

3D Slicer as image-guided therapy (IGT) software application platform

Andras Lasso

Laboratory for Percutaneous Surgery
School of Computing, Queen's University, Canada

Commercial software	Research software
Fully optimized for specific purposes	Very flexible, fits many purposes, easy to customize/extend
Simple, easy to use	Complex, may be difficult to use
Fast, robust	Might be slower, might have robustness problems
Uses closed source, in-house developed and maintained libraries	Uses state-of-the-art, actively developed open source libraries
Thoroughly tested, fully documented (fully FDA, CE compliant + as high quality as possible)	Tested & documented as reasonable (optimized for quality)
Very expensive	Mostly free



Commercial software

Fully optimized for specific purposes



documented (fully FDA, CE compliant + as high quality as possible)

Very expensive

Research software

Very flexible, fits many purposes, easy to customize/extend



reasonable (optimized for quality)

Mostly free

Without an application platform

- Completely new software is developed for each problem/procedure/device
- Each application is developed from ground up
- Significant work is needed to integrate new, advanced algorithms

Quick start. Huge waste of time/money/effort overall.

Building on an application platform

- Core functionalities are already implemented
- Many new, advanced algorithms are available
- New software module can be developed for specific needs

Huge investment at the beginning: learning.
Minimal wasted efforts.



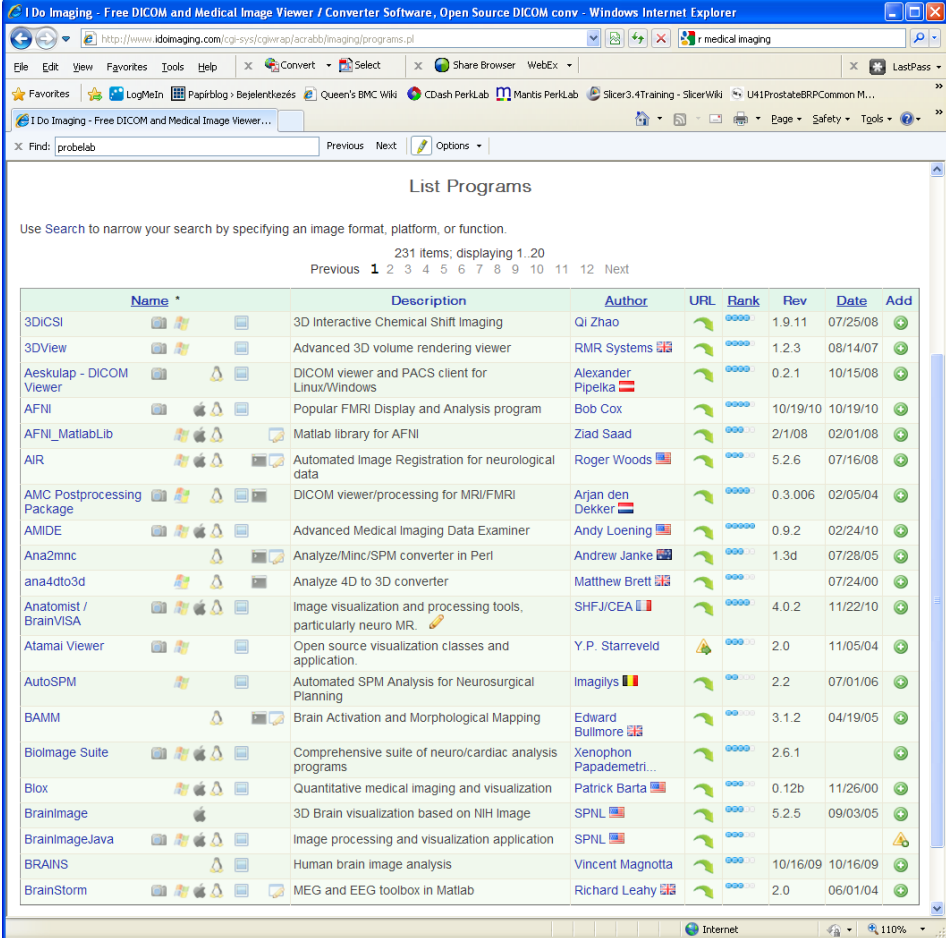
Which application platform?

100+ free medical imaging software applications

Most of them are designed to be extensible application platforms

I DO IMAGING
FREE MEDICAL IMAGING SOFTWARE

<http://www.idoimaging.com>



The screenshot shows a web browser window displaying the 'List Programs' page on the I Do Imaging website. The page lists 231 items, with 1-20 displayed. The table below is a representation of the data shown in the screenshot.

Name	Description	Author	URL	Rank	Rev	Date	Add
3DICS	3D Interactive Chemical Shift Imaging	Qi Zhao		1.9.11	07/25/08		
3DView	Advanced 3D volume rendering viewer	RMR Systems		1.2.3	08/14/07		
Aeskulap - DICOM Viewer	DICOM viewer and PACS client for Linux/Windows	Alexander Pipelka		0.2.1	10/15/08		
AFNI	Popular FMRI Display and Analysis program	Bob Cox		10/19/10	10/19/10		
AFNI_MatlabLib	Matlab library for AFNI	Ziad Saad		2/1/08	02/01/08		
AIR	Automated Image Registration for neurological data	Roger Woods		5.2.6	07/16/08		
AMC Postprocessing Package	DICOM viewer/processing for MRI/FMRI	Arjan den Dekker		0.3.006	02/05/04		
AMIDE	Advanced Medical Imaging Data Examiner	Andy Loening		0.9.2	02/24/10		
Ana2mnc	Analyze/Minc/SPM converter in Perl	Andrew Janke		1.3d	07/28/05		
ana4to3d	Analyze 4D to 3D converter	Matthew Brett			07/24/00		
Anatomist / BrainVISA	Image visualization and processing tools, particularly neuro MR.	SHFJ/CEA		4.0.2	11/22/10		
Atamal Viewer	Open source visualization classes and application.	Y. P. Starreveld		2.0	11/05/04		
AutoSPM	Automated SPM Analysis for Neurosurgical Planning	Imagilys		2.2	07/01/06		
BAMM	Brain Activation and Morphological Mapping	Edward Bullmore		3.1.2	04/19/05		
BiImage Suite	Comprehensive suite of neuro/cardiac analysis programs	Xenophon Papademetri...		2.6.1			
Blox	Quantitative medical imaging and visualization	Patrick Barta		0.12b	11/26/00		
BrainImage	3D Brain visualization based on NIH Image	SPNL		5.2.5	09/03/05		
BrainImage.Java	Image processing and visualization application	SPNL					
BRAINS	Human brain image analysis	Vincent Magnotta		10/16/09	10/16/09		
BrainStorm	MEG and EEG toolbox in Matlab	Richard Leahy		2.0	06/01/04		



Table 2 | A selective list of MRI visualization tools

Name	Cost	OS	Description	URL
3D Slicer*	Free	Win, Mac, Linux	Tools for visualization, registration, segmentation and quantification of medical data; extensible; uses VTK and ITK	http://www.slicer.org/
Amin*	€	Win, Mac, Linux	Allows 2D slices to be viewed from any angle; provides image segmentation, 3D mesh generation; surface rendering; data overlay and quantitative measurements	http://www.aminids.com/
Analyze	\$	Win, Mac, Linux	Medical image analysis software for Windows, Macintosh and Linux	http://www.slicer.org/
Anatomist	Free	Win, Mac, Linux	Medical image visualization and analysis software	http://www.slicer.org/
AVS	\$	Win, Mac, Linux	General purpose data visualization package	http://www.avs.com/
BioImage Suite*	Free	Win, Mac, Linux	Tools for biomedical image analysis; includes preprocessing, voxel-based classification; image registration; diffusion image analysis; cardiac image analysis; fMRI activation detection	http://bioimagesuite.org/
BrainSuite	Free	Win, Mac, Linux	Automated cortical surface extraction from MRI; orthogonal image viewer; automated and interactive segmentation and labeling; surface visualization	http://tiny.cc/0w6vx
BrainVISA	Free	Win, Mac, Linux	Toolbox for segmentation of T1-weighted images; performs classification and mesh generation on brain images; automated sulcal labeling	http://brainvisa.info/
BrainVoyager	\$	Win, Mac, Linux	Analysis and visualization of MRI and fMRI data and for EEG and MEG distributed source imaging	http://tiny.cc/4FKiv
Cardiac Image Modeller	\$	Irix	Visualization and functional analysis, in 3D space and through time of cardiac cine data	http://tiny.cc/4K16E
DTIStudio	Free	Win, Mac, Linux	DTI visualization and analysis software	http://tiny.cc/pvUSB
FreeSurfer	Free	Mac, Linux	Automated cortical surface extraction from structural MRI data	http://tiny.cc/H3uGS
FSL*	Free	Win, Mac, Linux	Comprehensive library of analysis tools for fMRI, MRI and DTI brain imaging data, includes widely used registration and segmentation tools	http://tiny.cc/WFP10
ImageJ	Free	Win, Mac, Linux	Image processing, extensible (in Java), large user community	http://rsb.info.nih.gov/ij/
ImagePro	€	Win	Image processing software	http://www.miproc.com/
ITK	Free	Win, Mac, Linux	Open source software for image processing and visualization	http://www.itk.org/
Jim	€	Win, Mac, Linux	Medical image visualization and registration; includes magnification, pan/zoom, image maps from file data	http://www.jim-software.com/
MRAT	Free	Win, Mac, Linux	Workflow environment bringing together online resources, a user's image data and biological atlases in a unified workspace; extensible via plug-ins	http://tiny.cc/MQTx2
MedINRIA	Free	Win, Mac, Linux	Many algorithms dedicated to medical image processing and visualization; provides many modules, including DTI and HARDI viewing and analysis	http://tiny.cc/RG6tv
MIPAV	Free	Win, Mac, Linux	Quantitative analysis and visualization of medical images of numerous modalities such as PET, MRI, CT or microscopy	http://mipav.cit.umd.edu/
OpenDX	Free/€	Win, Mac, Linux	General purpose data visualization package	http://www.opendx.org/
OsiriX*	Free	Mac	Medical image visualization software	http://www.slicer.org/
SCIRun	Free	Win, Mac, Linux	Environment for modeling, simulation and visualization of scientific problems, includes many biological analysis components, such as BioTensor, BioFEM and BioImage	http://tiny.cc/6C6ix
SPM	Free	Win, Mac, Linux	Statistical parametric mapping software; widely used in fMRI; provides segmentation and registration	http://tiny.cc/dVz7
TrackVis	Free	Win, Mac, Linux	Tools to visualize and analyze fiber track data from diffusion MRI (DTI, DSI, HARDI, Q-Ball) tractography	http://trackvis.org/
TractoR	Free	Linux	Tools to segment comparable tracts in group studies using FSL tractography	http://tiny.cc/0cBHO
VTK*	Free	Win, Mac, Linux	Library of C++ code that implements many state-of-the-art visualization techniques with a consistent developer interface	http://www.vtk.org/

Non-BSD license (GPL), set of tools/applets

Mainly 2D visualization, Java

Very basic viewing and registration functions only

Non-BSD license, a few nice, small apps

Closed source

Not free

Not multi-platform

Not a software application

Only for brain images

Other

(Nature Methods Supplement, VOL.7 NO.3s, MARCH 2010)

*Recommended and popular tools. Free means the tool is free for academic use; \$ means there is a cost; free/\$ means free for Windows and Linux, at a cost for Mac OS X. OS, operating system: Win, Microsoft Windows; Mac, Macintosh OS X. Tools running on Linux usually also run on other versions of Unix. Irix is SGI's Unix operating system. 2D, two-dimensional; CT, computed tomography; PET, positron emission tomography; HARDI, high angular resolution diffusion imaging.

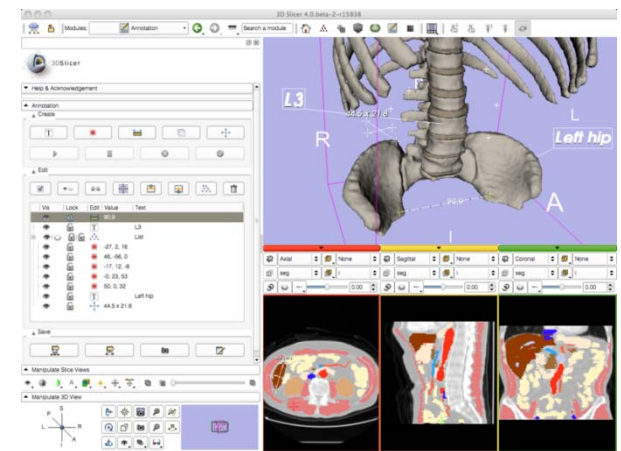
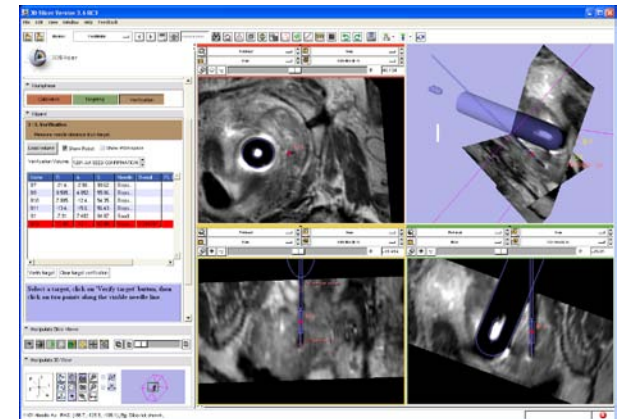
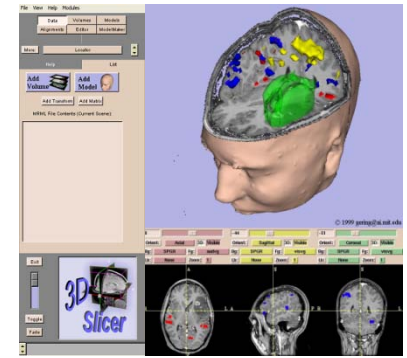


3D Slicer history

- Slicer 1: Started by Harvard SPL and MIT CSAIL labs (1998-)
- Slicer 2: fully reworked, not yet usable
- Slicer 3: full reworked, finally usable, current stable version (2007-2011)
- Slicer 4: fully reworked, not yet usable, but will be really good (2011-)

<http://www.slicer.org/slicerWiki/index.php/Slicer4>

- Graphical user interface: QT
- Performance and usability improvements
- New libraries: ITK4, OpenIGTLink2, ...
- Expected for RSNA 2011 (December)



Using 3D Slicer for image-guided therapy

- Most of the needed functions are already available
- Flexible, extensible with plug-ins
- Large user and developer community: continuous improvement, good support
- Free (BSD-style), based on standard open source libraries
- Multi-platform (Windows, Linux, Mac)
- Several successful IGT examples
- Not optimized for a specific procedure: custom module and/or add experienced user needed in the OR
- Not optimized for speed or robustness



The screenshot displays the NA-MIC Wiki Events page in a Firefox browser. The page title is 'Events - NAMIC' and the URL is 'http://www.na-mic.org/Wiki/index.php/Events'. The page content includes a search bar, a navigation menu, and a list of 'Past Events' for the year 2011. The events listed are:

- July 19-21: Slicer 4 Review and Programming Sprint
- June 26-30: 3DSlicer Booth, OHBM 2011, Quebec City
- June 20-24: **Summer Project Week at MIT**
- June 15: Slicer Workshop at the Biomedical Imaging
- June 13: Summer 2011 Tutorial Contest Submission
- June 7: UCSF Diffusion Imaging Workshop, San Francisco
- May 5: Computational Methods for Radiation Oncology
- April 27: Slicer and OpenIGTLink Hands-on Training
- April 22: Slicer Hands-on Training For The Utah Affiliates
- April 12: Talk by Simon DIMaio "da Vinci and Beyond"
- April 5: Training Workshop at Johns Hopkins University
- March 16-18: VIZBI 2011 in Cambridge, MA including
- March 15-16: Harvard Catalyst Biomarkers and Image Processing Approaches including NA-MIC and
- March 11: 3D Slicer Quantitative Medical Image Data Visualization Hands-On workshop, Countway room 403, (12-1pm)
- March 4: New Slicer3.6.3 Patch Release
- February 19-23: Registration Retreat

An inset image on the right side of the screenshot shows a group of people in a conference room, likely attending one of the events listed on the page. The room is filled with people sitting at tables, some using laptops, and a presentation screen is visible in the background.

- 2 project weeks per year (≈ 150 developers)
- 30-40 events per year
- Mailing lists, wiki, ...

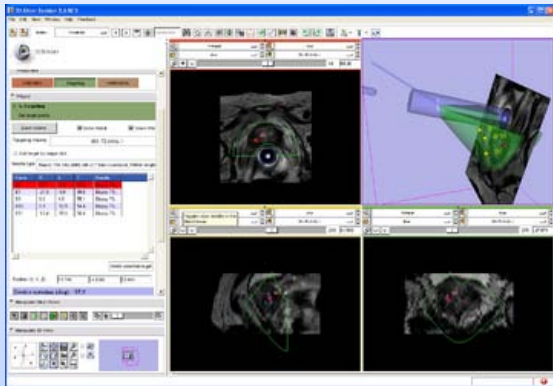


Using 3D Slicer for image-guided therapy

- Most of the needed functions are already available
- Flexible, extensible with plug-ins
- Large user and developer community: continuous improvement, good support
- Free (BSD-style), based on standard open source libraries
- Multi-platform (Windows, Linux, Mac)
- Several successful IGT examples
- Not optimized for a specific procedure: custom module and/or add experienced user needed in the OR
- Not optimized for speed or robustness



Image-guided therapy applications in Slicer 3.6

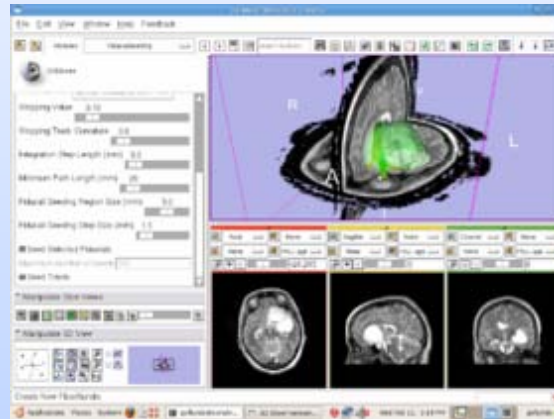


ProstateNav

- Prostate biopsy
- Used on patients

LiverAblation

MRABlation

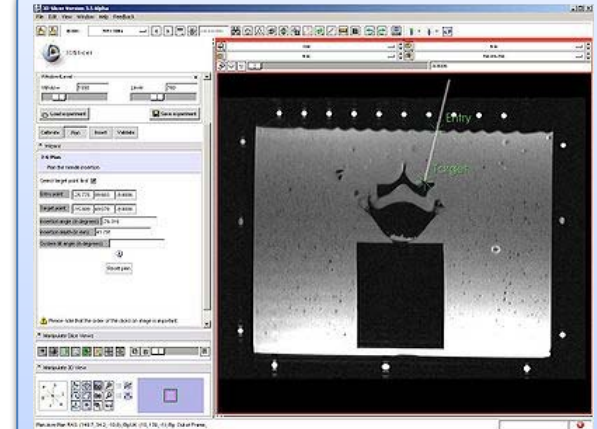


NeuroNav

- Neuro navigation
- Used on patients

IGTPlanning

IGTNavigation



PerkStation

- Spine needle insertion with AR display
- Cadaver studies

...



Using 3D Slicer for image-guided therapy

- Most of the needed functions are already available
- Flexible, extensible with plug-ins
- Large user and developer community: continuous improvement, good support
- Free (BSD-style), based on standard open source libraries
- Multi-platform (Windows, Linux, Mac)
- Several successful IGT examples
- Not optimized for a specific procedure: custom module and/or add experienced user needed in the OR
- Not optimized for speed or robustness



Summary

- 3D Slicer
 - Research application
 - Platform
 - Good for IGT
 - Many advantages, some limitations
 - Slicer4 is coming

www.slicer.org

