Universität Bremen

3D SLICER

GOVERNANCE AND POLICY

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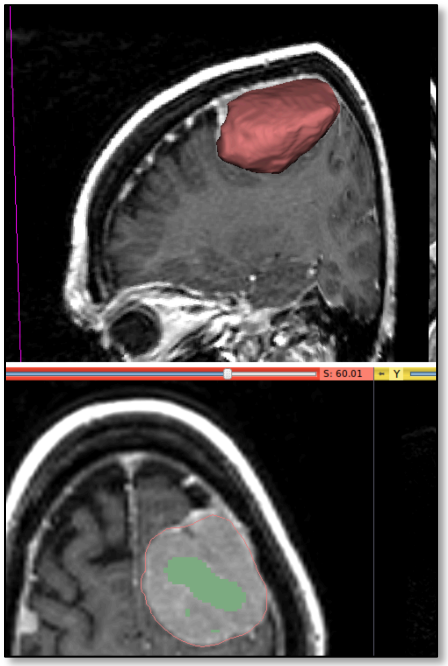
What is MIC

http://wiki.slicer.org/slicerWiki/index.php/Documentation/Nightly/Modules/RobustStatisticsSegmenter

The extraction of information and knowledge from medical images using computational methods

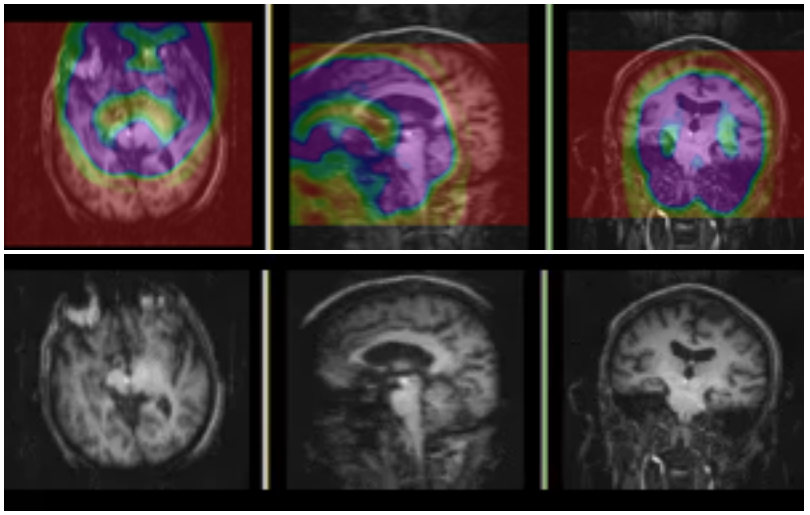
- Technologies:
  - image segmentation
  - image registration
  - image-based physiological modeling
  - visualization

result

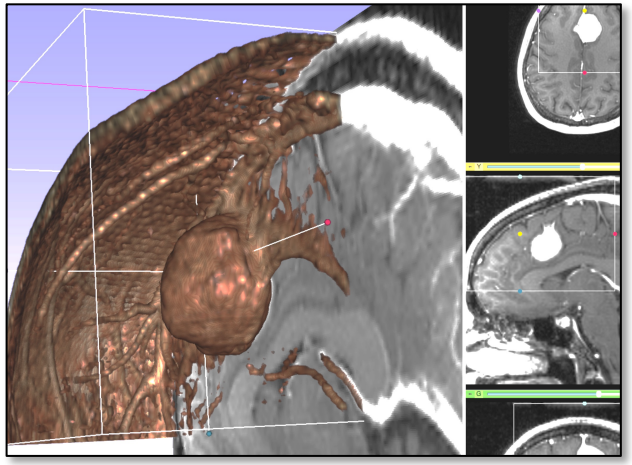


initialization

before



after



Volume rendering

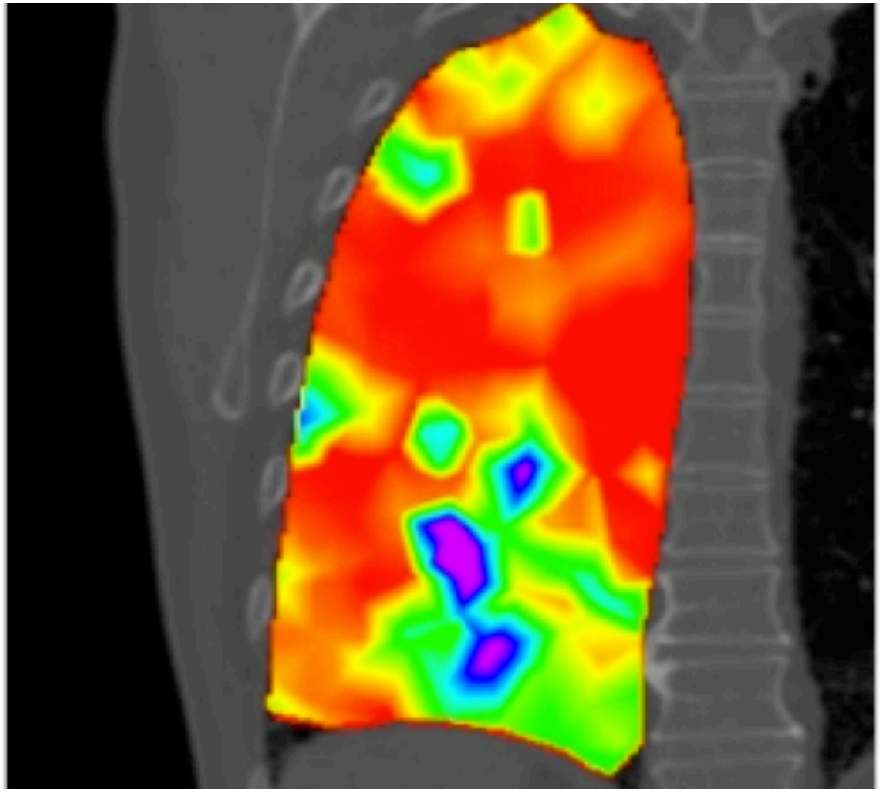
MIC = Medical Image Computing

https://en.wikipedia.org/wiki/Medical_image_computing

Slicer RegistrationLibrary:RegLib_C14

Increasing Importance of MIC

- More applications
  - Discovery, Diagnosis
  - Therapy monitoring
- More data and complexity
  - Gigabytes to terabytes
  - fMRI, molecular imaging, dMRI, 4DUS
- Translational infrastructure is needed

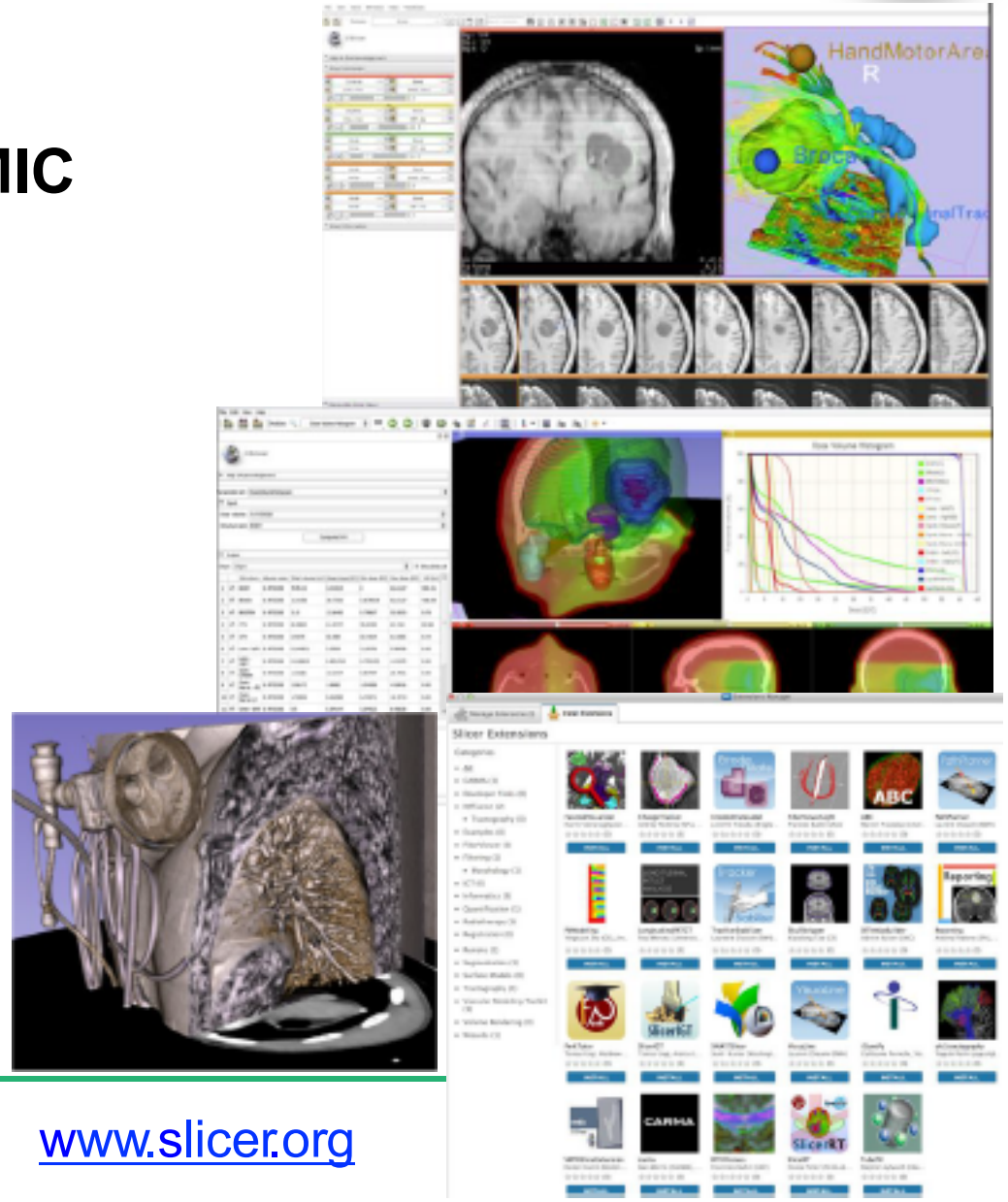


Risholm P., Ross J., Washko G.R., Wells III W.M. *Probabilistic Elastography: Estimating Lung Elasticity*. Inf Process Med Imaging. 2011;22:699-710. PMID: 21761697. PMCID: PMC3249413.

3D Slicer

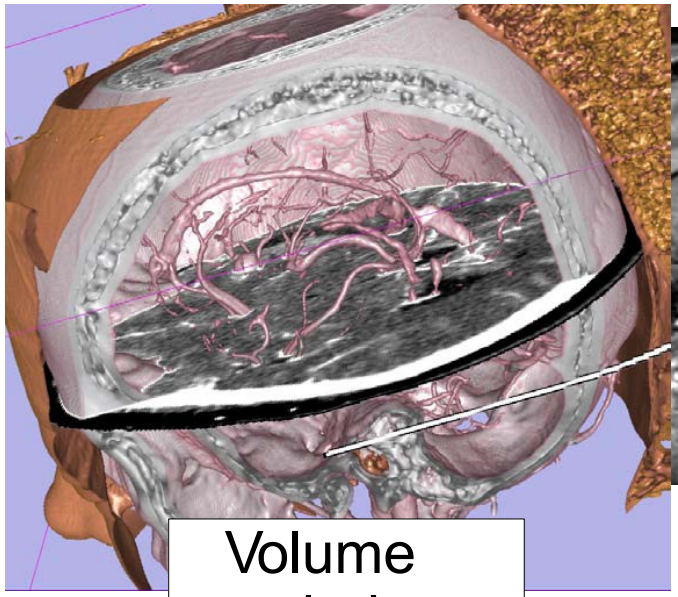
3D Slicer is software for MIC

- Free open source
  - no reciprocity requirements
  - you choose what to share
- Cross-platform
  - “One-click” installers for Windows, Mac and Linux
- Support and training
- Industry-strength engineering
- Extensible
  - Community “App store”
- Research software
  - not FDA approved

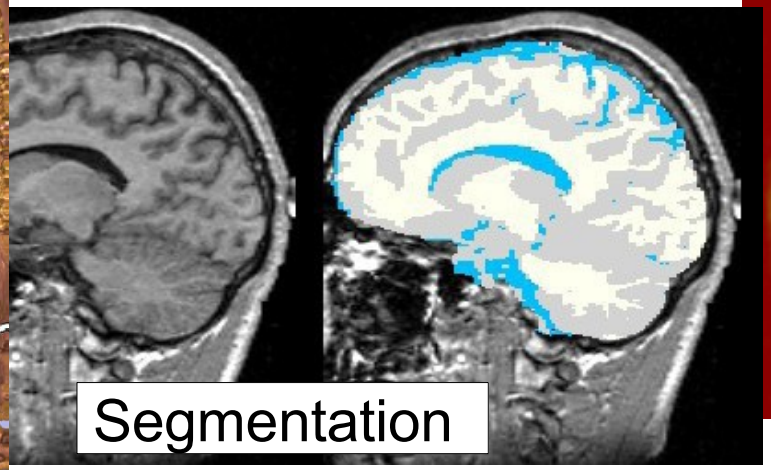


www.slicer.org

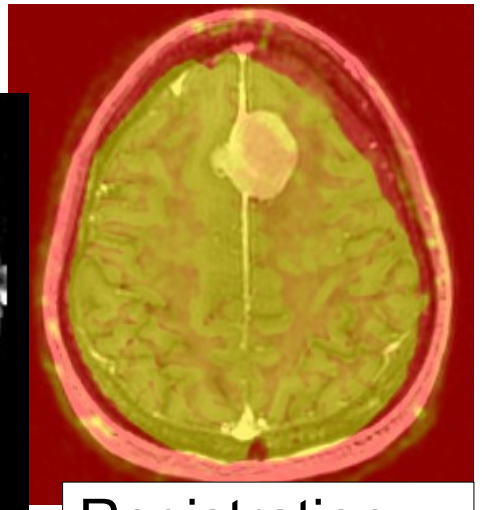
The Engines of Slicer



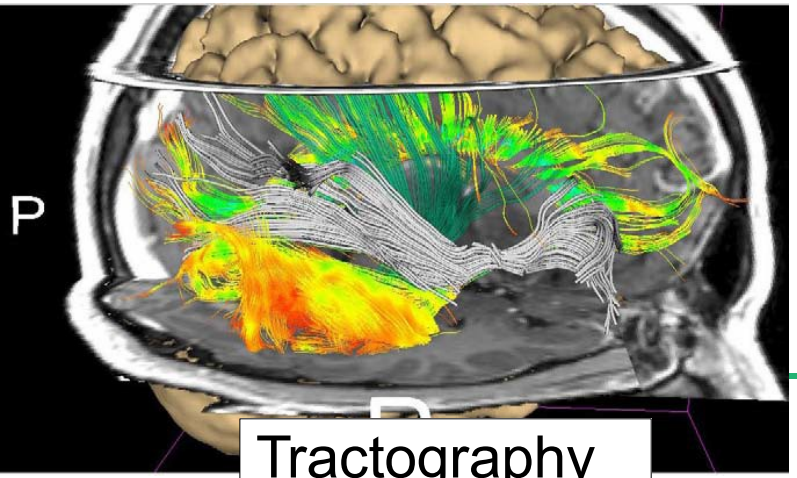
Volume rendering



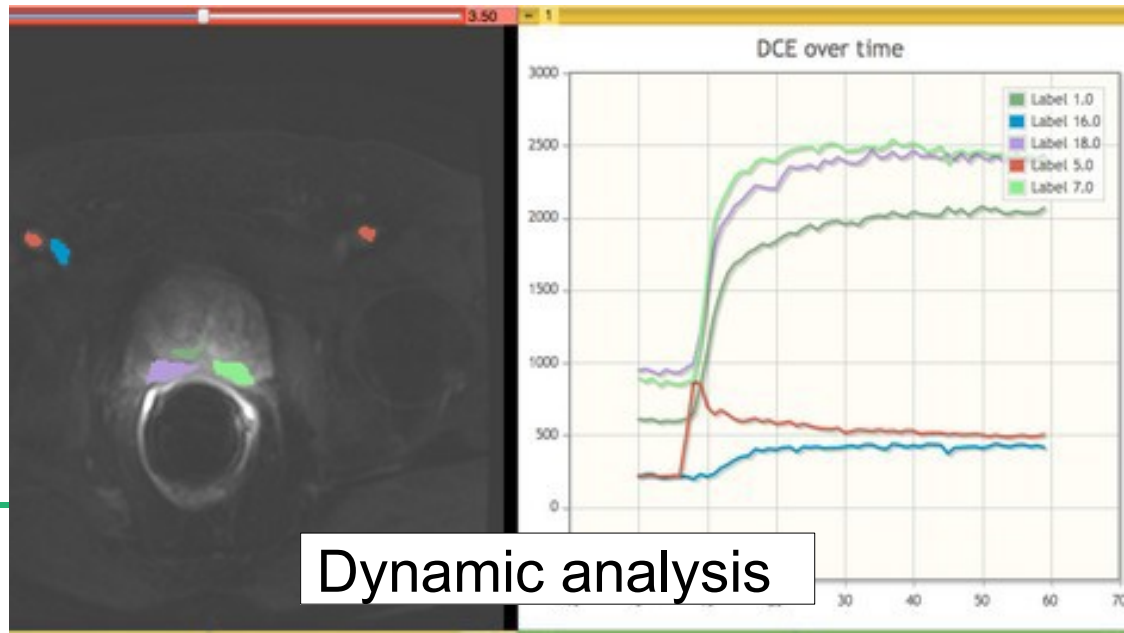
Segmentation



Registration



Tractography



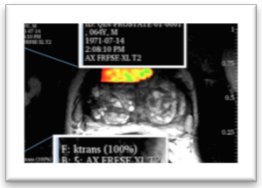
Dynamic analysis

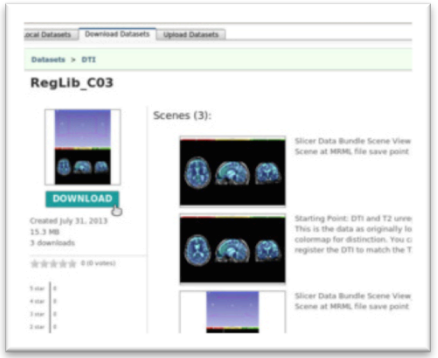
Slicer Enables Reproducible Science

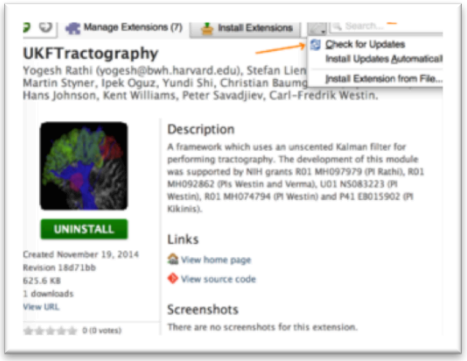
- Reproducible Science requires access to:
  - Software
  - Data
  - Parameters
- See the following:
  - Collins F., Tabak L. (2014). Policy: NIH plans to enhance reproducibility. *Nature*. 505, 612–613. doi:10.1038/505612a
  - Topalidou M, Leblois A, Boraud T, Rougier NP. A long journey into reproducible computational neuroscience. *Frontiers in Computational Neuroscience*. 2015;9:30. doi:10.3389/fncom.2015.00030.

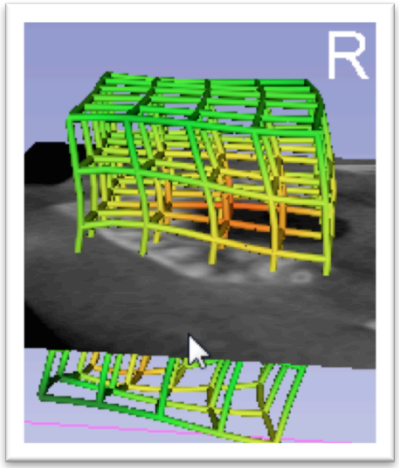
Slicer Addresses Unmet Needs

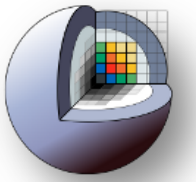
- Stability and longevity
- Unique combination of high level features:
  - Usable by non-programmer
  - Free
  - Open source
  - Modular
  - Multi-platform
  - Customizable UI
  - Extensible
  - Business-friendly license (BSD)











Slicer Community

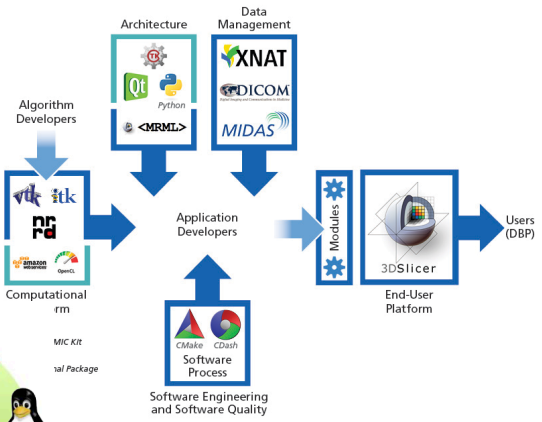
In a Nutshell, Slicer...

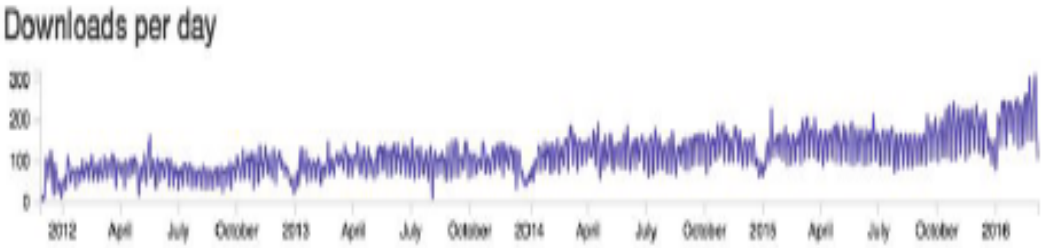
... has had 41,724 commits made by 127 contribut
representing 1,437,273 lines of code

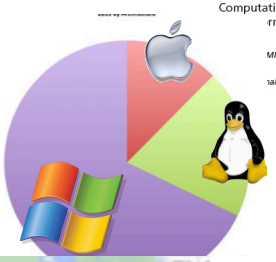
... is mostly written in C++
with an average number of source code comm

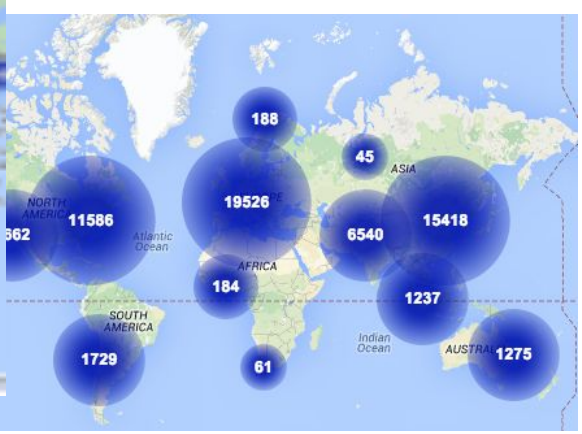
... has a well established, mature codebase
maintained by a large development team
with stable Y-O-Y commits

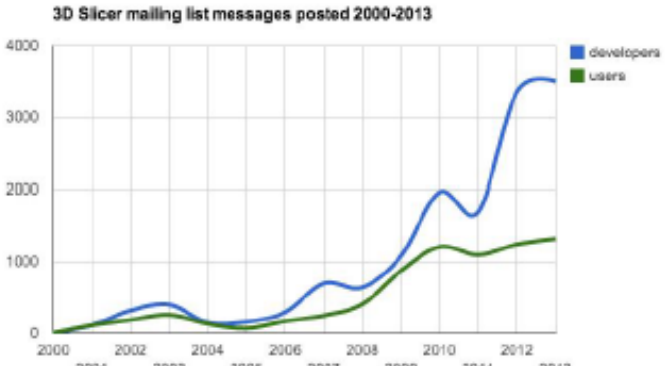
... took an estimated 406 years of effort (COCOMO mo
starting with its first commit in January, 2000
ending with its most recent commit 6 days ago





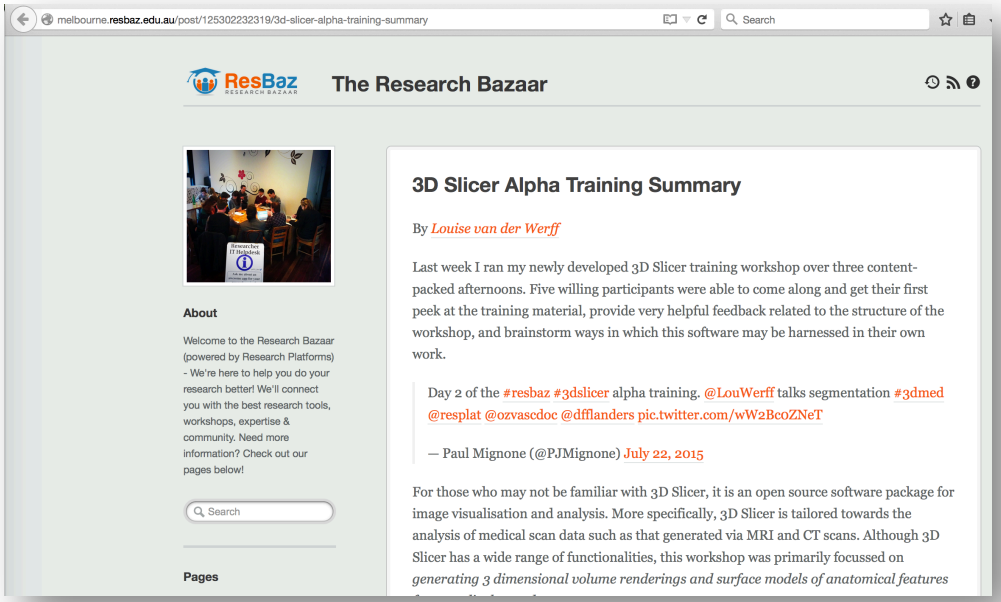


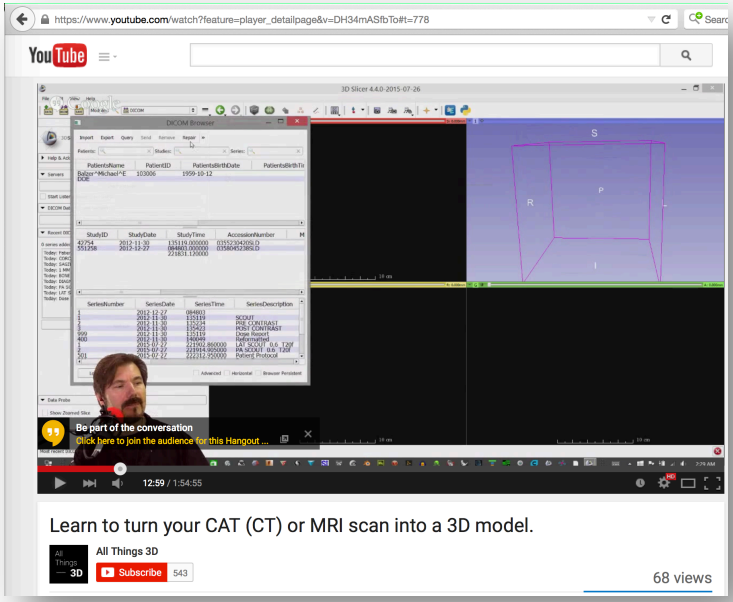




Slicer User Community

- Increasing use of Slicer is reflected in a large number of publications
- Volunteer contributions include participation in the mailing list and providing training materials



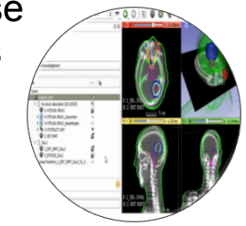


Slicer Developer Community

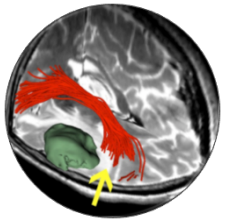
- Worldwide, distributed community
- Internet based technologies for development and communication
- Face-to-face meetings
  twice a year
  play a critical role

Examples of Clinical Research

Radiation dose calculations

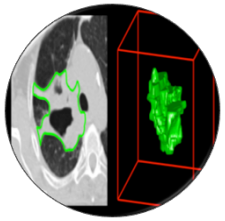


Tracking peritumoral white matter fibers

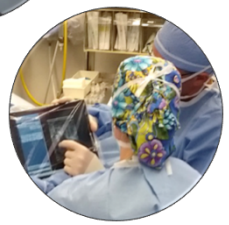


Prostate procedures

Diagnosis of Different Tumors in Lung Cancer

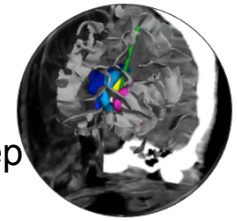


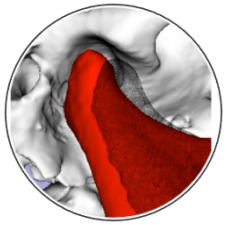
Clinical users drive creation of technology



Breast cancer surgery guidance

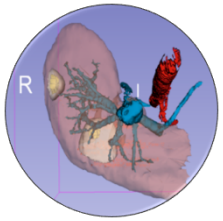
Model-Guided Deep Brain Simulation

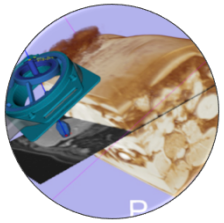




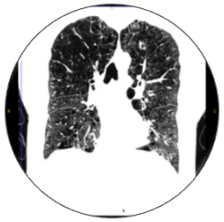
Diagnosis of Osteoarthritis Degeneration

Surgical navigation





Liver procedures



Quantitative assessment of COPD

Slide courtesy of L. Cevidanes

Companies Use Slicer


Known commercial activities range from use “as is” to full blown product development:

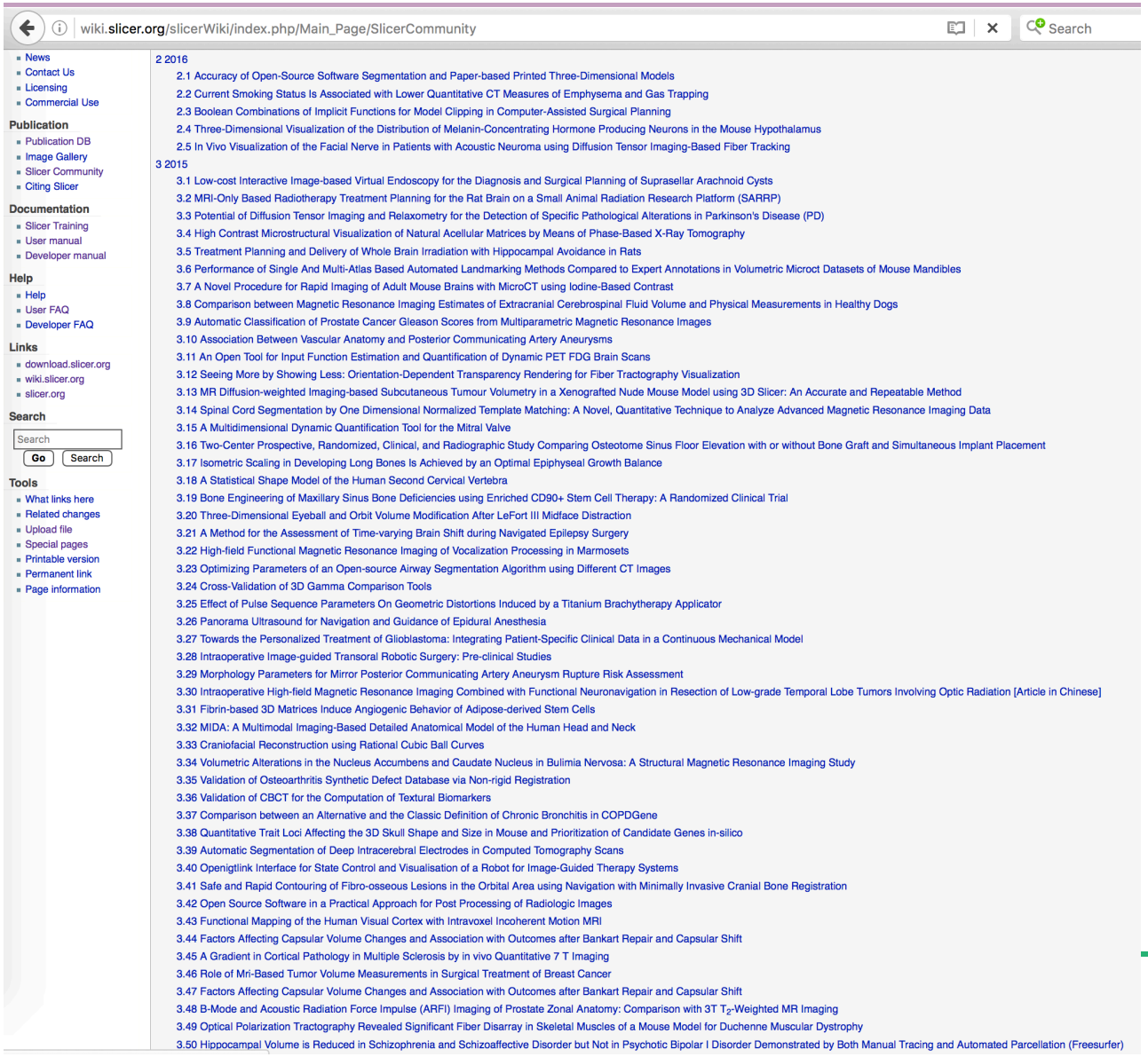
- Xstrahl (small animal radiation product)
- mebio (radiology product, prostate guidance)
- SonoVol (ultrasound product) (R43CA192482...)
- Novartis (quantitative imaging clinical trials)
- New Frontier (navigation system)
- KUKA (surgical robotics)
- Siemens (diagnostic and interventional research)
- Canon (robotic interventions)
- GE (research and products)
- NDI (trackers for surgical navigation)
- Isomics (research, consulting)
- Kitware (research, consulting)
  - 10+ Slicer based projects in the past two years
  - 5 commercial products being launched

Business Model

- Enable science
- Apply for infrastructure funds

- Underlying philosphy:
  - Open community-based approach
  - Free open source software with liberal license

Slicer Enables NIH Research



Hundreds of papers published using 3D Slicer

https://www.slicer.org/pages/Slicer_Community

Licensing model

License has to:

- Facilitate scientific exchange
- Enable commercial use
- Be acceptable to the institution

- Result: BSD open source license
  - **you** choose what to share
  - Key concept: “Not intended”

Long-Term Funding Strategy

Developed an “ecosystem” of funded efforts, both US and internationally

- Community based approach: no single point of failure
- Slicer is attractive as a platform for solution development:
  - Stability
  - Longevity
  - Supported
  - Maintained

Toolmakers Use Slicer

- SlicerCIP (Raul San Jose Estepar)-R01 HL116931, R01 HL116473
- SlicerCMF (Lucia Cevidanes, Martin Styner, Beatriz Panagua)-R01 DE024450
- SlicerProstate (Clare Tempany)-U01 CA151261, R01 CA111288, U24 CA180918, P41 EB015898
- SlicerRadiomics (Hugo Aerts)-U01 **CA**190234, U24 **CA**194354
- QIICR (Ron Kikinis, Andriy Fedorov)-U24 **CA**180918
- SlicerGyn – Pelvic floor research (John DeLancey, U Michigan) P50 HD044406, R01 HD038665, P30 AG024824
- OpenIGTLink (Junichi Tokuda)-R01 EB020667
- SlicerTractography (Lauren O'Donnell)-U01 **CA**199459
- SlicerIGT (Gabor Fichtinger, Andras Lasso, Tamas Ungi)-Ontario Govt. funded
- SlicerRT (Csaba Pinter, Gabor Fichtinger, Greg Sharp)-Ontario Govt. funded
- SlicerDBS (Pierre Jannin)-French Govt. funded
- IASEM (Bradley Lowecamp)-NLM intramural funding
- Bender (Stephen Aylward)-AFRL
- VesselView (Stephen Aylward)-R44 **CA**165621
- Slicer remote rendering (Al Johnson)-P41 EB015897
- Slicer (Ron Kikinis, Carl-Frederik Westin)-P41 EB015902

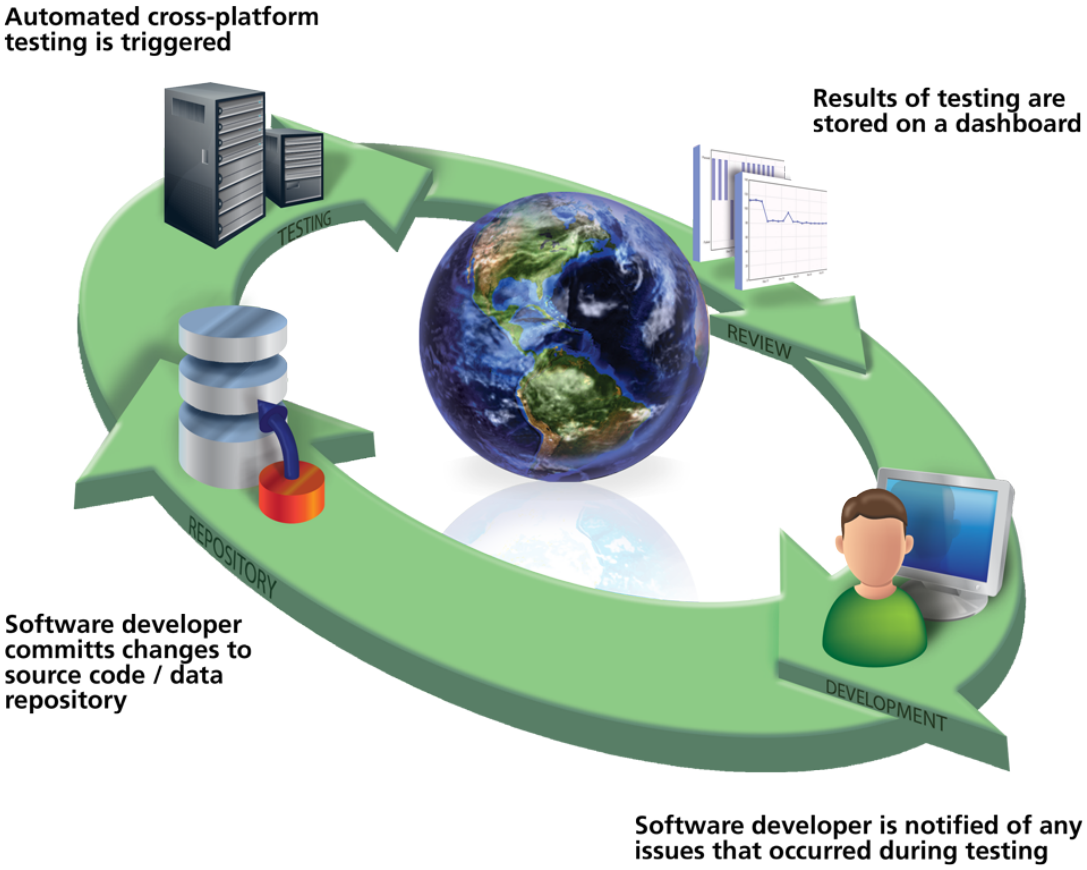
Green indicates clinical research focus

Maintenance

- A documented and principled software engineering methodology is key
- 3D Slicer has a core engineering team consisting of professional software engineers
- The Slicer community is actively participating in maintenance

Software Engineering Methodology

- Designed for a geographically distributed team
- Community driven activities
- More than 600 automatic tests
- Extensive documentation
- Extreme programming approach: publish early, publish often



Graphic courtesy of JC Fillion-Robin, Kitware

Core Engineering Activities

Ongoing need for maintenance to keep Slicer attractive to end-users and developers

Maintenance means:

- Review contributed code
- Porting to new OS releases
- Update software components such as ITK and VTK
- Investigate and resolve bug reports
- Maintain factory machines for nightly and stable builds across platforms and including extensions
- Monitor and troubleshoot extensions
- Maintain download servers and data bases
- Update wiki pages
- Write tutorials
- Answer emails
- ….

Core Engineering Team

Available funding amounts to 4.5 FTE in 2015:

- NAC: 0.75 FTE (IC: EB)
- NCIGT: 0.25 FTE (IC: EB)
- QIICR: 0.5 FTE (IC: CA)
- Kitware: 1 FTE (multiple IC's)
- Queen's University: 2 FTE (mostly Canadian funding)

Funding for core engineering is spread across several projects and requires foresight in the grant application process

P.S. Core engineering is different from application engineering.

Community Contributions

Participants outside the core engineering team

- Developers
  - Mailing lists,
  - weekly electronic meetings,
  - focus meetings on particular topics
  - twice a year weeklong in-person events
- Users
  - Mailing lists
  - Electronic training materials with sample data sets
  - Hands-on training events at conferences and on request
  - Individual support

Challenges

- Funding for core engineering
- Healthy balance between stability and innovation
- The academic culture and reward system: Reviewers often lack understanding of the role of engineering

Summary

3D Slicer is an effective tool for **translation** of MIC and informatics technologies **into clinical research**.

- NIH funded projects have enabled a huge range of scientific activities:
  - Major NIH-supported projects use 3D Slicer
  - Grassroots activities worldwide
- This is due to an effective operational model:
  - A strong leadership team
  - A robust software with no liabilities
  - A "community of the willing"
    - Developers who write, share, and maintain the software
    - Users who request features and report problems

Thanks For Your Attention

Questions and comments?

http://www.slicer.org

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