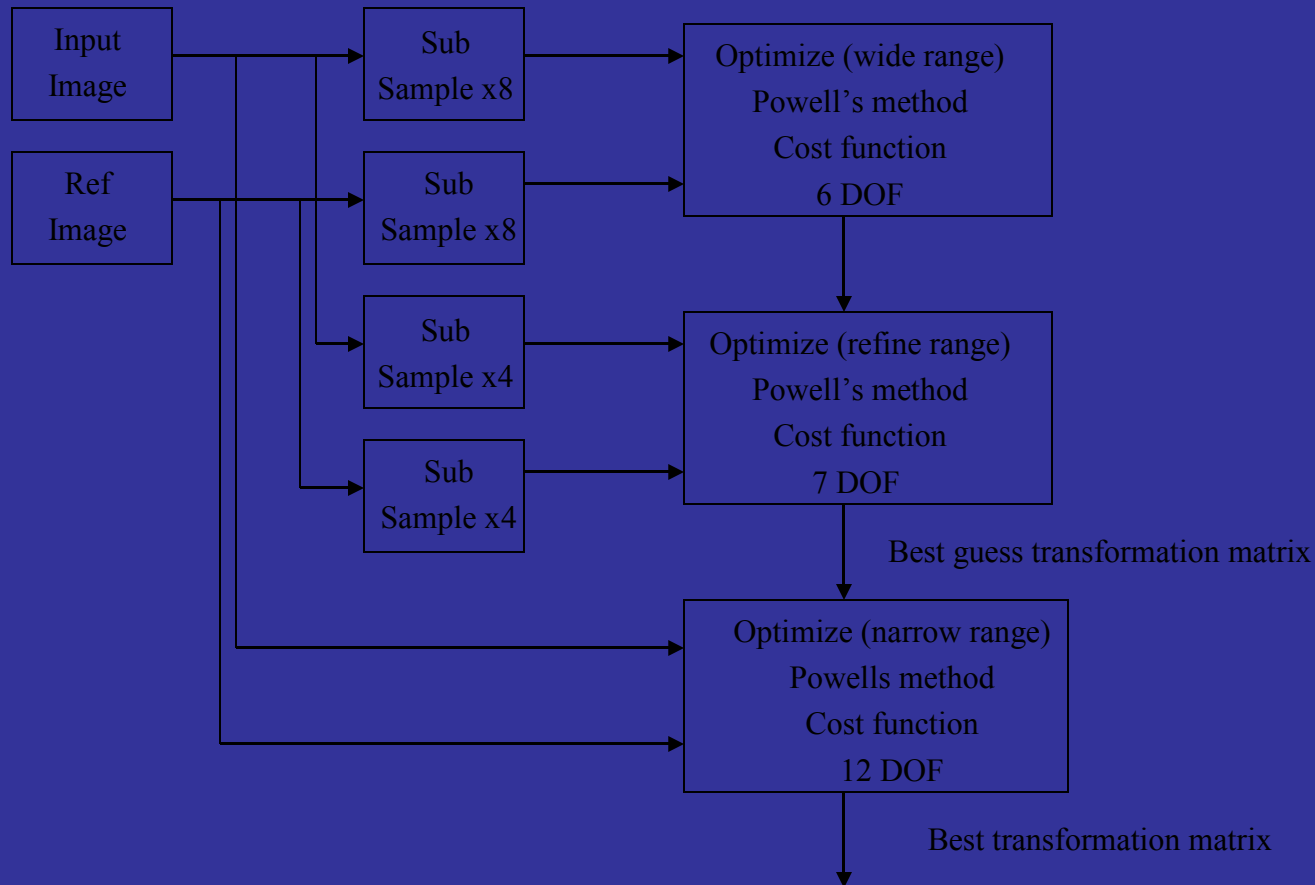
- Feeder vessels can be identified in ICG Images using IR light spectrum
- Feeder vessels cannot be seen in the visible light spectrum, where treatment occurs



ICG Time Series Before Registration



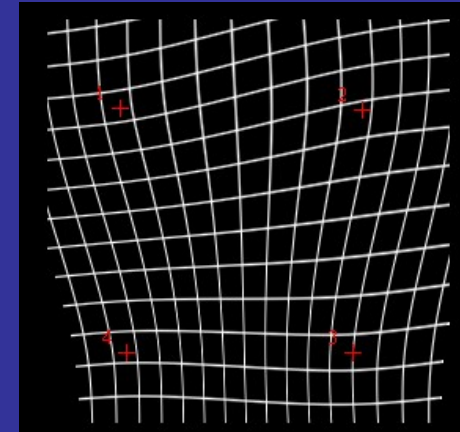
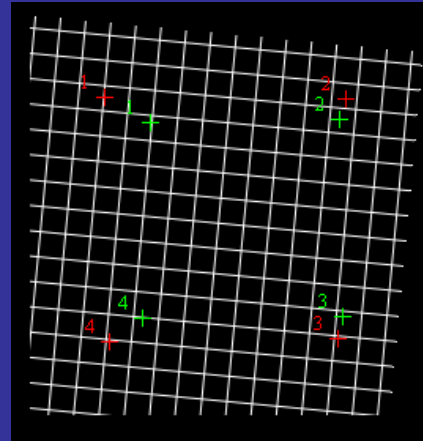
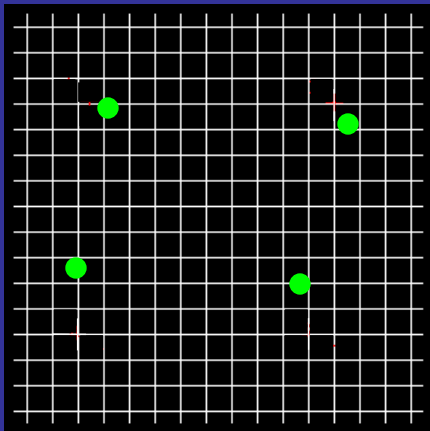
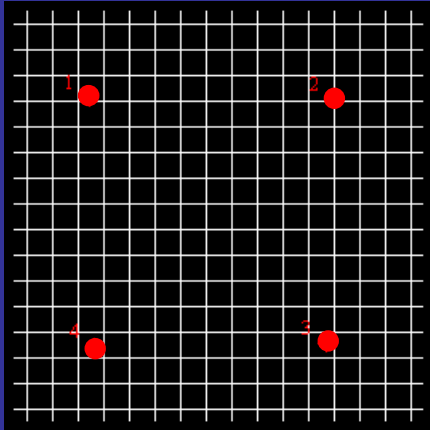
Multi-scale Registration



ICG Time Series After Registration



Landmark Registration Techniques



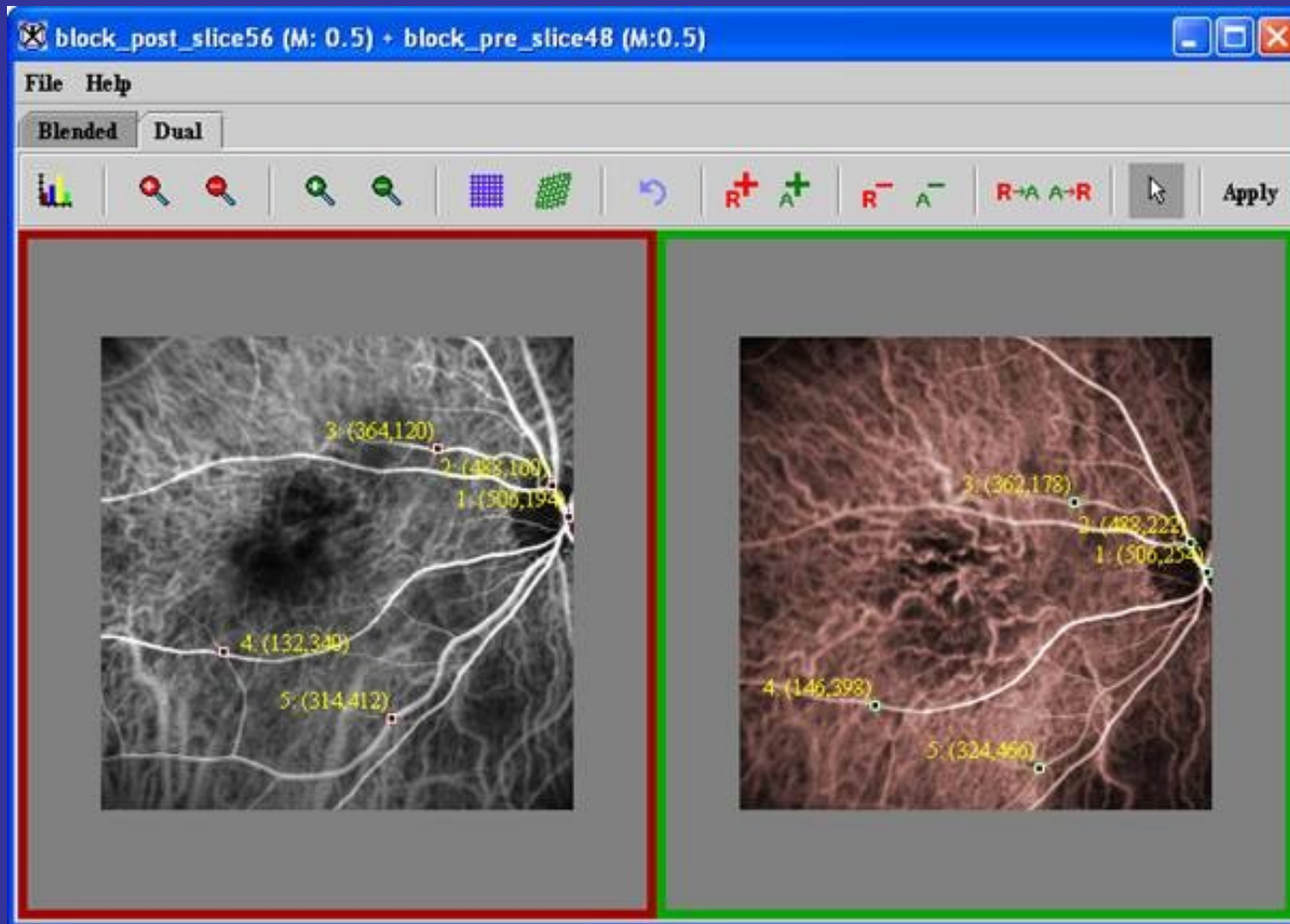
Least squares registration
(rotation & translation)

Thin plate splines registration
(rotation, translation, scale,
and non-linear)

Grid with landmarks
points



Landmark Registration Techniques



Red Free Image blended with registered ICG Image



Cell Motion Study (Registration)



Unregistered

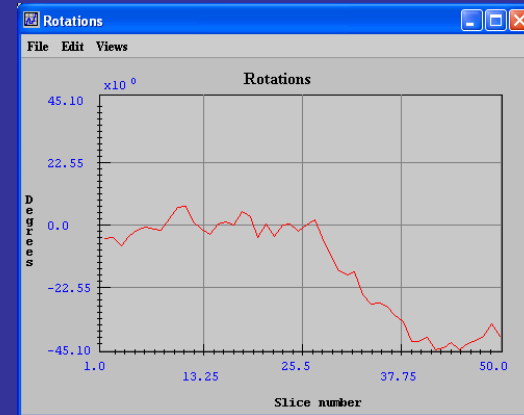
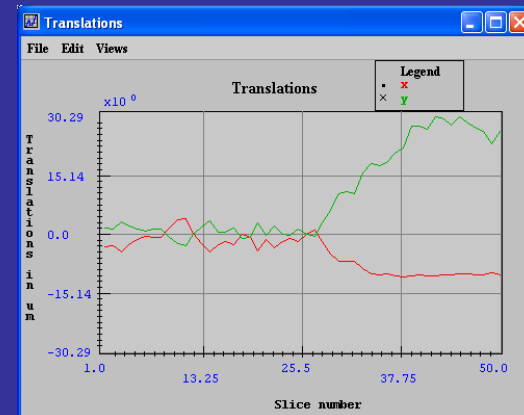


Model based registration (2 DOF)

Cell Motion Study (Registration)

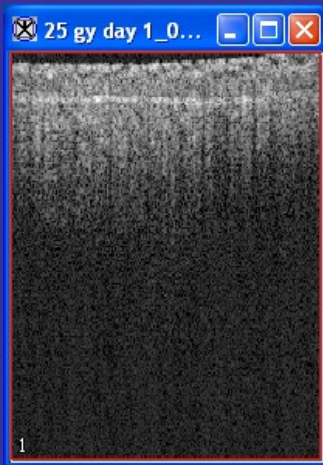


Pixel similarity registration (3 DOF)

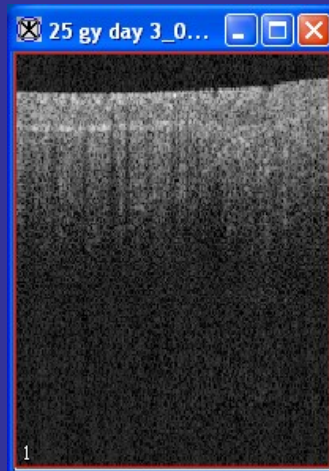


Radiation Treatment Study - NCI

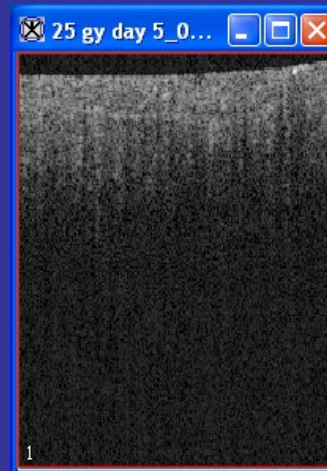
Image collected using Optical Coherence Tomography (OCT)



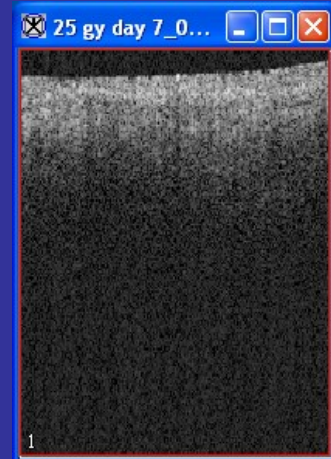
Day 1



Day 3



Day 5



Day 7

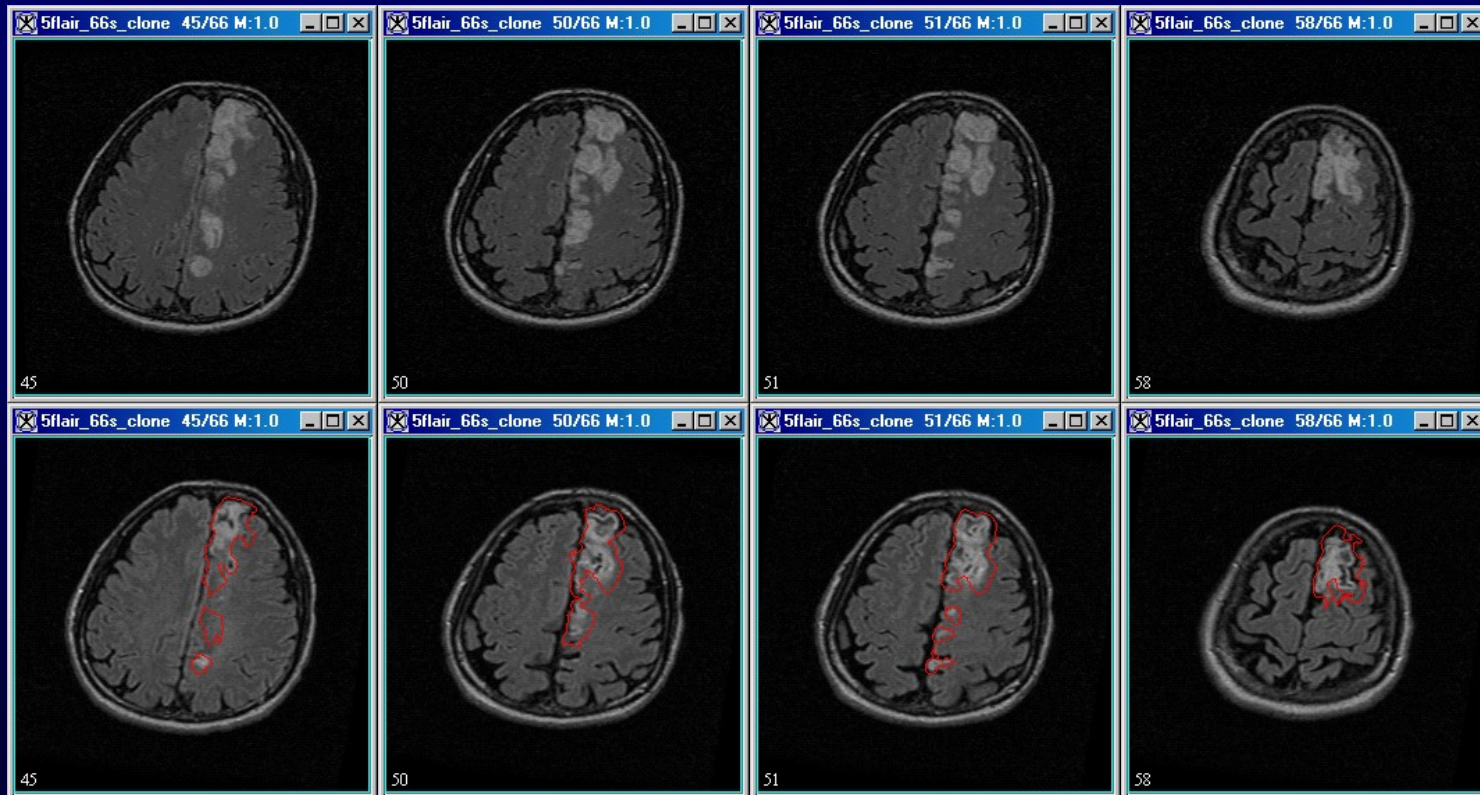
Rat tongue exposed to 25Gy

25 gy day 1_03_clone Average length = 47.38 pixel thickness
25 gy day 3_03_clone Average length = 45.285 pixel thickness
25 gy day 5_03_clone Average length = 38.725 pixel thickness
25 gy day 7_03_clone Average length = 34.795 pixel thickness

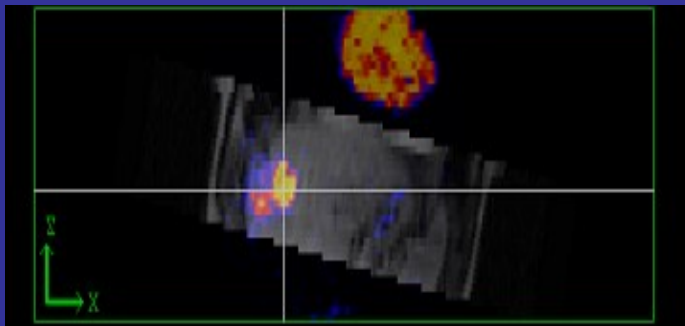
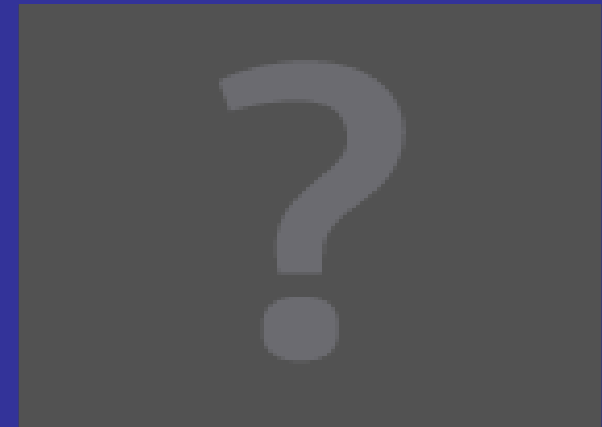
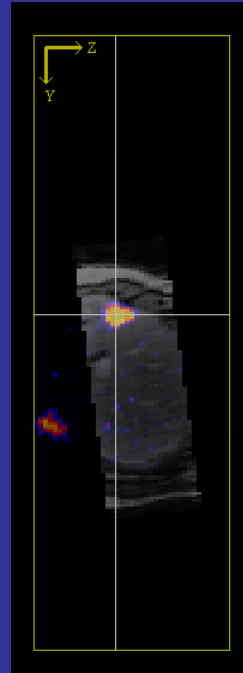
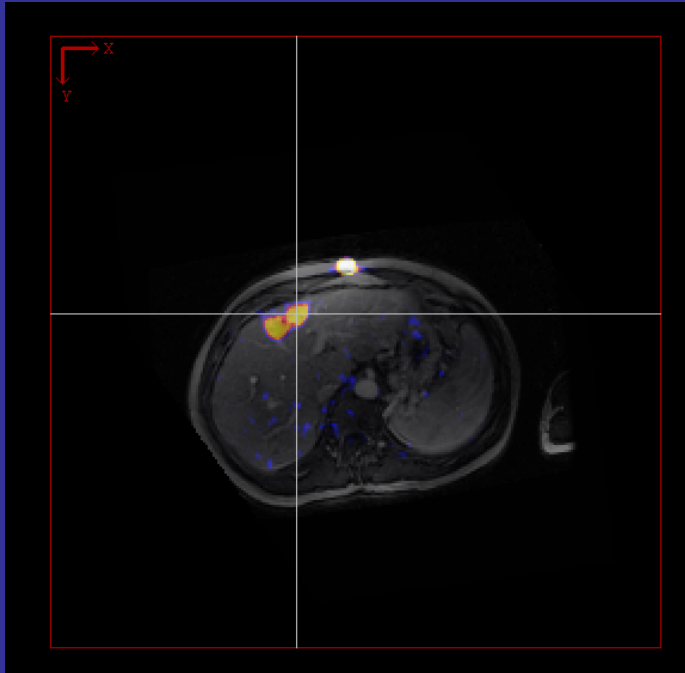
Method: Median filter, Otsu Thresholding, Vertical Thickness calculation



Reduction in swelling?

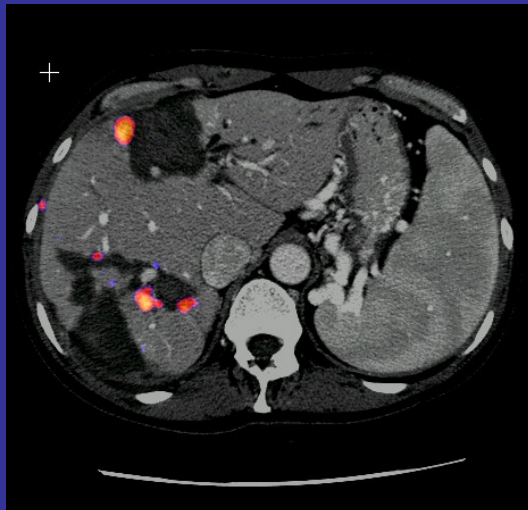


PET and MRI Fusion

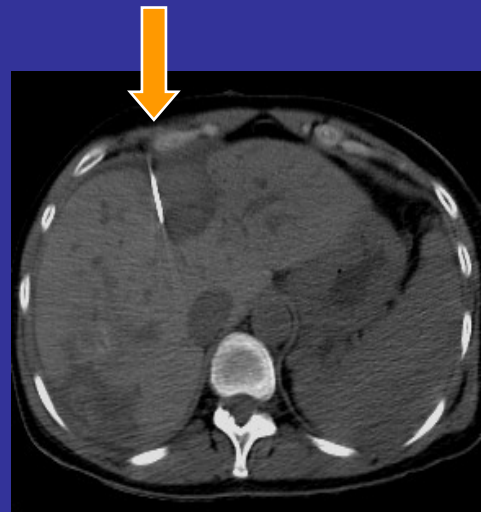


Co-registration – Guidance for Radio Frequency Ablation (RFA)

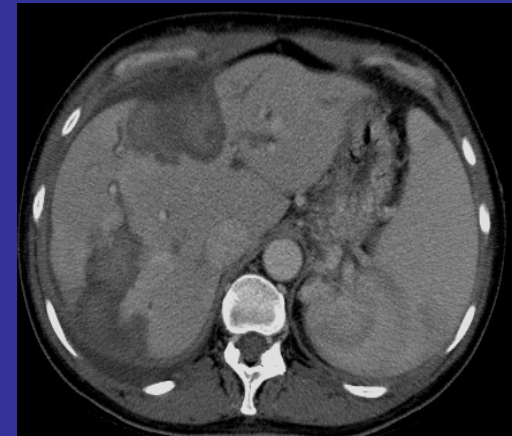
PET and CT fused
Pre-RFA



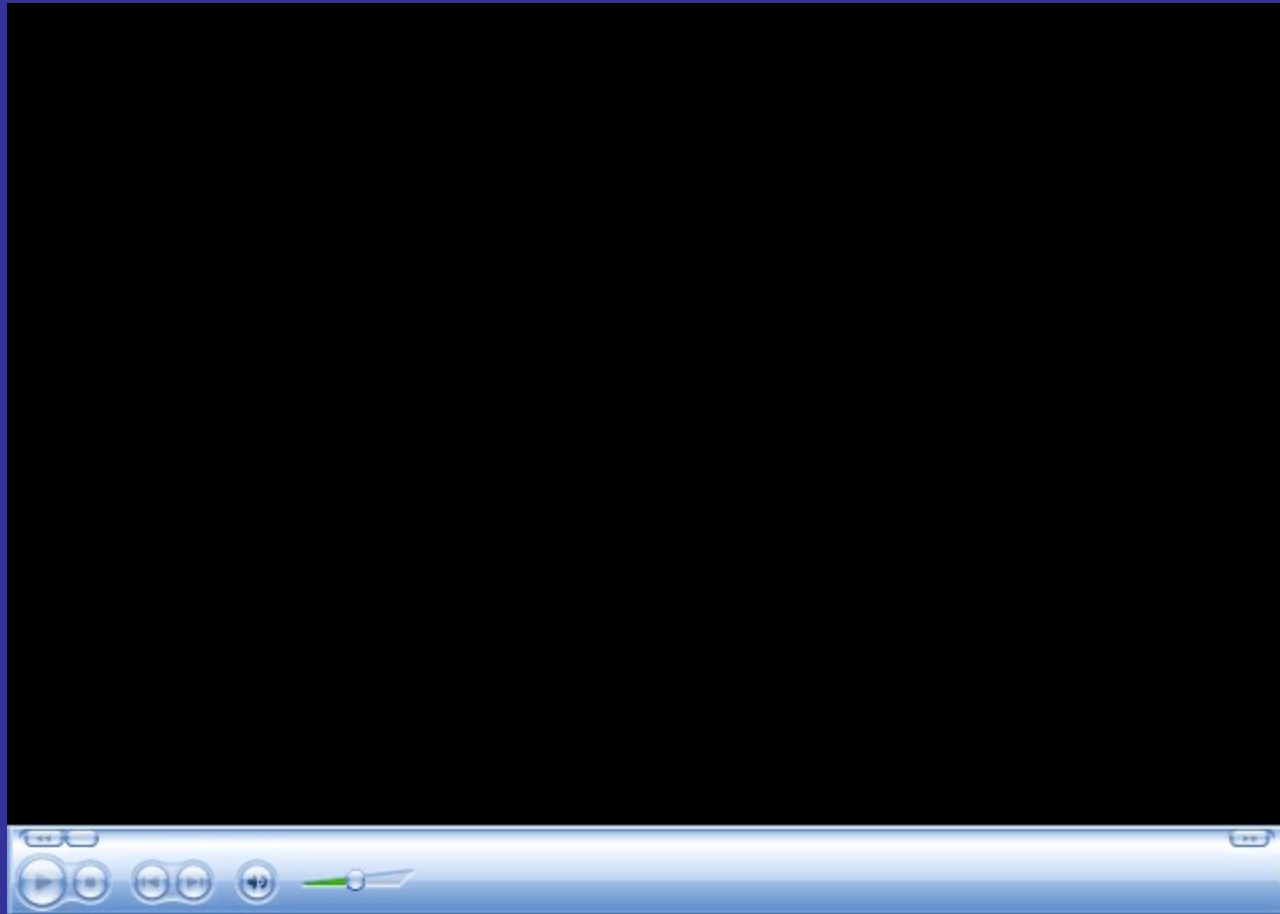
RFA probe



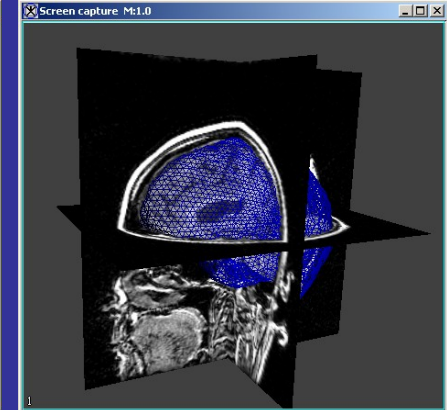
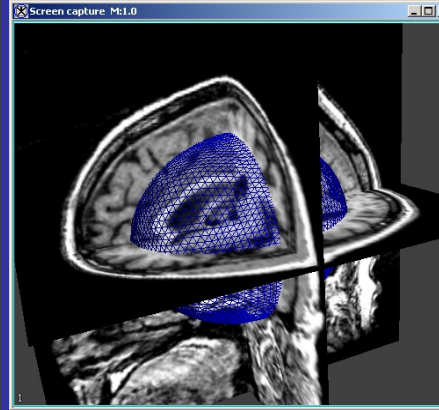
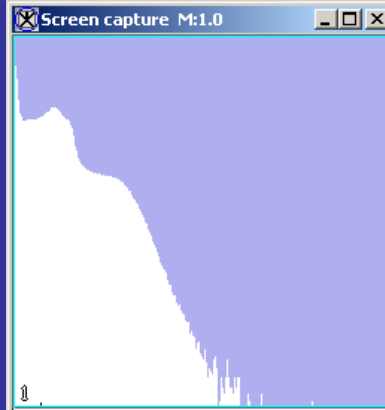
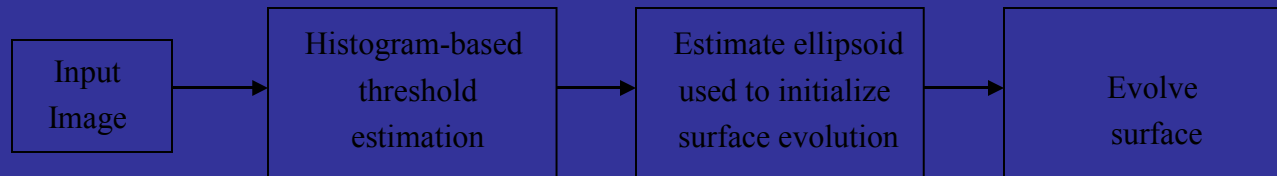
Post-RFA



Radio Frequency Ablation (RFA)



Surface Model Example “Deskulling”



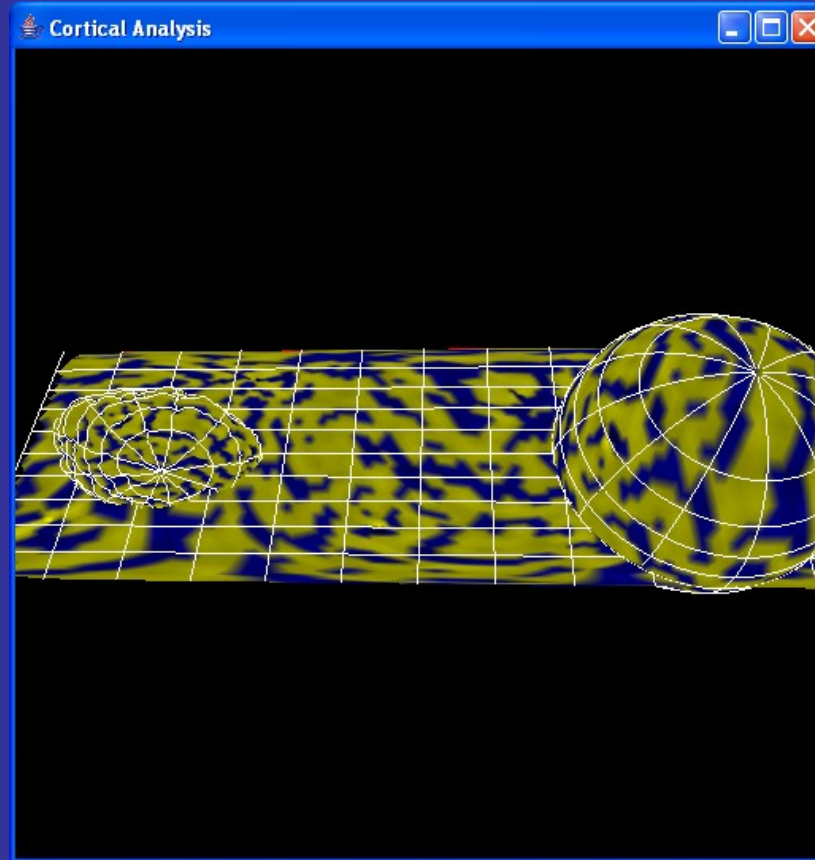
Based on: Brain Extraction Tool (BET)

Deskulling data

- Evaluation 511 patients T1 MRI datasets of the head where acquired on a 1.5 Tesla GE Signa Advantage
 - Each dataset was manually segmented and used to represent truth. Average total volume (ATV) = 1482 cm³
 - The datasets where segmented using
 - Brain Extraction Tool (BET) ATV = 1676 cm³ correlation 94%
 - Brain Surface extractor (BSE) ATV = 1449 cm³ correction 87%
 - MIPAV implementation of the BET tool (with some mods.)
ATV = 1540 cm³ correction 94%



Cortical Surface (work in progress)



Future Directions

- Brain imaging
 - Brain segmentation (done)
 - Tissue classification via Fuzzy C-means (done)
 - Affine Registration (done)
 - Talairach mapping (done)
 - Cortical surface mapping (in progress)
 - Nonlinear registration (done)
 - Model based segmentation (future)
- Enhance volume rendering tools
 - Volume rendering (working)
 - Surface rendering (working)
- Port and develop new algorithms
- Update user manual
- Improve scripting (done)



