

DICOM and Slicer: A Tutorial

Sonia Pujol, Ph.D. Assistant Professor of Radiology Director of 3D Slicer Training & Education Brigham and Women's Hospital Harvard Medical School spujol@bwh.harvard.edu





Objective

This tutorial provides a basic introduction to the DICOM standard, and shows how to visualize DICOM images in 3D Slicer version 5.0



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Tutorial Outline







Part 3: Loading and Visualizing DICOM data in Slicer

Tutorial material

3D Slicer version 5.0 https://download.slicer.org

SlicerDICOMTutorialData DICOM Torso CT DICOM Breast MRI





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Install Slicer Extensions	Download Sample Data						
Customize Slicer	Explore Loaded Data						
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We are always interested in imp your problem or submit a bug rep	roving 3D Slicer, to tell us about ort, open Help -> Report a Bug.						
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Disclaimer

- 3D Slicer is a free open source software application distributed under a BSD style license
- The software is not FDA approved or CE marked, and is for research use only



Reproducible Science

• Reproducible science is critical to drive research and accelerate discoveries

 Open-source software tools such as 3D Slicer and data standards such as DICOM contribute to the reproducibility of scientific results in biomedical research





F.A.I.R. Principles

www.nature.com/scientificdata SCIENTIFIC DATA Amended Addendur **Comment:** The FAIR Guiding SUBJECT CATEGORIES Principles for scientific data » Research data » Publication management and stewardship characteristics Mark D. Wilkinson et al." There is an urgent need to improve the infrastructure supporting the reuse of scholarly data. A diverse set of stakeholders-representing academia, industry, funding agencies, and scholarly publishers-have come together to design and jointly endorse a concise and measureable set of principles that we refer Received: 10 December 2015 to as the FAIR Data Principles. The intent is that these may act as a guideline for those wishing to Accepted: 12 February 2016 enhance the reusability of their data holdings. Distinct from peer initiatives that focus on the human Published: 15 March 2016 scholar, the FAIR Principles put specific emphasis on enhancing the ability of machines to automatically find and use the data, in addition to supporting its reuse by individuals. This Comment is the first

formal publication of the FAIR Principles, and includes the rationale behind them, and some exempla

The FAIR Guiding Principles for scientific data management and stewardship. Wilkinson et al. Sci. Data 2016 <u>http://go-fair.org/fair-principles</u>

implementations in the community.

- Findable: Data are easily findable
- Accessible: Users know how to access the data, including authentication and authorization
- Interoperable: Data can be integrated with other data and can interoperate with applications for storage and analysis
- **Reusable:** Data can be replicated or combined for new research

The DICOM standard

• DICOM (Digital Imaging and Communications in Medicine) is the international standard for handling, storing, printing and transmitting medical imaging data

• Clinical imaging equipment (CT scanners, MR scanners, X-Ray and ultrasound machines) generate DICOM files



DICOM History

- 1982: The American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) initiate standards for the interconnection of medical imaging devices
- 1985: Publication of the ACR-NEMA Digital Imaging and Communications Standards version 1.0
- 1988: Publication of the ACR-NEMA Digital Imaging and Communications Standards version 2.0
- 1993: Publication of the ACR-NEMA Standards version 3.0 also referred to as the Digital Imaging and Communications in Medicine (DICOM) standard

DICOM Today

- The DICOM standard is continuously being refined to address new community needs through multiple releases every year
- As of 2020/07/06, the DICOM standard is DICOM PS3 2020c and contains 4,000 pages
- DICOM Working Groups are established to expand the capabilities of the standard given the continuous evolution of imaging modalities

(e.g. WG-16 Magnetic Resonance) https://www.dicomstandard.org/wgs

FAIR Data and the DICOM Standard





The DICOM Standard facilitates compliance of imaging data with FAIR principles

DICOM Data Model



- In the DICOM data model, a
 DICOM Study consists of several
 DICOM Series, and each DICOM
 Series contains DICOM Instances
- Each of the DICOM Studies, Series and Instances are assigned a Unique Identifier (UID)

Example of DICOM instances: DICOM MRI Image data



An MRI image is an example of DICOM instance that consists of a DICOM header and an image dataset

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- The DICOM header contains metadata which include information on the patient, study and imaging data.
- DICOM provides a standardized way to present metadata which makes it searchable
- The metadata information is accessible through **DICOM tags**
- DICOM tags uniquely identify DICOM attributes
- Original data from the scanner tell users important elements about the acquisition

Example of DICOM header content



The Life Cycle of Medical Imaging Data - Sonia Pujol, Ph.D. Functional Magnetic Resonance Imaging: Data Acquisition and Analysis Harvard-MIT Health Sciences and Technology (HST.583)

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HIPPA Patient privacy

The Health Insurance Portability and Accountability Act of 1996 (HIPAA) protects the privacy and security of certain health information

http://www.hhs.gov/hipaa/index.html

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Examples of Standard DICOM Instances

- DICOM images produced by imaging equipment: single X-Ray slice , DICOM CT or DICOM MR volume, DICOM multi-frame object (e.g. fMRI experiment, diffusion MRI, DCE)
- DICOM Segmentation Object (SEG): voxels labelled in regions of interest (ROIs)
- DICOM Structured Report (SR): clinical information (e.g. diagnosis, pathology, surgery, etc.), measurements computed from segmented ROIs



Examples of Standard DICOM Instances

DICOM Images

Prostate MRI Images

DICOM Segmented Structures

Prostate gland, peripheral zone, lesion, normal tissue

Measurements

Volumes of prostate gland, peripheral zone, lesion, normal tissue

Segmented structure	SegmentedPropertyCategoryCodeSequence	SegmentedPropertyTypeCodeSequence	AnatomicRegionSequence
Prostate gland	("T-D000A", "SRT, "Anatomical Structure")	("T-9200B", "SRT", "Prostate")	NA
Peripheral zone of the prostate gland	("T-D000A", "SRT, "Anatomical Structure")	("T-D05E4", "SRT", "Peripheral zone of the prostate")	NA
Lesion in the peripheral zone of the prostate gland	("M-01000", "SRT", "Morphologically Altered Structure")	("M-01100", "SRT", "Lesion")	("T-D05E4", "SRT", "Peripheral zone of the prostate")
Normal tissue in the peripheral zone of the prostate gland	("T-D0050", "SRT, "Tissue")	("G-A460", "SRT", "Normal")	("T-D05E4", "SRT", "Peripheral zone of the prostate")

Measured structure	Finding	Finding Site
Prostate gland *	(T-F6078, SRT, "Entire Gland")	("T-9200B", "SRT", "Prostate")
Peripheral zone of the prostate gland	(R-404A4, SRT, "Entire")	("T-D05E4", "SRT", "Peripheral zone of the prostate")
Lesion in the peripheral zone of the prostate gland	(R-42037, SRT, "Abnormal")	("T-D05E4", "SRT", "Peripheral zone of the prostate")
Normal tissue of peripheral zone of the prostate gland	("G-A460", "SRT", "Normal")	("T-D05E4", "SRT", "Peripheral zone of the prostate")

DICOM Terminology

- DICOM provides support for segmentation objects and annotations
- DICOM Structured Reports enable provenance tracking
- DICOM derived data can be stored on a DICOM server or on other archive (e.g. TCIA) with permission, and is compliant with FAIR principles





Anas et al. MICCAI 2017

DICOM for Artificial Intelligence Studies

- DICOM defines syntax rules and vocabularies that enable easy extraction of knowledge from the data
- The DICOM framework for medical imaging data management enables the automation of cohort formation and maximizes the interoperability of the data for AI studies



Slicer DICOM module

- The Slicer DICOM module provides the infrastructure for storing, loading and exporting DICOM data
- Slicer supports CT, MRI, PET, X-Ray and ultrasound DICOM data
- Dedicated Slicer Extensions can be added to Slicer for importing additional DICOM instances (e.g. DICOM RT Dose, DICOM Segmentation Object, Diffusion Weighted MRI, etc.)

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Part 3: Loading and Visualizing DICOM data in Slicer

Tutorial Dataset

• Download the **SlicerDICOMTutorialData.zip** file to your computer

• Create a **SlicerData** folder on your computer and move the SlicerDICOMTutorialData.zip file to the SlicerData folder

• Unzip the SlicerDICOMTutorialData.zip



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Dataset #1 Torso CT

Loading a DICOM dataset in Slicer

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The DICOM dataset is loaded into Slicer as a patient-study-series DICOM hierarchy

Patient:

Series:

Instance: **CT** Slice

Visualizing a DICOM dataset in Slicer

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and select Edit properties

Right-click on 6: CT_Thorax_Abdomen

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Position the mouse cursor over the red banner in the Red Viewer to display the slice menu.

Click on the Links icon to link the slice controls across all Slice Viewers

Click on the Eye icon to display the three anatomical slices in the 3D Viewer



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Click on the second icon on the top row of the 3DView controller to center the 3D view

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Histogram

Data Probe

Show Zoomed Slice

В









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Dataset #2 Breast MRI

Breast MRI Dataset

- The Breast MRI dataset is part of the BREAST-DIAGNOSIS collection of The Cancer Imaging Archive (TCIA) of the National Cancer Institute
- The dataset was acquired on patient with right breast infiltrating ductal carcinoma
- The DICOM images consist of one study and three series: T2, STIR and BLISS
- BLISS is an MRI sequence for breast MRI studies. BLISS provides the measurement of two bilateral volumes in a single acquisition.

Bloch, B. Nicolas, Jain, Ashali, & Jaffe, C. Carl. (2015). Data From BREAST-DIAGNOSIS. The Cancer Imaging Archive. <u>http://doi.org/10.7937/K9/TCIA.2015.SDNRQXXR</u>

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Click on the PatientID BreastDx-01-0005 to display the study and the three T2W, STIR and BLISS series

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- CT Thorax Abdomen (20050601)

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Click on the double arrow to display the list of DICOM readers

DICOM database settings

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Slicer DICOM Plugins

✓ DICOMScalarVolumePlugin
 ✓ DICOMSlicerDataBundlePlugin
 ✓ DICOMVolumeSequencePlugin
 ✓ MultiVolumeImporterPlugin

 Slicer implements a list of DICOM plugins to handle a diverse set of DICOM data objects

 These plugins need to be enabled in order to read specific DICOM data objects such DICOM RT data or DICOM DWI data

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DICOM networking

DICOM database settings

Data Probe

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Show Zoomed Slice

Click on the Adjust window/level button, and use the left mouse button in the 2D view to adjust the window and level of the MR images



R: 73.8949m

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Data Probe

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Show Zoomed Slice





Conclusion

- This tutorial introduced the DICOM standard and showed how to load and visualize DICOM CT and MR images in Slicer
- 3D Slicer and the DICOM standard enable compliance with the FAIR principles for biomedical research
- By enabling interoperability between research and clinical environments, 3D Slicer and the DICOM standard lower the inherent barriers to the translation of research advances to patient care



Acknowledgments

Neuroimaging Analysis Center (NIBIB P41 EB015902)

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