RSNA 2015 – RCA22
A Practical Introduction to Structured Reporting Tools and Resources

DICOM Structured Reports (SR)

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PixelMed Publishing

Background & Disclosures

- Owner, PixelMed Publishing, LLC
- Radiologist
- Independent Consultant
- Sub-contractor on NCI QIICR project
- Editor of DICOM Standard
- Formerly co-chair DICOM Standards Committee
- Formerly co-chair IHE Radiology Technical Committee

Overview of DICOM SR

- Motivation
- Background and clinical use
- Basic principles
- Research, quantitative imaging, translation
- Templates for measurements
- Coded terminology

Motivation

- Utility
  - e.g., extraction of measurements to use in another context, such as automatically merging into another table, database, report or document
- Semantic Interoperability
  - standard encoding, recognizable pattern, recognizable codes produced by different systems and consumed by different systems
- No human required
  - i.e., “machine readable” without need for OCR or NLP
  - beyond screen shots and “pretty pictures” or uncoded graphics

What is “structure” anyway

- *“arrangement of and relations between the parts or elements of something complex” (Oxford)*
- Some or all of
  - an organized outline (vs. arbitrary prose)
  - controlled vocabulary/terminology (i.e., coded concepts)
  - measurements related to images and regions of interest
- Distinguish:
  - narrative form (+/- augmented with non-narrative content)
  - structured encoding

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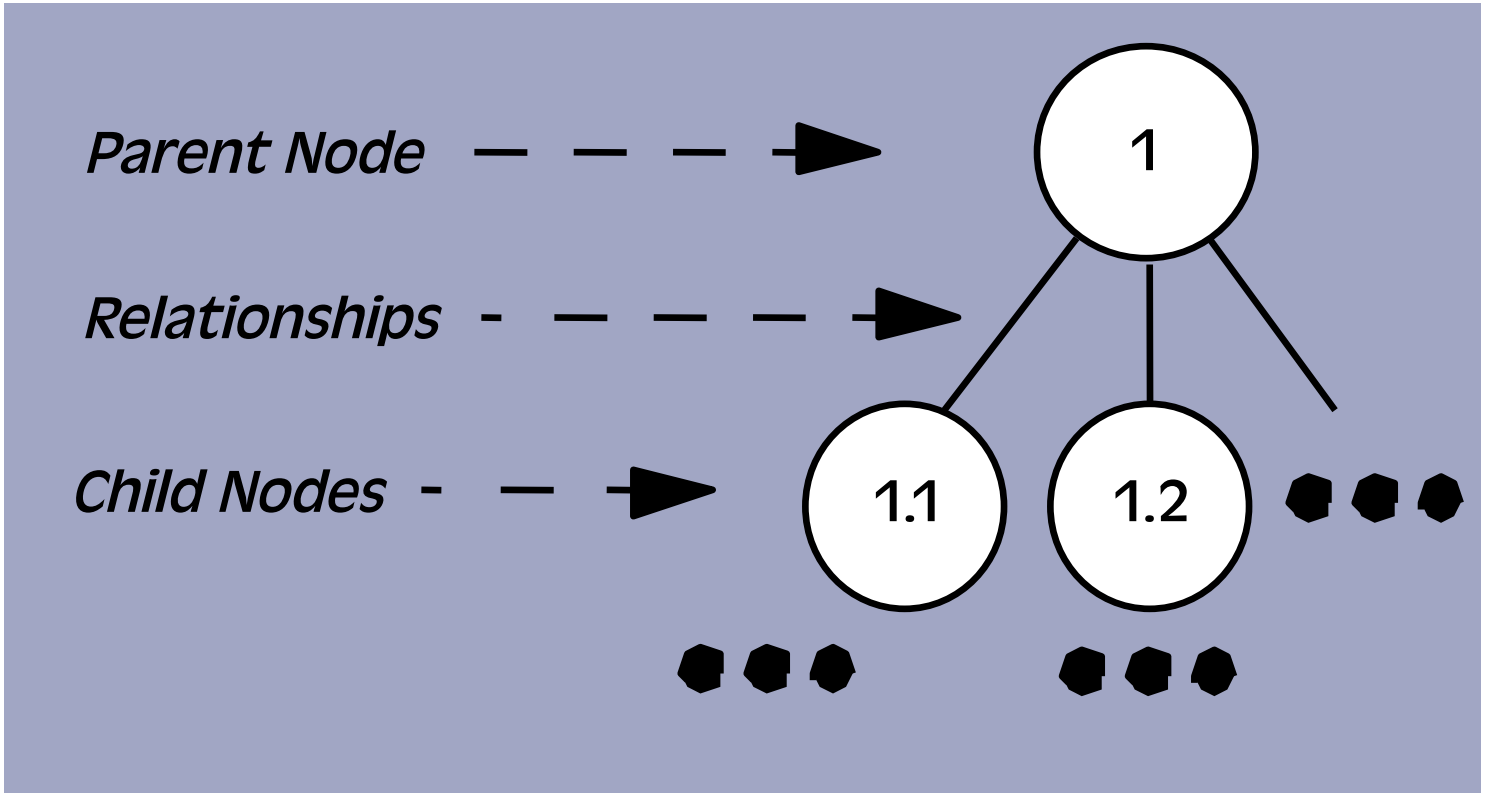
DICOM Structured Report (SR)

- Extends the DICOM standard beyond attributes in "image header”
- Into a “tree” of structured content
- Each tree node (“content item”) is a "name-value" pair
- Or a “container” (provides an outline of “headings”)
- Name is always coded, value may or may not be
- Generic framework - recursively nested content of unbounded complexity
- Complexity constrained for specific use cases by "templates"

SR Content Tree



SR Content Tree

- : CONTAINER: Imaging Measurement Report [SEPARATE] (DCMR,1500)
  - HAS CONCEPT MOD: CODE: Language of Content Item and Descendants = English
    - HAS CONCEPT MOD: CODE: Country of Language = United States
  - HAS OBS CONTEXT: CODE: Observer Type = Person
  - HAS OBS CONTEXT: PNAME: Person Observer Name = User3
  - HAS CONCEPT MOD: CODE: Procedure reported = PET whole body
  - CONTAINS: CONTAINER: Image Library [SEPARATE] (DCMR,1600)
    - CONTAINS: CONTAINER: Image Library Group [SEPARATE]
      - HAS ACQ CONTEXT: CODE: Modality = Positron emission tomography
      - HAS ACQ CONTEXT: DATE: Study Date = 19860810
      - HAS ACQ CONTEXT: TIME: Study Time = 124529.439000
      - HAS ACQ CONTEXT: DATE: Content Date = 19860810
      - HAS ACQ CONTEXT: TIME: Content Time = 132849.000000
      - HAS ACQ CONTEXT: DATE: Acquisition Date = 19860810
      - HAS ACQ CONTEXT: TIME: Acquisition Time = 131803.409000
      - HAS ACQ CONTEXT: UIDREF: Frame of Reference UID = 1.3.6.1.4.1.14519.5.2.1.2744.7002.148581826664809938988000313184
      - HAS ACQ CONTEXT: NUM: Pixel Data Rows = 128 pixels
      - HAS ACQ CONTEXT: NUM: Pixel Data Columns = 128 pixels
      - HAS ACQ CONTEXT: CODE: Radionuclide = ^18^Fluorine
      - HAS ACQ CONTEXT: CODE: Radiopharmaceutical agent = Fluorodeoxyglucose F^18^
      - CONTAINS: IMAGE: = 1.2.840.10008.5.1.4.1.1.128 : 1.3.6.1.4.1.14519.5.2.1.2744.7002.221784495212110180451913187136
      - CONTAINS: IMAGE: = 1.2.840.10008.5.1.4.1.1.128 : 1.3.6.1.4.1.14519.5.2.1.2744.7002.227723169531643726818780678655

Content Item Encoding

- Container or name-value pair
- Content items have a value type
- Concept name is always coded
- Value may be text or a code depending on value type
- Codes are from external sources or defined in DICOM
- Content items are related by “relationships”

SR Content Item Value Types

- CONTAINER
- TEXT
- CODE
- NUM
- PNAME
- DATE
- TIME
- DATETIME
- UIDREF
- COMPOSITE
- IMAGE
- WAVEFORM
- SCOORD
- SCOORD3D
- TCOORD

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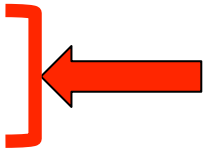

SR Content Item Encoding

```
1.5.1.9: HAS ACQ CONTEXT: NUM: (110910,DCM,"Pixel Data Rows”)
                                                    = 128 ({pixels},UCUM,"pixels")
1.5.1.10: HAS ACQ CONTEXT: NUM: (110911,DCM,"Pixel Data Columns”)
                                                    = 128 ({pixels},UCUM,"pixels")
1.5.1.11: HAS ACQ CONTEXT: CODE: (C-10072,SRT,"Radionuclide”)
                                                    = (C-111A1,SRT,"^18^Fluorine")
1.5.1.12: HAS ACQ CONTEXT: CODE: (F-61FDB,SRT,"Radiopharmaceutical agent”)
                                          = (C-B1031,SRT,"Fluorodeoxyglucose F^18^")
```

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```

Encoding Codes

- A three-tuple of
  - Code Value
  - Coding Scheme Designator
  - Code Meaning
- E.g.
  - (C-B1031, SRT, "Fluorodeoxyglucose F^18^”)

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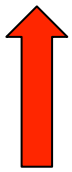

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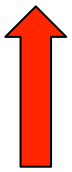

Which Codes from Where?

- SNOMED codes used by preference throughout DICOM
  - long historical relationship, esp. anatomy
  - agreement to allow license/fee free use in DICOM implementations
  - strong desire for semantic interoperability with clinical (non-imaging) systems that use SNOMED (or UMLS)
  - DICOM contributes imaging content to SNOMED
- LOINC (UMLS)
  - for measurements and report titles
  - now has relationship with SNOMED
- NCI Thesaurus (UMLS)
  - especially for oncology, research and clinical trial concepts not in SNOMED
- Foundational Model of Anatomy (UMLS) and NeuroNames
  - occasional anatomic concepts not in SNOMED (there is a SNOMED-FMA harmonization activity)
- RadLex
  - occasional radiology-specific concepts not in other schemes
- DICOM defined codes (“DCM”, in DICOM PS3.16)
  - for imaging-specific not appropriate for (or not yet added to) other schemes

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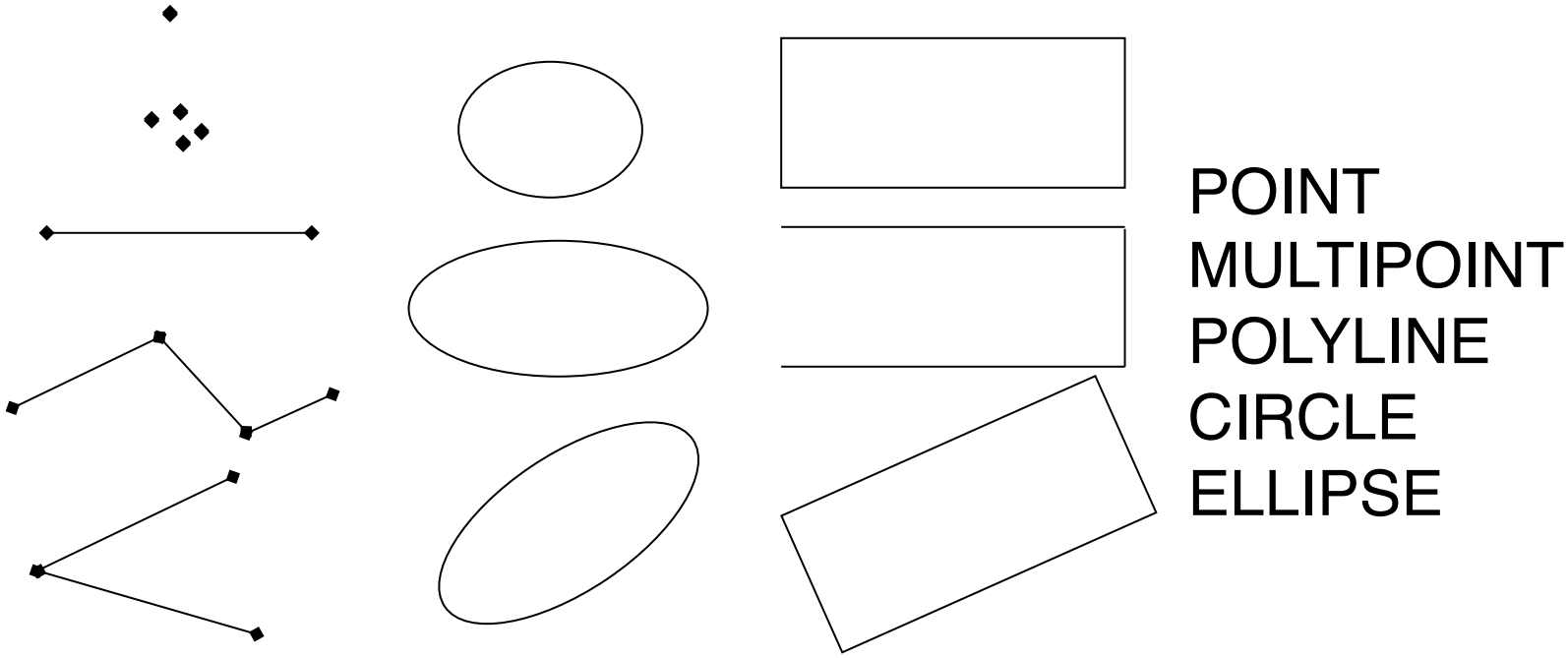
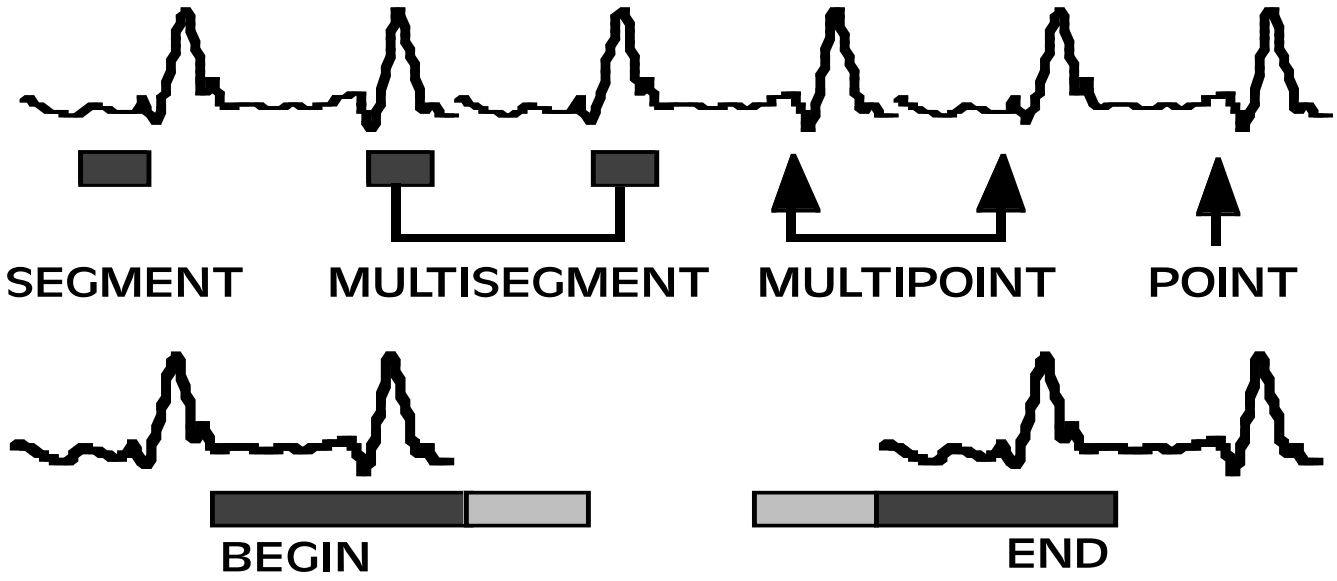
Image References

- Identify Image: SOP Instance UID
- Type of Image: SOP Class UID
- [Frame Number] (for multi-frame images)
- [Presentation State]
  - contrast transformations
  - standard grayscale space
  - spatial transformations

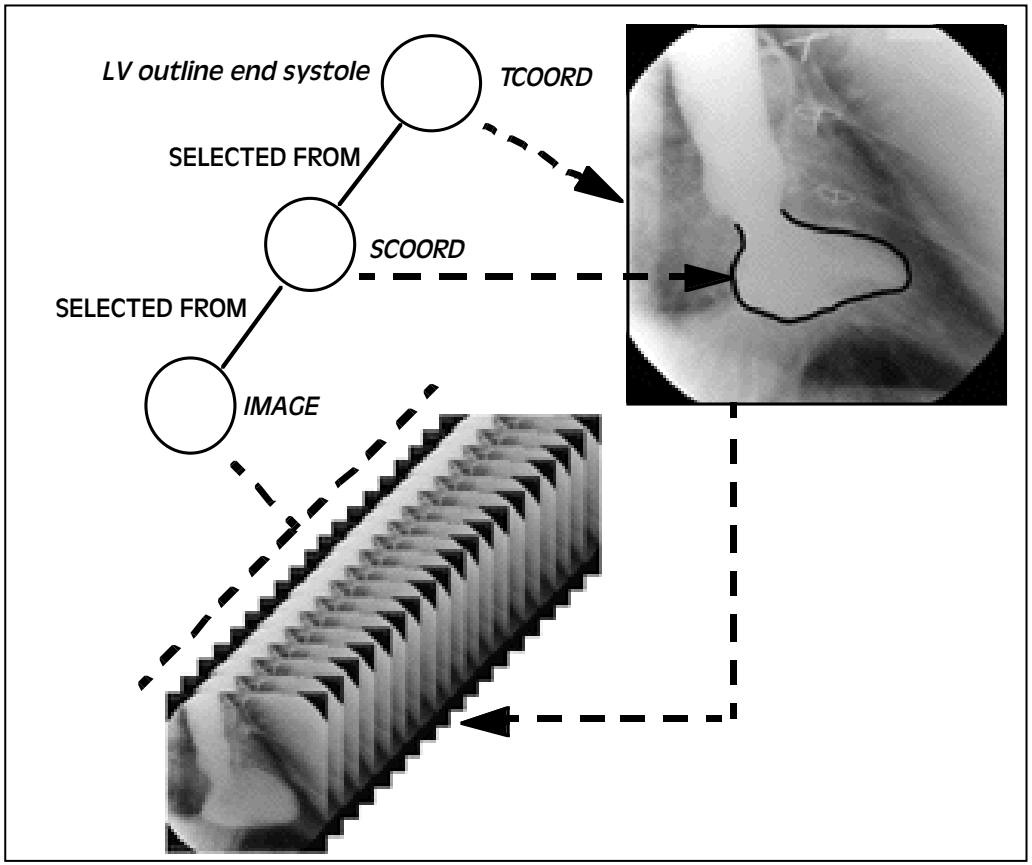
2D Spatial Coordinates



Temporal Coordinates



Temporal & Spatial Coordinates

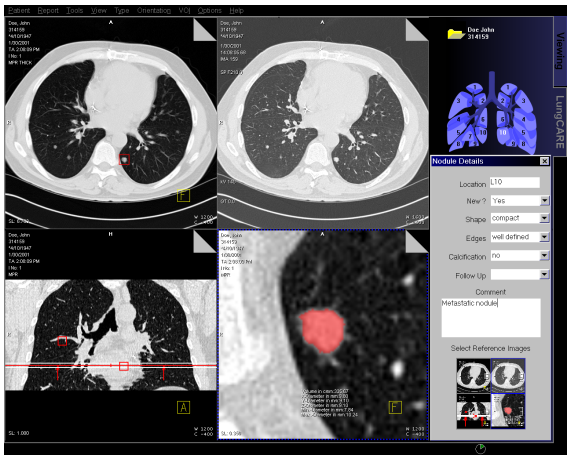


Complexity and Templates – Real World Applications

- Generic structure needs constraints
  - for specific real world use cases
  - allows for interoperable applications
- Templates specify
  - document title
  - outline (containers, section headings)
  - content by name, value type, possible values
  - what is mandatory, conditional, optional

Real World Applications

- “Evidence Documents”
  - Mammography CAD (also Chest, Colon)
  - Echocardiography and Cardiovascular Measurements
  - OB-GYN Ultrasound Reports
  - Radiation Dose (RDSR)
- Radiology reports
  - Basic Diagnostic Imaging Report
  - IHE Simple Image and Numeric Report (SINR) Profile
  - Transcribed Diagnostic Imaging Report
- Key Object Selection (KOS) (IHE Key Image Note (KIN))



DOE, JANE L. 02/10/09:123142 INSTITUTION 09 Oct 02

OB

AUA	15w3d	EDD(AUA):	03/30/2003
GA(LMP):	18w0d	EDD(LMP):	03/12/2003
LMP:	06/05/2002	Estab. Due Date:	03/19/2003

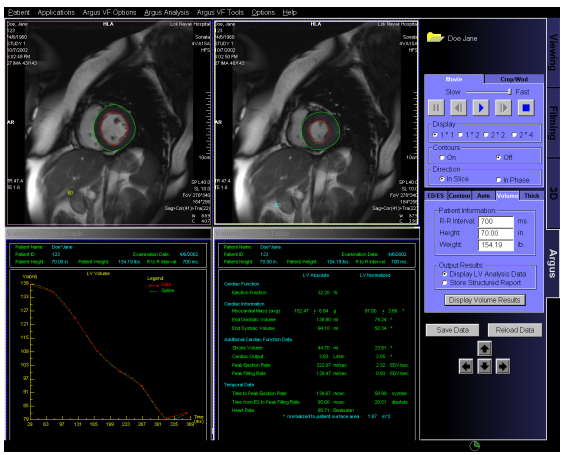
EFW: 138 g (+/-20g)
0lb 5oz
4 % Approx: 10-90%

CI:	88 %	70-86%	BPDa: 2.42 cm 14w1d
HC/AC:	1.02	(1.07-1.29)	
FL/BPD:	91 %		
FL/AC:	26 %		

Fetal Biometry

BPD	2.25	2.57	2.82	2.55	cm	Hadlock	14w3d [13w1d-15w5d]
OFD	2.60	3.04	3.09	2.91	cm		
HC	9.29c			9.29	cm	Hadlock	14w2d [13w0d-15w4d]
APD	2.63	[2.80]		2.72	cm		
TAD	2.94	[3.01]		2.97	cm		
AC	9.13c			9.13	cm	Hadlock	15w3d [13w5d-17w1d]
FL	2.65	2.25	2.10	2.33	cm	Hadlock	17w1d [15w5d-18w4d]
TTD	2.85	2.34		2.60	cm		
APTD	1.69			1.69	cm		

Edit Graphs Close 1 of 1




P
1:0.148
[0.472mm]
A P
1:0.148
[0.472mm]
1:0.148
[0.472mm]
A
1:0.148
[0.472mm]

Patient Name: Exam no:

Accession Number:

Patient ID: Discovery CT750 HD

Exam Description: CT HALS/THORAX/ABDOMEN

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
2	Helical	S15.750-I650.250	5.10	373.00	Body 32
5	Helical	S188.000-I105.000	5.10	182.72	Body 32

Total Exam DLP: 555.72

DICOM SR
as Input, Output or Both

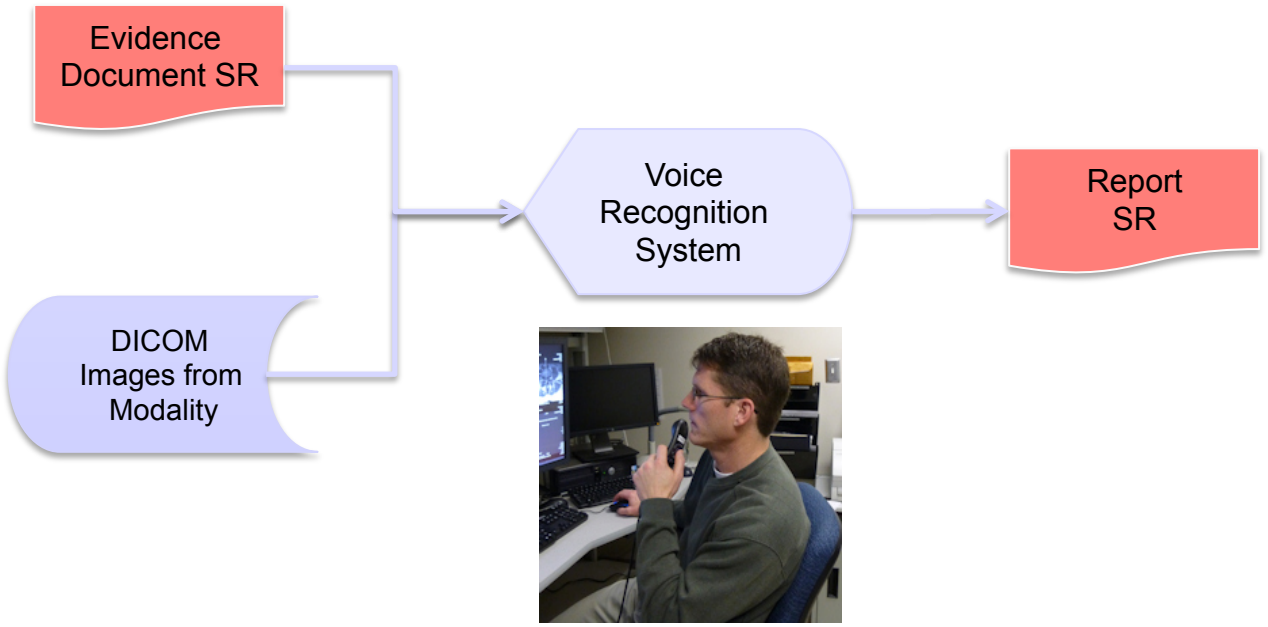


Image from David Weiss, Aunt Minnie 2013/01/18

Quantitative Imaging Research Applications

- Current real world use of "evidence documents”
  - e.g., off US carts
  - has not really leveraged the image relationship
  - often flat lists of numbers without image coordinate references
- Can do better for
  - advanced applications in all cross-sectional modalities
  - esp. interactive 3D and multi-modality (PET-CT) applications
  - save and recover semantic state of visualization using DICOM SR
- Two approaches
  - per-application specific templates (e.g., CT cardiovascular measurements)
  - sufficiently robust generic measurement templates for class of applications

TID 1500 Measurement Report

- “Goldilocks” approach
  - find the "sweet spot" of quantitative data recording for both clinical and research use
  - not too simple
  - not too complicated
  - just right - measurements of ROIs on images encoded as contours or segmentations +/- qualitative statements

Explanation of TID 1500

- Document title
- Image library
  - relevant characteristics of images used, e.g., radiopharmaceutical
- List of ROIs with measurements
  - planar, volumetric, other types
- List of qualitative (categorical) evaluations
  - i.e., coded questions, code or text values

ROI Measurement Groups

- Session (e.g., for multiple reads by same reader)
- Tracking identifier (e.g., "lesion 1") + UID
- Finding type (e.g., lesion, tumor, reference region)
- Time point (e.g., for longitudinal comparison baseline, prior, current)
- Measurement method (e.g. ”SUVbw") (common to all measurements)
- Target site (anatomic location) (common to all measurements)
- Coordinates, segmentation references, image references defining ROI
- List of measurements derived from the ROI
- List of qualitative evaluations

Each ROI Measurement

- Coded concept, numeric value, coded units (e.g., Volume = 33 mm3)
- Modifiers for concept name of measurement
- Measurement method (e.g. “SUVbw”)
- Measurement derivation (e.g., “mean”)
- Target site (anatomic location)
- Equation
- Reference authority
- Range authority
- Derivation parameter

Table TID 1411. Volumetric ROI Measurements

	NL	Rel with Parent	VT	Concept Name	VM	Req Type	Condition	Value Set Constraint
1			CONTAINER	EV (125007, DCM, "Measurement Group")	1	M		
1b	>	HAS OBS CONTEXT	TEXT	EV (C67447, NCIt, "Activity Session")	1	U		
2	>	HAS OBS CONTEXT	TEXT	DT (112039, DCM, "Tracking Identifier")	1	M		
3	>	HAS OBS CONTEXT	UIDREF	EV (112040, DCM, "Tracking Unique Identifier")	1	M		
3b	>	CONTAINS	CODE	EV (121071, DCM, "Finding")	1	U		$FindingType
4	>	CONTAINS	INCLUDE	DTID 1502 “Time Point Context”	1	U		
5	>	CONTAINS	SCOORD	EV (111030, DCM, "Image Region")	1-n	MC	XOR Rows 7, 10	GRAPHIC TYPE = not {MULTIPOINT}
6	>>	SELECTED FROM	IMAGE		1	M		
7	>	CONTAINS	IMAGE	EV (121191, DCM, "Referenced Segment")	1	MC	XOR Rows 5, 10	Reference shall be to a Segmentation Image or Surface Segmentation object, with a single value specified in Referenced Segment Number
8	>	CONTAINS	IMAGE	EV (121233, DCM, "Source image for segmentation")	1-n	MC	XOR Row 9 and IFF Row 7	

- CONTAINS: CONTAINER: Imaging Measurements [SEPARATE]
  - CONTAINS: CONTAINER: Measurement Group [SEPARATE] (DCMR,1411)
    - HAS OBS CONTEXT: TEXT: Activity Session = 2
    - HAS OBS CONTEXT: TEXT: Tracking Identifier = primary tumor
    - HAS OBS CONTEXT: UIDREF: Tracking Unique Identifier = 2.25.321931685067302978142568823813987841964
    - CONTAINS: CODE: Finding = Neoplasm, Primary
    - HAS OBS CONTEXT: TEXT: Time Point = 1
    - CONTAINS: IMAGE: Referenced Segment = 1.2.840.10008.5.1.4.1.1.66.4 : 1.2.276.0.7230010.3.1.4.8323329.22968.1436800951.875753[Segment 1]
    - CONTAINS: UIDREF: Source series for image segmentation = 1.3.6.1.4.1.14519.5.2.1.2744.7002.117357550898198415937979788256
    - CONTAINS: COMPOSITE: Real World Value Map used for measurement = 1.2.840.10008.5.1.4.1.1.67 : 1.2.276.0.7230010.3.1.4.8323329.21218.1436800935.45195
    - HAS CONCEPT MOD: CODE: Measurement Method = SUV body weight calculation method
    - HAS CONCEPT MOD: CODE: Finding Site = base of tongue
    - CONTAINS: NUM: SUVbw = 3.58285 Standardized Uptake Value body weight
      - HAS CONCEPT MOD: CODE: Derivation = Mean
    - CONTAINS: NUM: SUVbw = 3.17526 Standardized Uptake Value body weight
      - HAS CONCEPT MOD: CODE: Derivation = Minimum
    - CONTAINS: NUM: SUVbw = 4.42643 Standardized Uptake Value body weight
      - HAS CONCEPT MOD: CODE: Derivation = Maximum
    - CONTAINS: NUM: Volume = 3.21039 Milliliter
      - HAS CONCEPT MOD: CODE: Measurement Method = Sum of segmented voxel volumes
    - CONTAINS: NUM: Total Lesion Glycolysis = 11.5024 Gram
    - CONTAINS: NUM: SUVbw = 0.253951 Standardized Uptake Value body weight
      - HAS CONCEPT MOD: CODE: Derivation = Standard Deviation
    - CONTAINS: NUM: SUVbw = 3.38131 Standardized Uptake Value body weight
      - HAS CONCEPT MOD: CODE: Derivation = 25th Percentile Value
    - CONTAINS: NUM: SUVbw = 3.49684 Standardized Uptake Value body weight
      - HAS CONCEPT MOD: CODE: Derivation = Median
    - CONTAINS: NUM: SUVbw = 3.72015 Standardized Uptake Value body weight
      - HAS CONCEPT MOD: CODE: Derivation = 75th Percentile Value
    - CONTAINS: NUM: SUVbw = 4.21502 Standardized Uptake Value body weight
      - HAS CONCEPT MOD: CODE: Derivation = Upper Adjacent Value
    - CONTAINS: NUM: SUVbw = 3.59184 Standardized Uptake Value body weight
      - HAS CONCEPT MOD: CODE: Derivation = RMS
    - CONTAINS: NUM: Glycolysis Within First Quarter of Intensity Range = 4.98963 Gram
    - CONTAINS: NUM: Glycolysis Within Second Quarter of Intensity Range = 4.30593 Gram

Documents DB

Viewers 2D Viewer ROIs 4D Viewer Report

None All modalities Patient Name Soundex Local Studies only

Time Interval Modality Search by Patient Name

Accession	Study Description	Modality	ID	Comments	Stat	Date Acquired	# im	#
2076699673350889	Thorax 1H..._Neck_Petct	SR	0			7/13/15, 10:22 AM	0	1

Qin-Headneck-01-0024

Thorax 1Head_Neck_... SR
7/13/15 0 images

Image size: 1224 x 1584
WL: 127 WW: 255

Qin-Headneck-01-0024 QIN-HEADNECK-01-0024 (- , -)
Thorax 1Head_Neck_Petct

Source series for image segmentation:
1.3.6.1.4.1.14519.5.2.1.2744.7002.117357550898198415937979788256
Real World Value Map used for measurement:
RealWorldValueMappingStorage

Concept Modifier: Measurement Method = SUV body weight calculation method (126410, DCM)
Concept Modifier: Finding Site = base of tongue (T-53131, SRT)

SUVbw:
3.58285 {SUVbw}g/ml

Concept Modifier: Derivation = Mean (R-00317, SRT)

SUVbw:
3.17526 {SUVbw}g/ml

Concept Modifier: Derivation = Minimum (R-404FB, SRT)

SUVbw:
4.42643 {SUVbw}g/ml

Concept Modifier: Derivation = Maximum (G-A437, SRT)

Volume:
3.21039 ml

Concept Modifier: Measurement Method = Sum of segmented voxel volumes (126030, DCM)

Total Lesion Glycolysis:
11.5024 g

Conclusion

- DICOM SR has a long history of solving clinical measurement and annotation problems
- Provides a reusable framework for semantic interoperability for all medical image related use cases
- As such is highly appropriate for all clinical and research quantitative imaging measurement problems
- Generic “region of interest measurement” use case addressed by a specific template

Tools Used

- Visualization of DICOM SR Content Tree
  - *com.pixelmed.dicom.StructuredReportBrowser*
  - in PixelMed Java DICOM toolkit (also contains SR API, SR<->XML conversion)
  - http://www.dclunie.com/pixelmed/software/
- Text rendering of DICOM SR
  - *dcsrdump* utility
  - in dicom3tools
  - http://www.dclunie.com/dicom3tools/
- HTML rendering of DICOM SR shown running in OsiriX
  - *dsr2html* utility in OFFIS dcmtk DICOM toolkit (also contains SR API, SR<->XML)
  - http://www.dcmtk.org/
  - OsiriX – http://osirix-viewer.com/