Quantitative Image Informatics for Cancer Research

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http://qiicr.org

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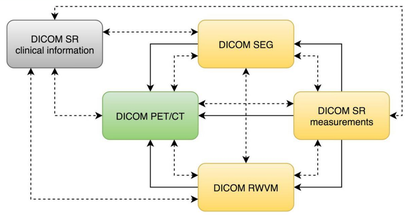
We develop informatics technology to enable 1) **extraction of quantitative imaging biomarkers** and 2) **structured standards-based communication of imaging biomarker data**, applied to clinical research in cancer treatment response assessment.
All of the technology we develop is available under **free open source permissible license with no restrictions on either academic or commercial use.**



DICOM linked data

Composite context (patient, study info) provides indirect referencing.
Explicit references are typically maintained for derived objects.

Tools

https://github.com/qiicr

- ***dcmqi***: QI-focused DICOM library: command-line conversion routines
- ***DICOM Search Index***: online searchable DICOM resource
- *DCMTK*: API for read/write of advanced DICOM objects
- *3D Slicer QI extensions (see list below)*: interactive and batch processing tools for QI extraction and interfacing data repositories
- Atom *dicom-dump* package: DCMTK convenience wrappers

Bold faced are platforms/tools maintained by QIICR. The rest of the tools are extensions/plugins maintained by QIICR, while the platforms are maintained primarily by other projects/groups.

Standardized data representation using *Digital Imaging and Communications in Medicine* (DICOM)

Guiding principles

- Apply existing standard as possible, introduce corrections as needed via the DICOM community process
- Documentation, sample data, sample code, worked out use cases, educational materials
- Support developers and end users (clinical researcher, imaging biomarker developer, DICOM developer)
- Outreach to promote and demonstrate adoption of the standard

Image data

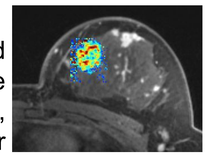
- DICOM image data produced by clinical equipment is typically in legacy format with multiple slices/files per dataset
- We are developing tools for converting legacy formats into modern, multi-frame (MF) representation
- MF advantages: less duplication of metadata, convenience, less error-prone

Image-like data

- **Image segmentations**

Labeling areas of the image into distinctive regions (pathology areas, organs, etc)

- DICOM Image Segmentation object
  - Size efficiency (MF and bit-encoded)
  - Structured terminology for semantics
  - Encoding of presentation (color)
  - Multi-voxel occupancy
  - Binary and fractional



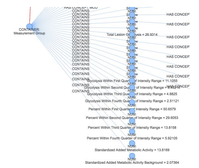
- **Parametric maps**

Encoding of real-world values associated with the image pixels (diffusion, cellularity, vascular transfer rate, etc)

- DICOM Parametric Map object
  - Size efficiency (MF)
  - Structured terminology for quantity, units
  - Data and algorithm provenance

Non-image-like data

DICOM Structured Reporting (SR) is a versatile object type that enable encoding of structured hierarchical data, which can reference other DICOM objects (i.e., images, segmentations), while maintaining composite context. We apply DICOM SR to encode



- **Clinical data**
  - Demographics
  - Outcomes
  - Therapy
- Derived measurements
  - Volumetric ROI measurements
  - References to the PET images and segmentations used for measurements
  - Structured terminology for quantitities and units
  - Explicit encoding of operator, timepoint, session identification

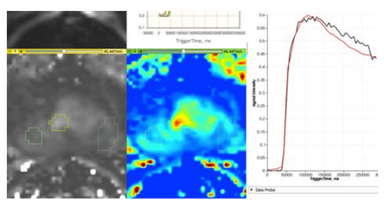
DICOM Digital Imaging and Communications in Medicine

Open source tools for quantitative imaging applied to cancer treatment response assessment

Our imaging biomarker software tool development is motivated by the needs of the three clinical research projects of the NCI Quantitative Imaging Network (QIN) in head and neck (U. Iowa), prostate (Brigham and Women's) and brain (Mass General) cancers.

DCE MRI modeling

- Tofts model implemented
- Population and individualized AIF support
- Volume transfer rate (Ktrans), extravascular extracellular space (ve) maps
- Batch mode tool



DWI MRI modeling

- Mono-/bi-exp, kurtosis, gamma, stretched exp models implemented
- Vendor-specific parsing of b-values
- Batch processing tool

PET segmentation

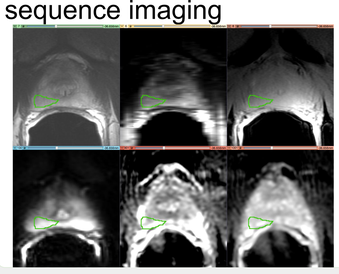
- "Just enough" interaction approach: iterative refinement as necessary on operator input
- Robust graph-based algorithm

PET quantitation

- Standard Uptake Value (SUV) conversion
- Calculation of ROI summary statistics and PET-specific quantitative measures
- Interactive workflow for end-to-end analysis
- Batch processing and interactive tools

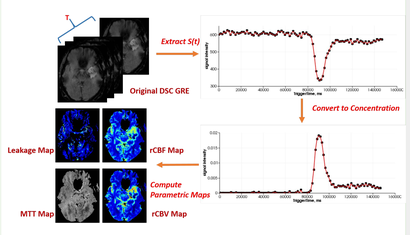
Multi-parametric image reporting

Visualization, segmentation, and exploration of multi-sequence imaging



DSC MRI modeling

- Mono-/bi-exp, kurtosis, gamma, stretched exp models implemented
- Vendor-specific parsing of DSC data
- Batch processing tool



MRI T1 estimation

- Variable flip angle approach
- Batch processing tool

Active collaborations

- Standardized encoding of radiomics features (U24 CA194354)
- Development of a 3D Slicer *SlicerPathology* extension for digital pathology image annotation (U24 CA180924)
- Standardized exchange of annotations; integration of web-based (client) and 3D Slicer (server) tools to support quantitative imaging research (U24 CA199460)
- DICOM interoperability community effort: connectathon, sample data, demonstrations; RSNA activities (academic and industry participation, including such groups/tools as MEVIS, OHIF, ePAD, MITK, Brainlab, 3D Slicer, etc.)

Opportunities for collaboration

- Integration of QIICR DICOM conversion tools into platforms/products, retrospective conversion of QI biomarker data
- Integration and evaluation of open source quantitative image analysis tools QIICR is developing
- Join our DICOM QI interoperability connectathon activities

Key references

- Fedorov et al. DICOM for quantitative imaging biomarker development. *PeerJ*. 2016
- Beichel et al. Semiautomated segmentation of head and neck cancers in 18F-FDG PET scans. *Medical physics*. 2016