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# Quantitative Image Informatics for Cancer Research (QICR)

## Motivation, Overview and Deliverables

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# Background: Quantitative Imaging Network

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- Aug 2008: NCI PAR-08-225
- Development and adaptation of tools for assessment of treatment response in clinical trials
- 17 imaging centers across US
- variety of modalities and cancer types
- collaborations with industry partners encouraged

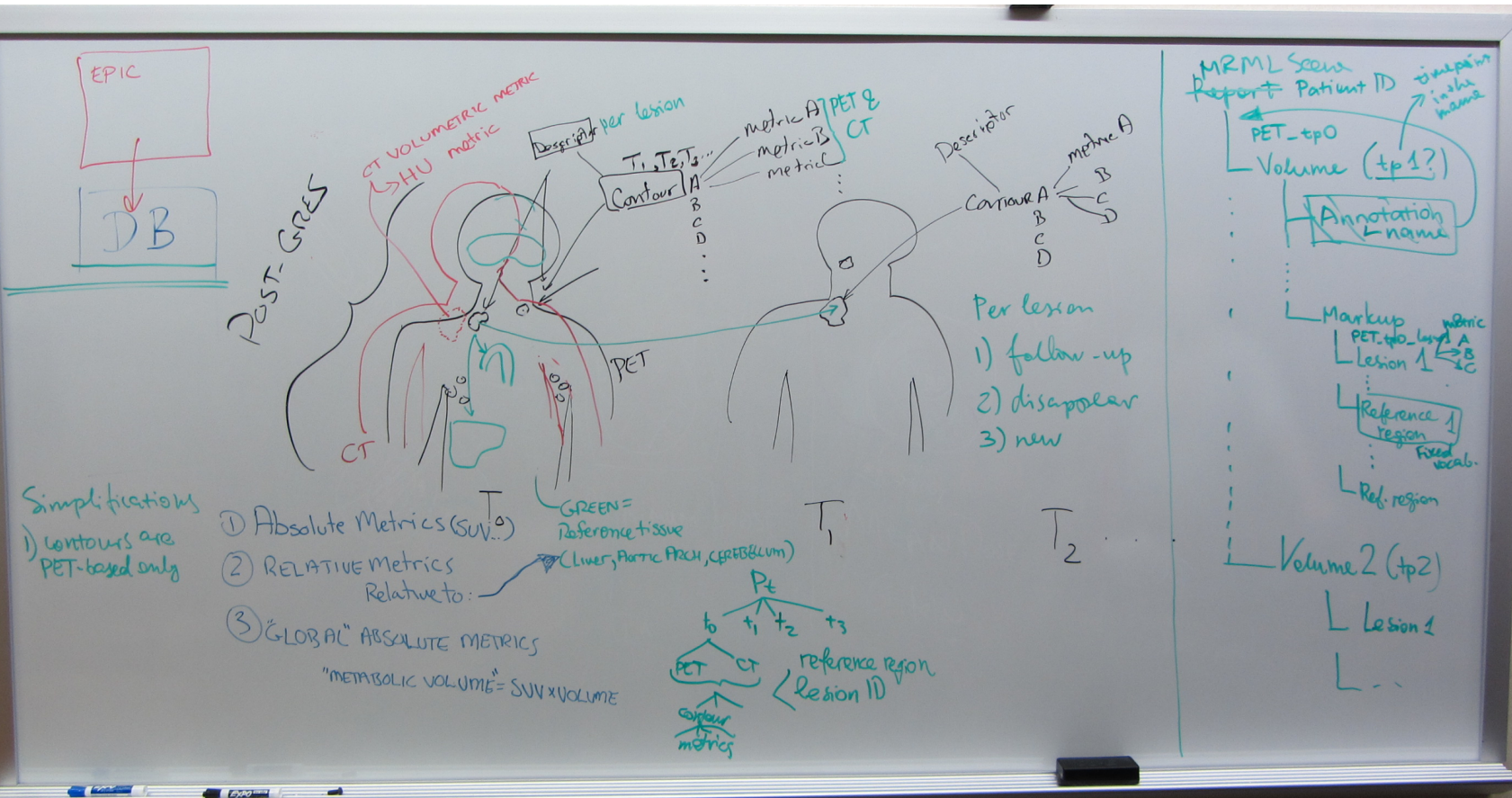


# QIN Priorities

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- Development of consensus on quantitative imaging methodology
  - evaluation and comparison of methods and tools
  - public data repositories
  - consensus metrology approaches
- Practical tools for the oncology community
  - software to support decision making
  - integration and evaluation in clinical trial setting

# Data sharing challenges



## Simplifications

- 1) contours are PET-based only
- 2) RELATIVE METRICS Relative to:
  - GREEN = Reference tissue (Liver, Aortic Arch, CEREBELLUM)
- 3) "GLOBAL" ABSOLUTE METRICS  
 "METABOLIC VOLUME" = SUV x VOLUME

# QIN Challenges

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- Data sharing
  - Site-specific solutions
  - Limited support of common formats
    - no agreement what that format should be
  - No repositories of annotated image data
- Tool sharing
  - Tools are generally developed for internal use
  - Different levels of maturity
  - Not always open source
- *Individual sites are not tasked with the development of the platform to facilitate sharing*



## *Informatics Technology for Cancer Research*

### 2012: portfolio of technology oriented FOAs

- “Central mission is to promote research-driven informatics technology development”
- “Funds requested must be used to support informatics technology development instead of research”
- “This FOA encourages applications that involve the development of innovative and user friendly informatics technologies of significant value to the whole spectrum of cancer research from bench to bedside“

# QIICR Grand Idea

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- Based on the needs of 3 specific QIN projects:
  - identify the image informatics needs
  - implement support for derived data and software tool sharing
  - converge on a format used for data sharing
  - facilitate adoption of the toolset
  - demonstrate by example what is feasible, what is missing
- Use DICOM as much as possible, consider improvements as needed
- Free open source

# QIICR Aims

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**Aim 1:** Workflows and tools for analyzing longitudinal imaging and derived data

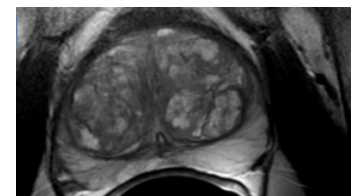
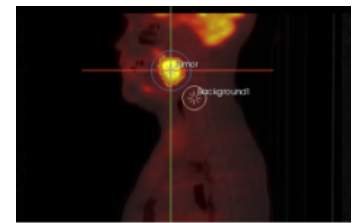
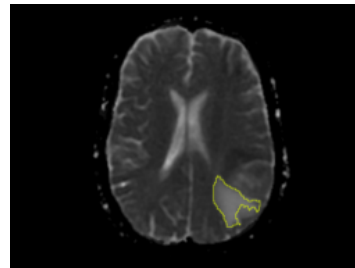
**Aim 2:** Standards-based structured reporting and representation of quantitative analysis results

**Aim 3:** User- and developer-level interfaces to data archives



# Driving QIN projects

Attribute	MGH QIN Site	Iowa QIN Site	BWH QIN Site
<i>Cancer target</i>	Glioblastoma Multiforme	Head and Neck Cancer	Prostate Cancer
<i>Underlying biological process</i>	Angiogenesis, membrane permeability, hypoxia	Tumor glycolysis, hypoxia	Angiogenesis, membrane permeability
<i>Quantitative Imaging Biomarker</i>	Pharmacokinetic response, tissue diffusivity	SUV-derived values	Pharmacokinetic response, tissue diffusivity
<i>Clinical Outcome / Standard of Care</i>	Progression free survival, Macdonald, RANO Criteria	Metastatic proliferation, survival, PERCIST	PSA, histopathology (Gleason)
<i>Longitudinal Relationships, Timepoints</i>	up to 30 timepoints	2 to 7 timepoints	2 to 3 timepoints
<i>Imaging</i>	MR: T1, T2, DWI, DSC, DCE, DTI, BOLD	PET/CT	MR: T1, T2, DWI, DCE
<i>Post-Processing</i>	$K^{trans}$ , $v_e$ , $v_p$ , TTP, ADC, rCBV, rCBF...	SUV	$K^{trans}$ , TTP, ADC...
<i>Segmentation Image</i>	GBM, Necrosis, Edema. Vessel (AIF)...	Tumor, Lymph Nodes, Reference Anatomy	Prostate Gland (Central and Peripheral Zones), Tumor, Normal Tissue, Vessel (AIF)
<i>Registration</i>	Distortion Correction, Motion Correction, Longitudinal Alignment	Longitudinal Alignment	Distortion Correction, Motion Correction, Longitudinal Alignment
<i>Markups</i>	Manual initialization Macdonald Criteria Measurements	Manual Segmentation Reference, Manual initialization (Seed, Sphere)	Manual Segmentation Reference
<i>Display</i>	Lightbox axial mode, statistical overlay, multivolume timecourse	Volume rendering compare view, statistical overlay	Lightbox MPR, statistical overlay

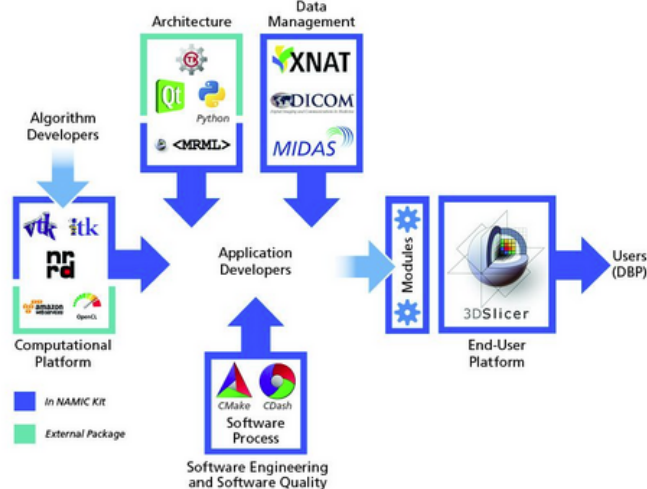


# QIICR Aim 1: Tools

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Understanding the applications and the user needs:

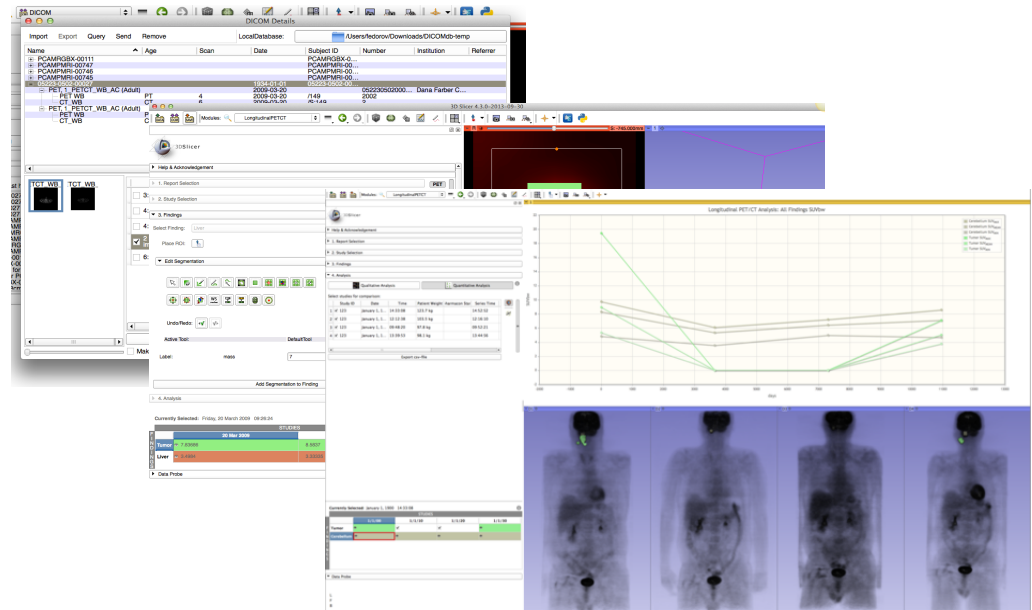
- user-level workflows (in 3D Slicer) integrating analysis tools
- data structures and information modeling
- improved provenance infrastructure in 3D Slicer



# QIICR Aim 1: Tools

## Interactive analysis workflows

- input data interpretation
- processing steps
- visualization
- quantification
- serialization



# Interactive analysis workflows



The screenshot displays the 3DSlicer software interface with several key components:

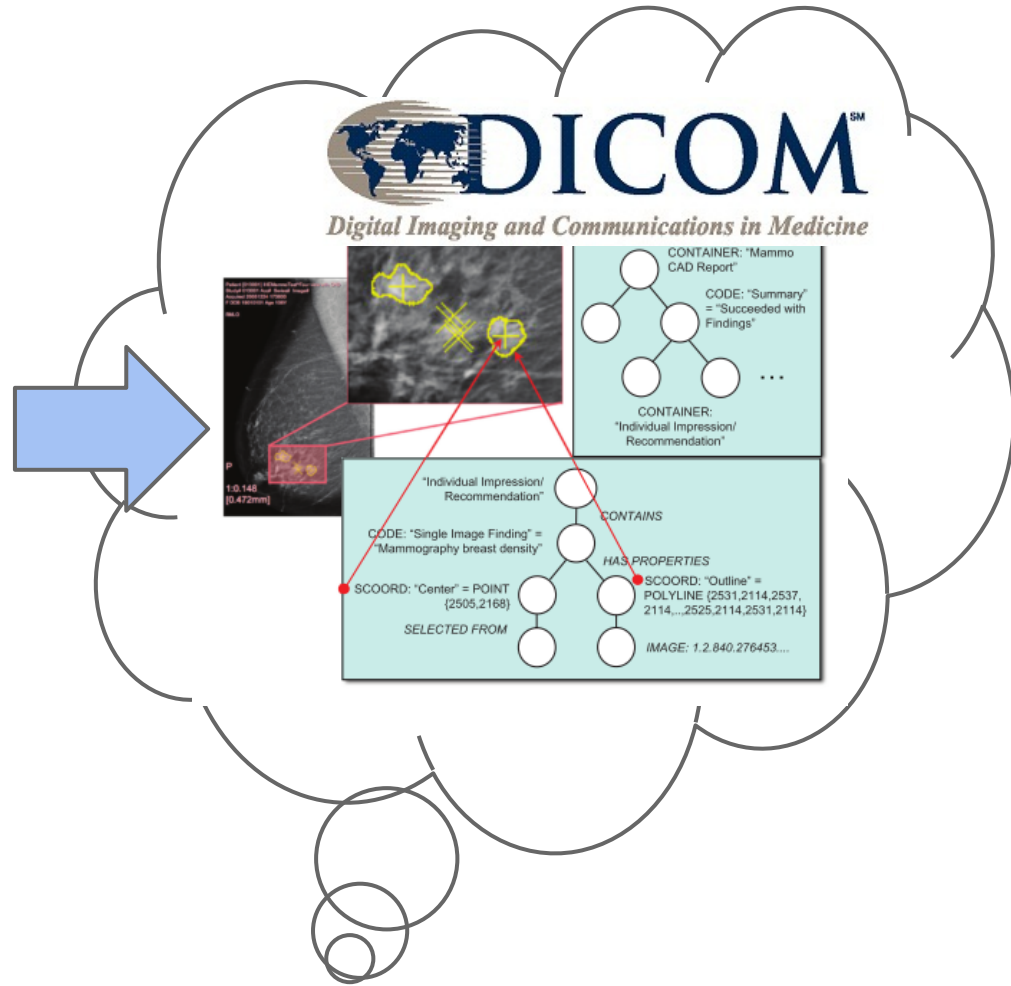
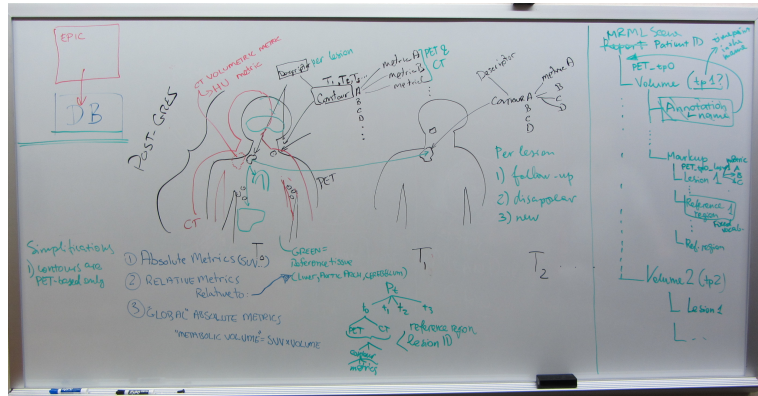
- DICOM Details:** A table listing patient information and scan details.
 

Name	Age	Scan	Date	Subject ID	Number	Institution	Referrer
PCAMRGBX-00111				PCAMRGBX-0...			
PCAMPMRI-00747				PCAMPMRI-00...			
PCAMPMRI-00746				PCAMPMRI-00...			
PCAMPMRI-00745				PCAMPMRI-00...			
05223-0502-00027			1034-01-01	05223-0502-00...			
PETCTWB	PT	4	2009-03-20		052230502000...	Dana Farber C...	
CTWB	CT	R	2009-03-20	/149	2002		
- Analysis Workflow:** A sidebar showing steps: 1. Report Selection, 2. Study Selection, 3. Findings, 4. Select Finding: Liver, 5. Place ROI, 6. Edit Segmentation.
- Quantitative Analysis:** A table for 'Longitudinal PET/CT Analysis: All Findings SUVbw'.
 

Study ID	Date	Time	Apparent Weight	Apparent Sur...	Series Time
1	1/1/10	14:33:08	123.7 kg		14:52:52
2	1/1/10	13:12:38	105.8 kg		13:28:30
3	1/1/10	09:48:20	97.8 kg		09:53:21
4	1/1/10	13:59:03	98.1 kg		13:49:58
- Findings Table:** A table showing findings for '20 Mar 2009'.
 

Findings	Value	Value
Tumor	7.83686	8.5837
Liver	-3.4984	-3.33323
- Visualizations:** A line graph showing SUVbw over time (Days) for different studies, and four coronal PET/CT scan images showing tumor and liver regions.

# QIICR Aim 1: Tools



Clunie, D. A. (2007). DICOM Structured Reporting and Cancer Clinical Trials Results. *Cancer Informatics*, 4, 33–56.

# QIICR Aim 2: DICOM

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Focus on interoperability, structured organization:

- reporting templates
- coded terminologies
- support of relevant parts of the DICOM standard
- go beyond support in 3D Slicer



# QIICR Aim 2: DICOM

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Specific parts of DICOM to support quantitative image analysis for treatment response assessment:

- Segmentation Objects
- Registration Objects
- Real World Value Mapping
- parameter maps
- Structured Reports (+ new specialized templates)

# QIICR Aim 3: Sharing

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Simplify interaction with public repositories to facilitate sharing of the analysis results:

- focus on 2 most popular repositories:
  - NCI TCIA
  - XNAT Central
- integrate developer API into 3D Slicer
- provide user-level “data browsers”
- support 2-way communication





# *Multi-tier support of imaging research*

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- Institution level
  - improve usability of tools
  - facilitate integration with clinical workflows
- Multi-site projects level - QIN
  - enable sharing, demonstrate by example
  - a resource to the QIN community
- Medical image computing community
  - reach out beyond QIN and clinical research domains
  - demonstrate advantages to encourage adoption

# Deliverables

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- Tool sharing:
  - Specialized 3D Slicer extensions for 3 QIN projects
- Data sharing:
  - Reporting templates, documentation, tools and working examples based on DICOM
  - Structured datasets from 3 QIN projects
- Comparison, validation and secondary analysis:
  - Support of public repositories
  - 3D Slicer interactive tools to interface repositories

# Our team

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## Leadership

- [Ron Kikinis, MD](#) - Brigham and Women's Hospital, Boston
- Andrey Fedorov, PhD - Brigham and Women's Hospital, Boston

## Driving Biological Projects

- Quantitative MRI of Glioblastoma response: Massachusetts General Hospital
  - [Jayashree Kalpathy-Cramer, PhD](#)
  - [Elizabeth Gerstner, MD](#)
  - [Karl Helmer, PhD](#)
- Head and Neck cancer response assessment with PET/CT: University of Iowa
  - [Reinhard Beichel, PhD](#) - Iowa University
  - [Milan Sonka, PhD](#) - Iowa University
- Quantitative MRI of prostate cancer: Brigham and Women's Hospital
  - [Fiona Fennessy, MD, PhD](#)
  - Andrey Fedorov, PhD

## 3D Slicer development technical lead

- [Steve Pieper, PhD](#) - Isomics Inc., Cambridge

## DICOM technical lead

- [David Clunie](#) - CoreLab Partners, Inc. and PixelMed Publishing, LLC

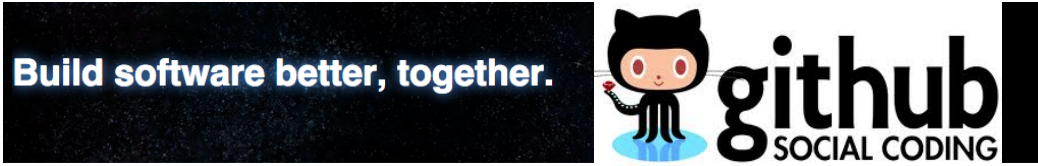
# *Coordination and Dissemination*

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Continue the best traditions of the existing projects:

- semi-annual hands-on meetings during NA-MIC project weeks
- coordination with QIN working groups
- leverage on-going efforts of NAC, NCIGT and NA-MIC projects
- in-person and screencast training sessions and tutorials
- wiki documentation

# Coordination and Dissemination



<http://qiicr.org>

**About**

- Team
- Jobs
- Press
- Blog

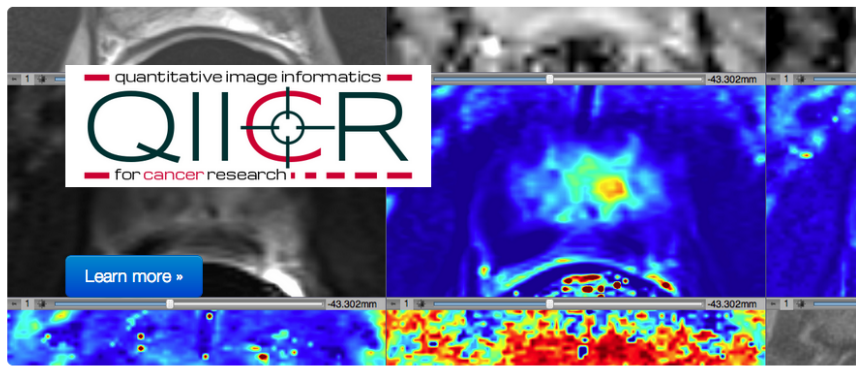
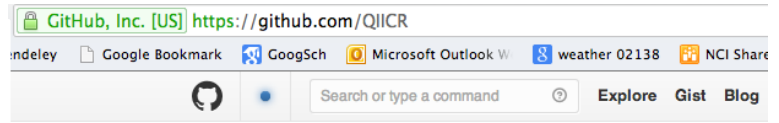
**FOUNDED** 2008

**HOME BASE** San Francisco

**HUBBERNAUTS** 211

**LOVEABLE MASCOT** The Octocat

**GitHub is the best place to share code** with friends, co-workers, classmates, and complete strangers. Over four million people use GitHub to build amazing things together.



Repositories Members

Find a repository...

**qiicr.github.io**  
Web page for QIICR  
Last updated 7 days ago

**Quantitative Image Informatics for Cancer Research**  
QIICR

<http://qiicr.org>  
Joined on Aug 30, 2013

## Open software

Free open source software plays enabling role in medical image computing research. We are developing open source imaging informatics tools to support research workflows of the NCI Quantitative Imaging Network.

## Open standards

One of our goals is to implement and improve support for interoperable exchange of derived image data using Digital Imaging and Communications in Medicine (DICOM) standard.

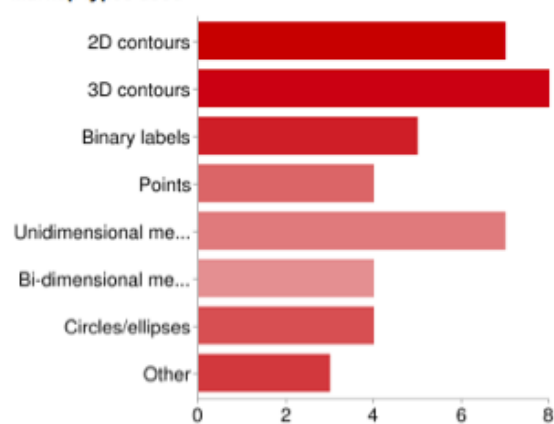
## Open

We believe enabled by interoperable and evaluate

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- QIICR is supported by NCI award U24 CA180918
  - The contents are solely the responsibility of the authors and do not necessarily represent the official views of the NCI.

# Derived data sharing: QIN site survey

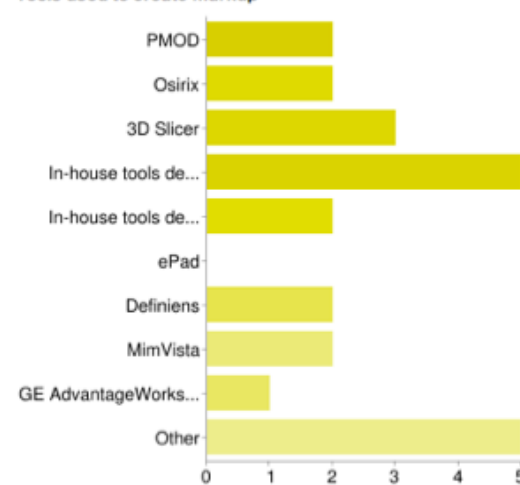
## Markup types used



2D contours	7	70%
3D contours	8	80%
Binary labels	5	50%
Points	4	40%
Unidimensional measurements (e.g., RECIST)	7	70%
Bi-dimensional measurements (e.g., WHO/MacDonald)	4	40%
Circles/ellipses	4	40%
Other	3	30%

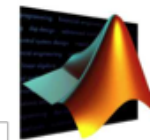
People may select more than one checkbox, so percentages may add up to more than 100%.

## Tools used to create markup



PMOD	2	20%
Osirix	2	20%
3D Slicer	3	30%
In-house tools developed in Matlab	5	50%
In-house tools developed in IDL	2	20%
ePad	0	0%
Definiens	2	20%
MimVista	2	20%
GE AdvantageWorkstation	1	10%
Other	5	50%

People may select more than one checkbox, so percentages may add up to more than 100%.



**MATLAB**  
The Language of Technical Computing



QIN BIDS WG site survey, May 2012