Quantitative Image Informatics for Cancer Research (QIICR)

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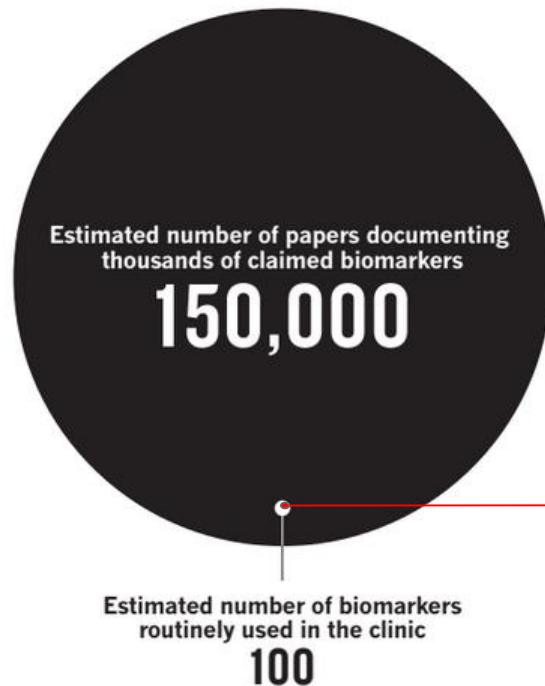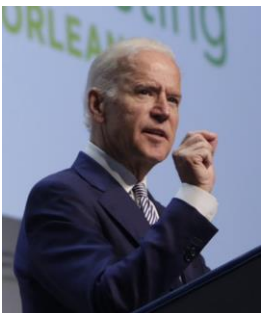
ITCR Face-to-face meeting
13 June 2016

A DROP IN THE OCEAN
Few of the numerous biomarkers so far discovered have made it to the clinic.

Estimated number of papers documenting thousands of claimed biomarkers
150,000

Estimated number of biomarkers routinely used in the clinic
100

Actual number of FDA qualified imaging biomarkers
1

Adapted from Poste G. "Bring on the biomarkers". Nature. 2011

"The way the system now is set up, researchers are not incentivized to share their data. […] every expert I've spoken to says we need to share this data in order to move the process more rapidly."

"I made a commitment that I will […] eliminate the barriers that get in your way, get in the way of science, the research and development."

Joe Biden, Vice president of the United States of America

"When we have the opportunity to share data, knowledge, tools, or techniques, we must do it."

Warren Kibbe, PhD, acting NCI Deputy Director, Director of the Center for Biomedical Informatics and Information Technology (CBIIT)
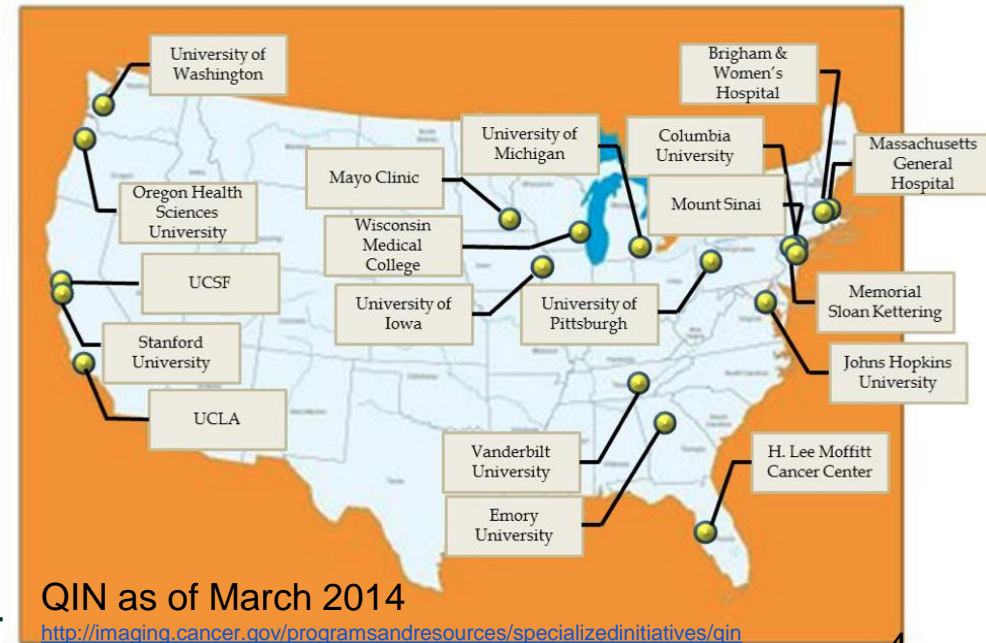

"We need that big data to be accessible. It's not enough to say that we are in a big data era for cancer. We also need to be in a big data access era."

Francis Collins, PhD, MD, director of the NIH

quantitative image informatics
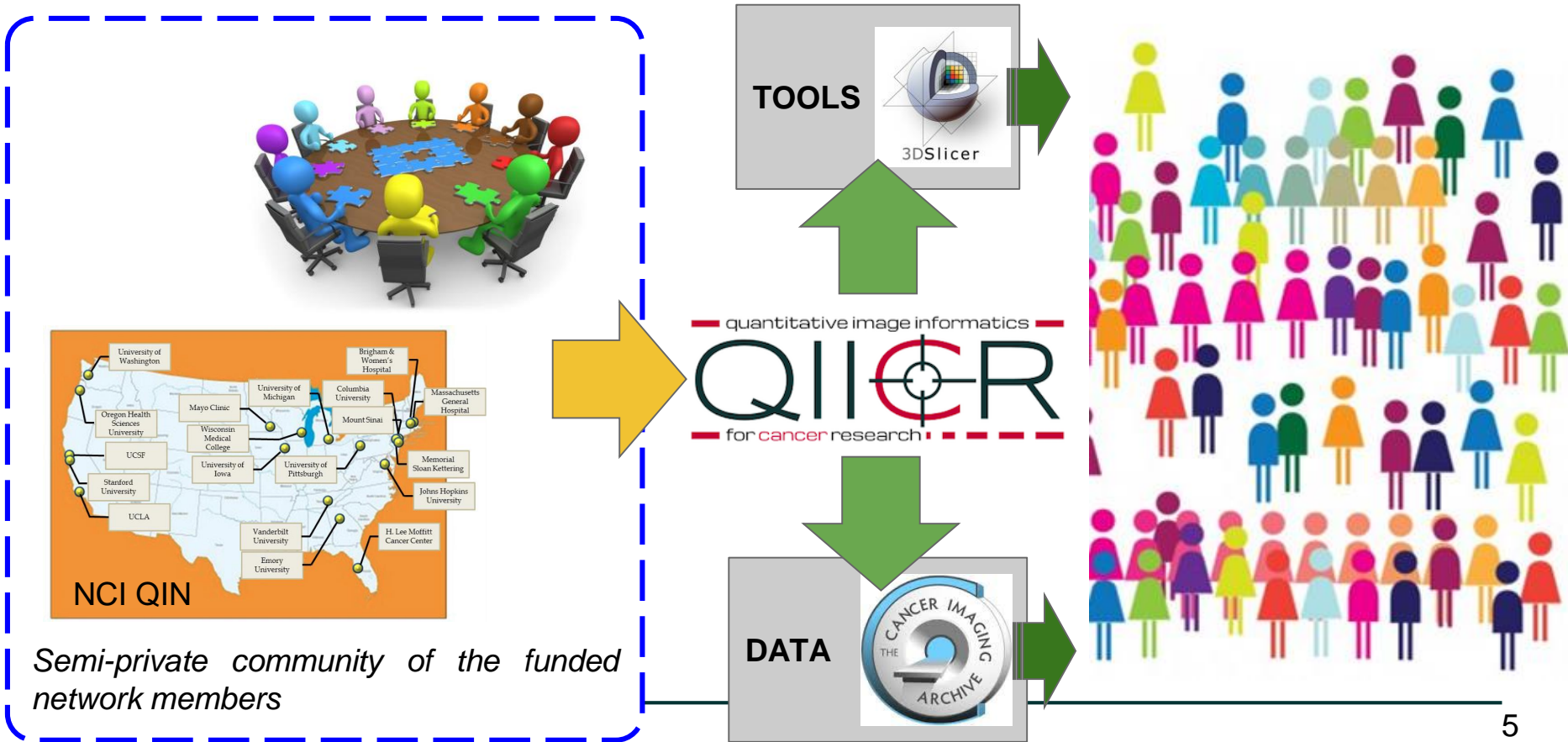QIICR
for cancer research

NCI Quantitative Imaging Network (QIN)

"The network is designed to promote research and development of quantitative imaging methods for the measurement of tumor response to therapies in clinical trial settings, with the overall goal of facilitating clinical decision making."

- Consensus building
- Best practices
- Performance measurement
- Collaborative activities
- Working Groups
- Tool comparison
- Image data sharing

University of Washington

Oregon Health Sciences University

UCSF

Stanford University

UCLA

Mayo Clinic

Wisconsin Medical College

University of Iowa

University of Michigan

University of Pittsburgh

Vanderbilt University

Emory University

Columbia University

Mount Sinai

Brigham & Women's Hospital

Massachusetts General Hospital

Memorial Sloan Kettering

Johns Hopkins University

H. Lee Moffitt Cancer Center

QIN as of March 2014
http://imaging.cancer.gov/programsandresources/specializedinitiatives/qin

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Quantitative Image Informatics for Cancer Research (QIICR)

TOOLS

3DSlicer

quantitative image informatics
QII CR
for cancer research

DATA

THE CANCER IMAGING ARCHIVE

University of Washington

Oregon Health Sciences University

Mayo Clinic

University of Michigan

Wisconsin Medical College

University of Iowa

University of Pittsburgh

Columbia University

Brigham & Women's Hospital

Massachusetts General Hospital

Mount Sinai

Memorial Sloan Kettering

Johns Hopkins University

UCSF

Stanford University

UCLA

Vanderbilt University

Emory University

H. Lee Moffitt Cancer Center

NCI QIN

Semi-private community of the funded network members

QIICR goals

Technology and tools for:

> standards-based sharing
> reproducible calculation

of (candidate) imaging biomarkers from clinical image data

QIICR guiding principles

Driven by the needs of clinical research projects
  Head and neck, brain and prostate cancers
"No-strings-attached" open source
Tools for developers and non-developers
Standardized data format
  imaging and non-imaging
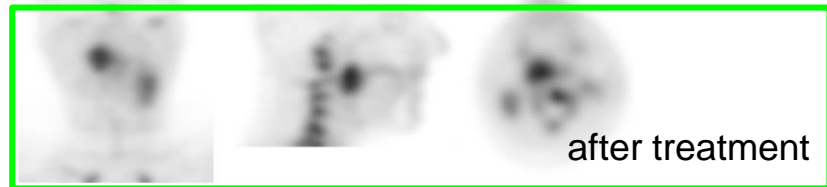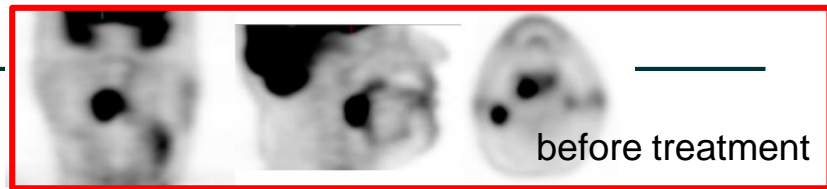Outreach, sample data, tutorials

Tumor metabolic activity

Imaging surrogate: **Positron Emission Tomography**

Quantitative image analysis:
 localization of the uptake regions
 quantification of metabolic activity

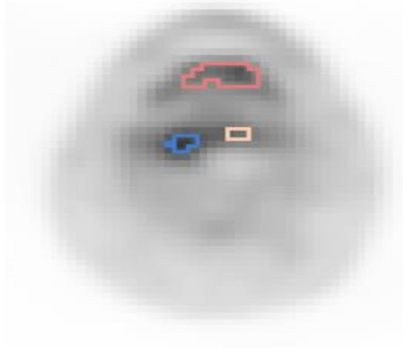Evaluation in H&N cancer

Collaboration with U.of Iowa QIN site

before treatment

after treatment
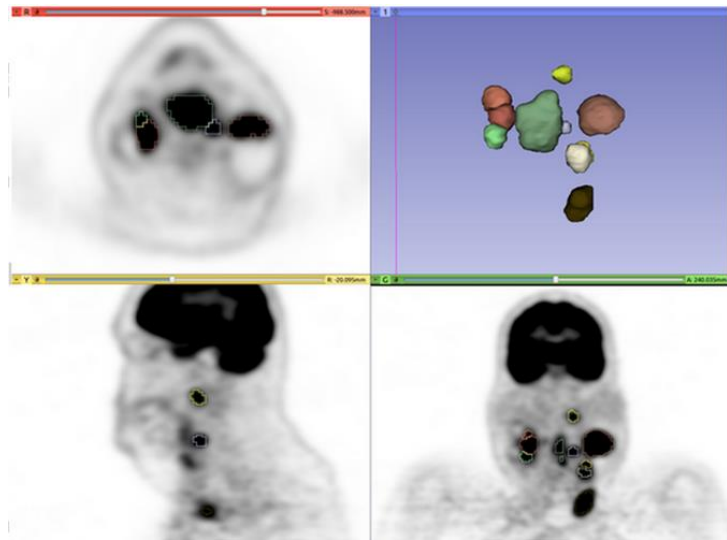
PET normalization

Standardized Uptake Value (SUV)

$$SUV(t) = \frac{c_{img}(t)}{ID/BW}$$

c_{img} - measured activity, *ID* - injected dose, *BW* - body weight

Reference regions - SUV Ratio (SUVR)
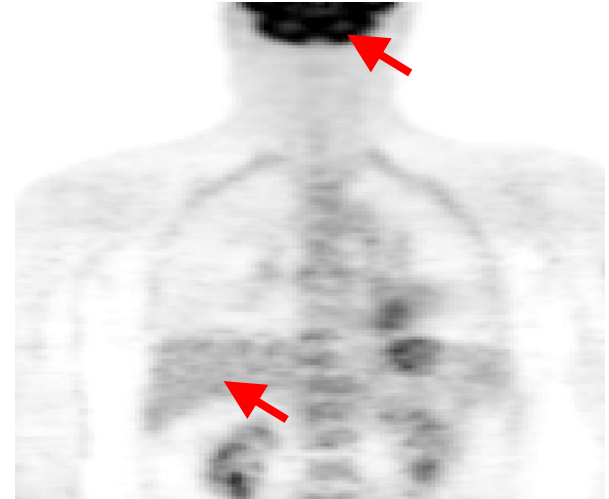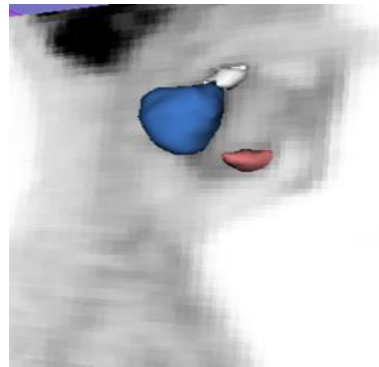
Quantitative imaging biomarkers: A review of statistical methods for technical performance assessment

David L Raunig,[1] Lisa M McShane,[2]
Gene Pennello,[3] Constantine Gatsonis,[4] Paul L Carson,[5]
James T Voyvodic,[6] Richard L Wahl,[7] Brenda F Kurland,[8]
Adam J Schwarz,[9] Mithat Gönen,[10] Gudrun Zahlmann,[11]
Marina V Kondratovich,[3] Kevin O'Donnell,[12] Nicholas Petrick,[3]
Patricia E Cole,[13] Brian Garra,[3] Daniel C Sullivan[14] and
QIBA Technical Performance Working Group

Anecdotally, reproducibility of structural measurements is reader- and algorithm-dependent and is amenable to analysis using these summary measures,[59] but the greater source of error for functional measurements such as the standardized uptake value (SUV) from fluorodeoxyglucose (FDG) PET imaging is outliers due to mistaken transfer of information such as patient weight and injection dose.[60] Specification of the random effects model is critical to the design, analysis, and interpretation of these studies. Additionally, note that published results of studies involving rater agreement should adhere to Guidelines for Reporting Reliability and Agreement Studies.[61]

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PET quantitation: Region of Interest (ROI)
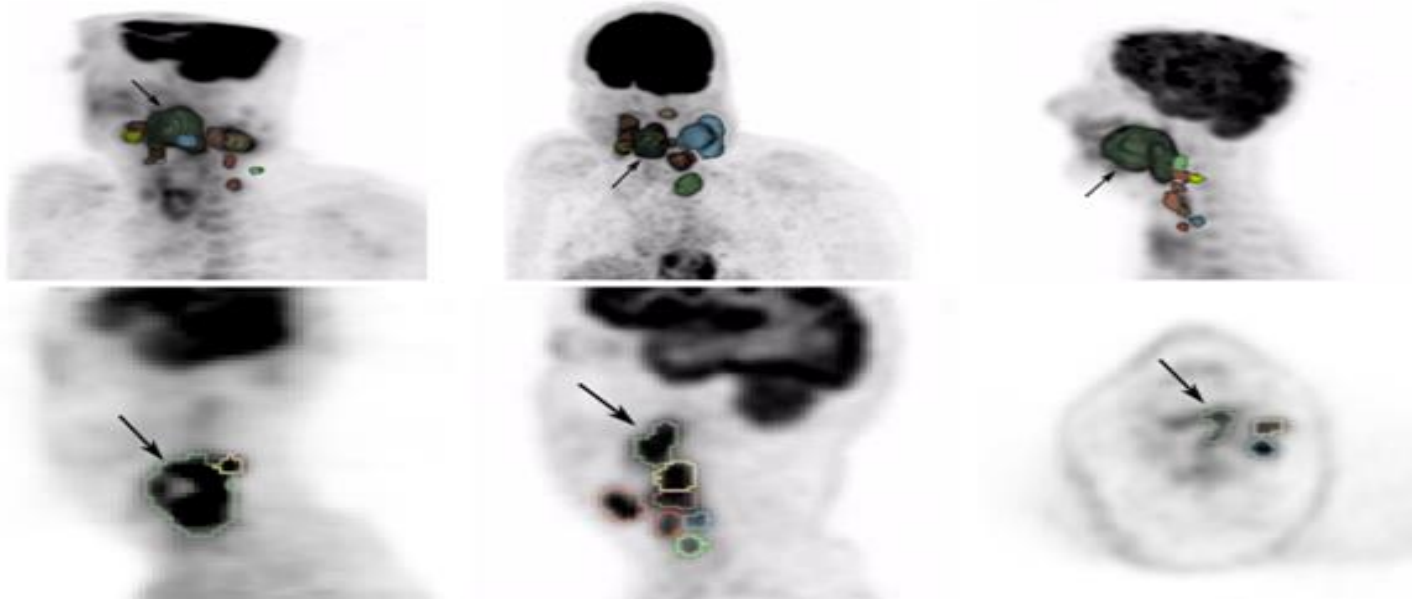
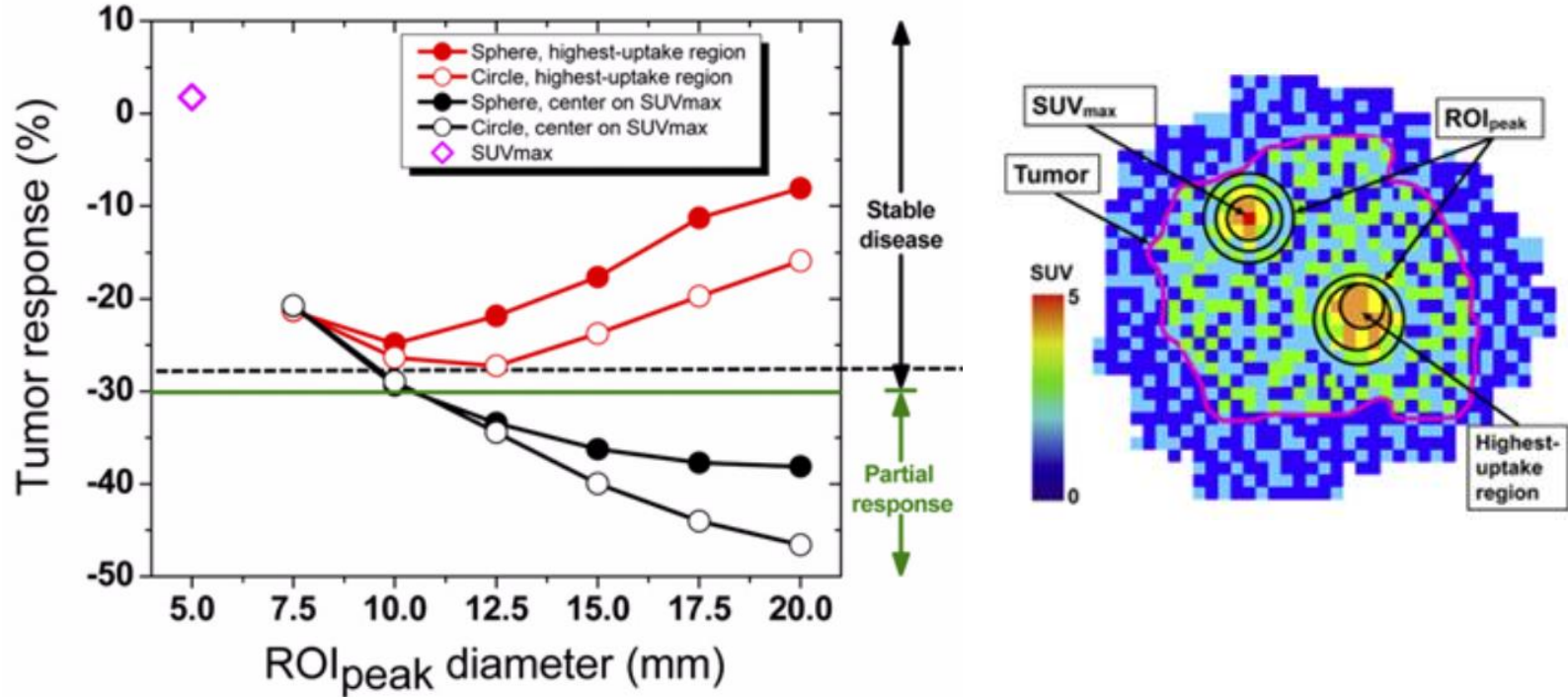

Primary tumor *vs* affected lymph nodes

Splitting lesions

Varying levels of uptake

Effect of ROI on the
    measurement **up to 55%**

PET quantitation: Feature extraction

Variety of quantitative descriptors

Candidate biomarker evaluation

treatment response assessment (QIN mission)

validate against clinical endpoint

"a characteristic or variable that reflects how a patient feels, functions, or survives"

must consider relevant clinical descriptors
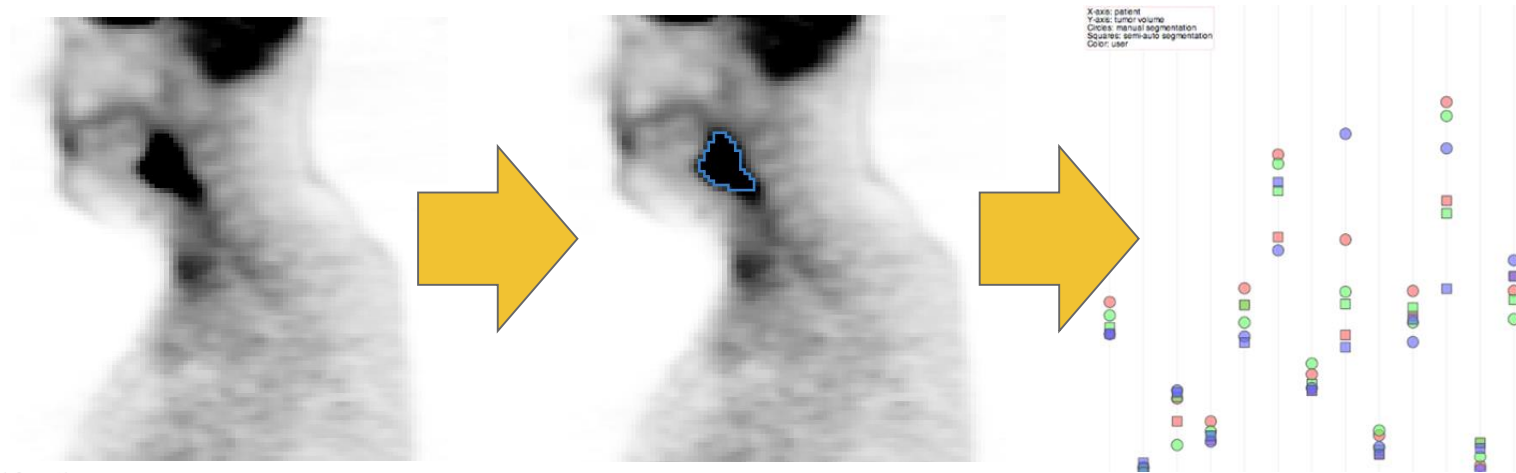
Demographics
Environment
Therapy
Complications

...

QIICR tools for PET/CT quantitative imaging

End-to-end automated processing tools
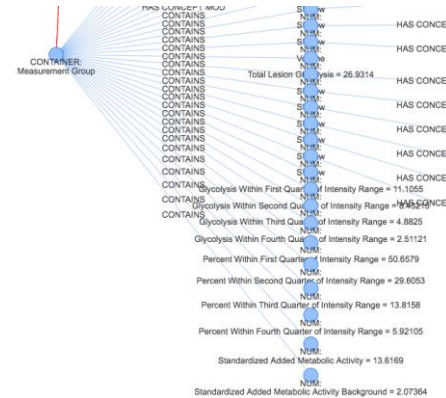From loading a PET image to candidate imaging
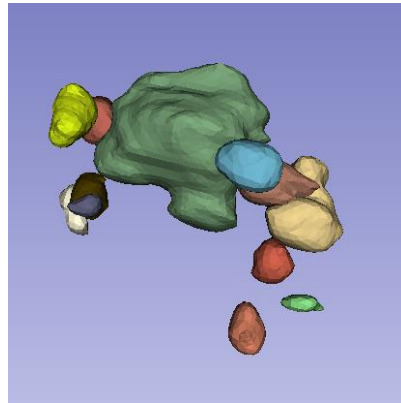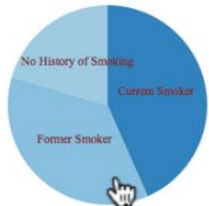biomarker measurements

QIICR data for PET/CT quantitative imaging

DICOM encoding of biomarker data

Segmentations, image normalization, semantics, provenance, clinical data, outcomes, treatment, …

Public on The Cancer Imaging Archive (TCIA)

DICOM for quantitative imaging biomarker development: a standards based approach to sharing clinical data and structured PET/CT analysis results in head and neck cancer research

Bioinformatics   Clinical Trials   Oncology   Radiology and Medical Imaging

Andriy Fedorov ✉ [1,2], David Clunie [3], Ethan Ulrich [4,5], Christian Bauer [4,5], Andreas Wahle [4,5], Bartley Brown [6], Michael Onken [7], Jörg Riesmeier [8], Steve Pieper [9], Ron Kikinis [1,2,10,11], John Buatti [12], Reinhard R. Beichel [4,5,13]

📌 Note that a Preprint of this article also exists, first published November 26, 2015.

› Author and article information

⌄ Abstract

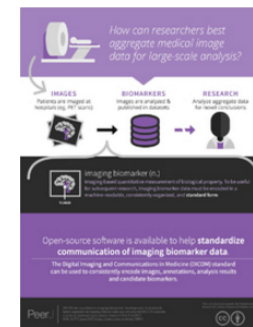2-year citation median PeerJ articles   4

Download   Follow article

Report problem

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ⓘ Meta

Peer Review history

Citations in Google Scholar

Questions

Links

Visitors   349

Views   514

Downloads   99

Broader utility contributions

Contributions to the DICOM standard process
    1 supplement and 18 correction proposals

Implementation of the relevant DICOM components
  in DCMTK library
    Simplify creation of relevant DICOM objects

Tools to simplify interaction with DICOM
    Web search index
    Editor plugin

Collaborations - ITCR

Standardized encoding of radiomics features (U24 CA194354, PI Aerts)

Development of a 3D Slicer *SlicerPathology* extension for digital pathology image annotation (U24 CA180924, PI Saltz)

Standardized exchange of annotations; integration of web-based (client) and 3D Slicer (server) tools to support quantitative imaging research (U24 CA199460, PI Harris)

Collaborations - beyond ITCR

- DICOM interoperability community effort:
  - connectathon, sample data, demonstrations
  - RSNA activities (academic and industry participation: MEVIS, OHIF, ePAD, MITK, Brainlab, 3D Slicer, etc.)

Interoperable communication of quantitative image analysis results using DICOM standard

Andrey Fedorov[1], Daniel Rubin[2], Jayashree Kalpathy-Cramer[3], Justin Kirby[4], David Clunie[5], Michael Onken[6], David Flade[7], Pattanasak Mongkolwat[8], Rajesh Venkateraman[9], Jan Bertling[10], Steve Pieper[11], Ron Kikinis[1]

[1]Brigham and Women's Hospital, [2]Stanford University, [3]Massachusetts General Hospital, [4]NCI Fredrick, [5]PixelMed Publishing, [6]OpenConnections GmbH, [7]Brainlab, [8]Mahidol University, [9]Eigen Medical, [10]Hermes Medical, [11]Isomics Inc

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Introduction

As quantitative imaging (QI) is gaining momentum in research and commercial platforms, it becomes important to support its usage scenarios:

Image Segmentation and Quantitative Imaging

Image segmentation is concerned with labeling areas of the image into distinctive regions. These regions can correspond to pathology areas,

DICOM for Image Segmentation Storage

DICOM SEG is the preferred way of communicating segmentations represented as labeled voxels. Some of the important features supported

Community building: NA-MIC Project Week

Established in 2005 under umbrella of National Alliance for Medical Image Computing (NA-MIC)

Twice a year, hands-on, open invite, academic/industry welcome

MICCAI-endorsed event

Last event: 77 attendees

Join us for the next project week!

June 20-25, 2016: Heidelberg, Germany (CARS/IPCAI/DKFZ)

January 9-13

Demo video

https://youtu.be/wK2TGyVQjzs