DICOM
Digital Imaging and Communications in Medicine

DICOM Educational Conference
Brisbane, Australia

SEPTEMBER 24-25, 2018

DICOM STRUCTURED REPORTS

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PIXELMED PUBLISHING, LLC

Disclosures

- Editor of the DICOM Standard (NEMA Contract)
- Owner of PixelMed Publishing, LLC
- Author of book on DICOM Structured Reporting
- Consulting for GE, Carestream, MDDX (Bioclinica), Curemetrix, HCTS, Hologic
- Supported by NIH U24CA180918 QIICR, NCI Leidos BOA 29XS219 Task Order #05

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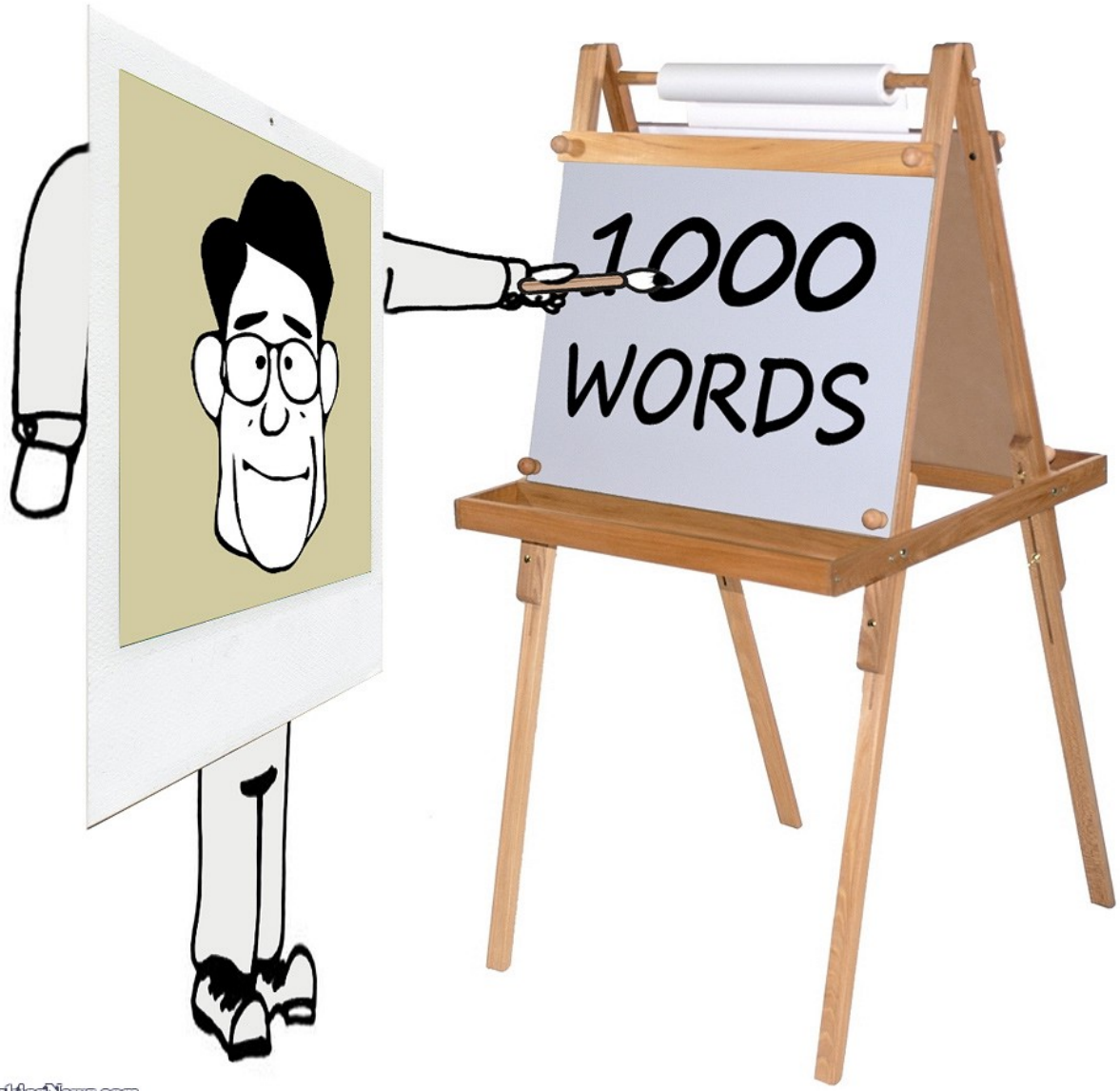

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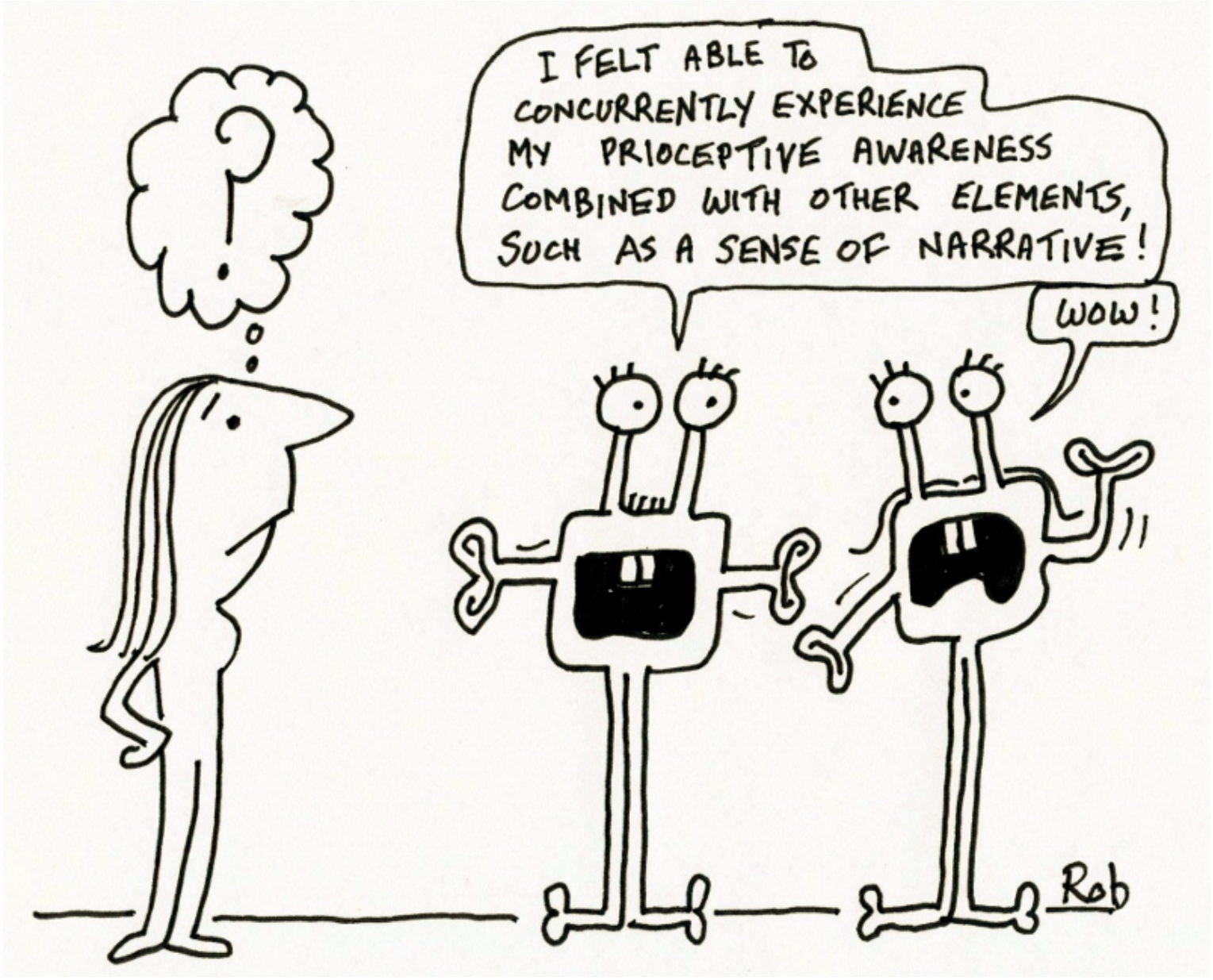

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A Picture Is Worth A Thousand Words:

Needs Assessment for Multimedia Radiology Reports in a Large Tertiary Care Medical Center

Lina Nayak, MD, Christopher F. Beaulieu, MD, PhD, Daniel L. Rubin, MD, MS, Jafi A. Lipson, MD

Rationale and Objectives: Radiology reports are the major, and often only, means of communication between radiologists and their referring clinicians. The purposes of this study are to identify referring physicians' preferences about radiology reports and to quantify their perceived value of multimedia reports (with embedded images) compared with narrative text reports.

Materials and Methods: We contacted 1800 attending physicians from a range of specialties at large tertiary care medical center via e-mail and a hospital newsletter linking to a 24-question electronic survey between July and November 2012. One hundred sixty physicians responded, yielding a response rate of 8.9%. Survey results were analyzed using Statistical Analysis Software (SAS Institute Inc, Cary, NC).

Results: Of the 160 referring physicians respondents, 142 (89%) indicated a general interest in reports with embedded images and completed the remainder of the survey questions. Of 142 respondents, 103 (73%) agreed or strongly agreed that reports with embedded images could improve the quality of interactions with radiologists; 129 respondents (91%) agreed or strongly agreed that having access to significant images enhances understanding of a text-based report; 110 respondents (77%) agreed or strongly agreed that multimedia reports would significantly improve referring physician satisfaction; and 85 respondents (60%) felt strongly or very strongly that multimedia reports would significantly improve patient care and outcomes.

Conclusions: Creating accessible, readable, and automatic multimedia reports should be a high priority to enhance the practice and satisfaction of referring physicians, improve patient care, and emphasize the critical role radiology plays in current medical care.

Key Words: Multimedia reports; radiology reporting; digital images; communication; radiology practice.

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Radiology

Structured Radiology Reporting:
Are We There Yet?[1]

Curtis P. Langlotz, MD, PhD

Given the prominent role that information technology will play in the future of health care delivery, the potential benefits of structured reporting systems now seem more relevant than ever. These systems may lead to rapid cohort design. The same 25 brain magnetic resonance (MR) imaging cases were reviewed in two distinct phases by two separate groups of residents: a control group and an intervention group. The MR imaging cases contained a representative

What is a "Structured Report"?

- Human perspective (radiologist, cardiologist, pathologist, referring physician …)
  - Not a massive blob of prose (narrative)
  - Organized
  - Hierarchical
  - Sections and sub-sections
  - Bullet lists
  - Question and answer rather then single sentence
- Machine perspective
  - coded section headings
  - coded questions with answers:
    - coded answer
    - text answer
    - numeric answer (with coded units)
  - links to images, regions of interest, coordinates (spatial & temporal)

Machine Readable Reports

Source: DARPA

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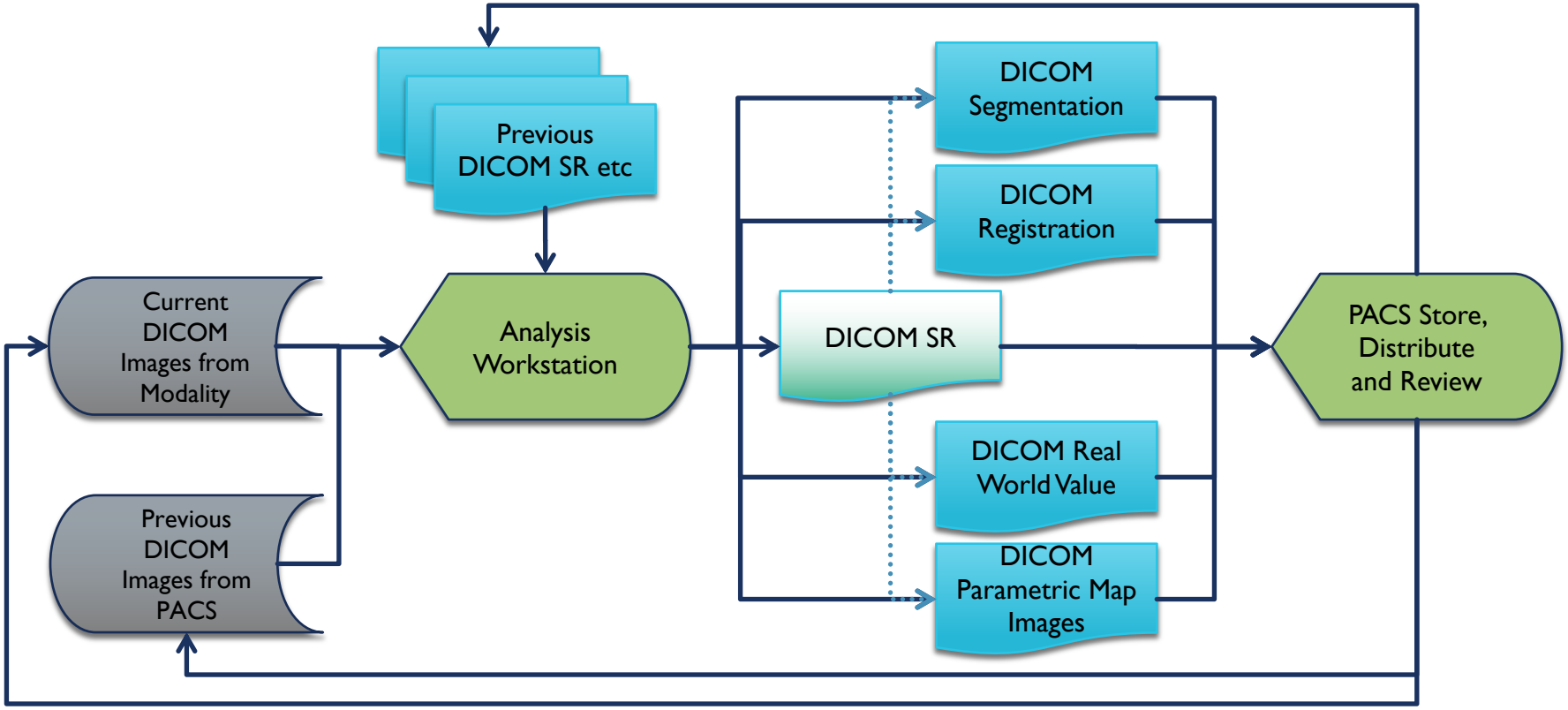
AI CHANGES THE GAME

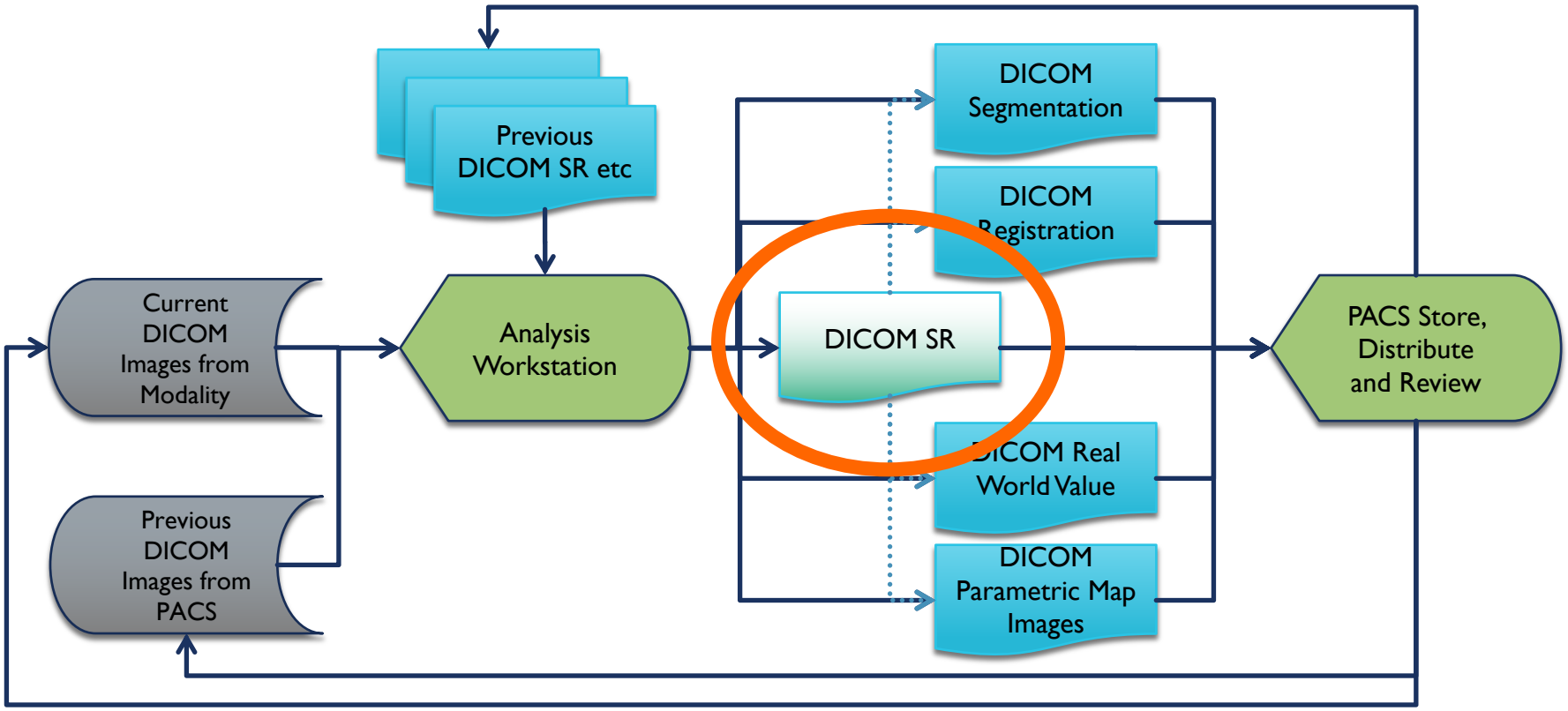
DICOM Structured Reports

- A machine-readable structured report that satisfies humans too
- Added to DICOM circa 2000
- Primary use-cases circa 2018
  - Ultrasound cart output – echocardiography, obstetric measurements
  - Mammography CAD output
  - Radiation Dose from CT and projection X-Ray devices (RDSR)
  - Key Object Selection (KOS)
  - limited use for human-generated narrative reports with section structuring
- Major new use-cases in the quantitative/machine learning era
  - tumor/lesion region of interest encoding
  - quantitative measurements and categorical classification
    - created by humans or machines
    - consumed by humans or machines

DICOM Non-Image Objects



DICOM SR organizes them …



DICOMDIR

Top

Patient TCGA-BP-4343 TCGA-BP-4343

Study 19870620 19870620 Renal

Series 3 {CT}

Series 105 {CT} 3 MIN DELAY

Series 4578 {SR} Crowds Cure Cancer

SR Document 1

CompletionFlag	ContentDate	ContentTime	Insta
COMPLETE	20171126	224217	1

TCGA-BP-4343[TCGA-BP-4343]:[19870620:Renal]:4578[SR:Crowds Cure Cancer Annotation as Measuremen

: 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: PNAME: Person Observer Name = accomplished_peafowl

HAS CONCEPT MOD: CODE: Procedure reported = CT Abdomen

CONTAINS: CONTAINER: Image Library [SEPARATE]

CONTAINS: CONTAINER: Image Library Group [SEPARATE]

CONTAINS: IMAGE: = 1.2.840.10008.5.1.4.1.1.2 : 1.3.6.1.4.1.14519.5.2.1.9203.4004.26801842228881857322651602376

HAS ACQ CONTEXT: CODE: Modality = Computed Tomography

HAS ACQ CONTEXT: DATE: Study Date = 19870620

HAS ACQ CONTEXT: TIME: Study Time = 135823

CONTAINS: CONTAINER: Imaging Measurements [SEPARATE]

CONTAINS: CONTAINER: Measurement Group [SEPARATE]

HAS OBS CONTEXT: TEXT: Tracking Identifier = 5b6eb4301d3175942d29985a3d0fbb00

HAS OBS CONTEXT: UIDREF: Tracking Unique Identifier = 1.3.6.1.4.1.5962.1.1.0.0.0.1535644357.22655.1

HAS CONCEPT MOD: CODE: Finding Site = Kidney

CONTAINS: NUM: Length = 66.43856134 mm

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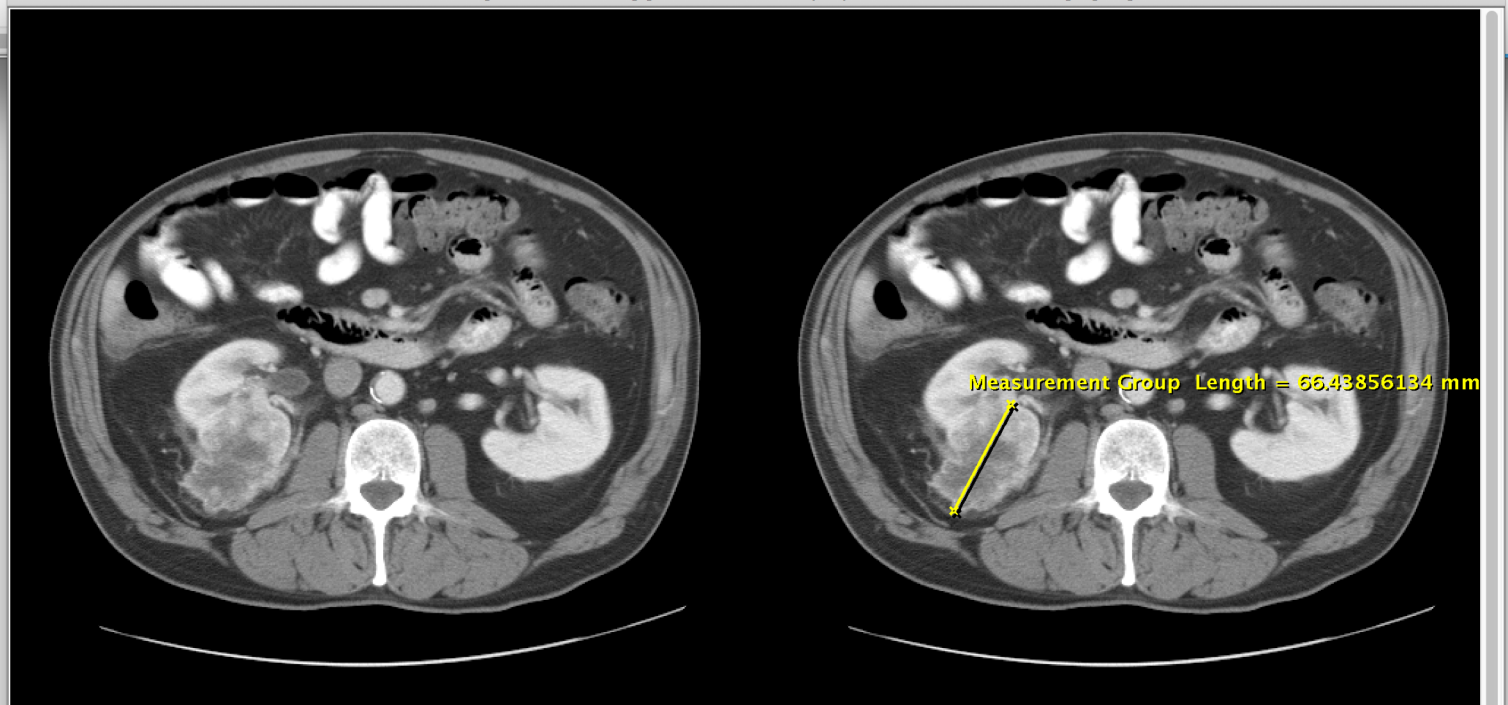
TCGA-BP-4343[TCGA-BP-4343]:[19870620:CT CH/AB/PEL KIDNEY PROTOCOL]:3[CT:]:57:



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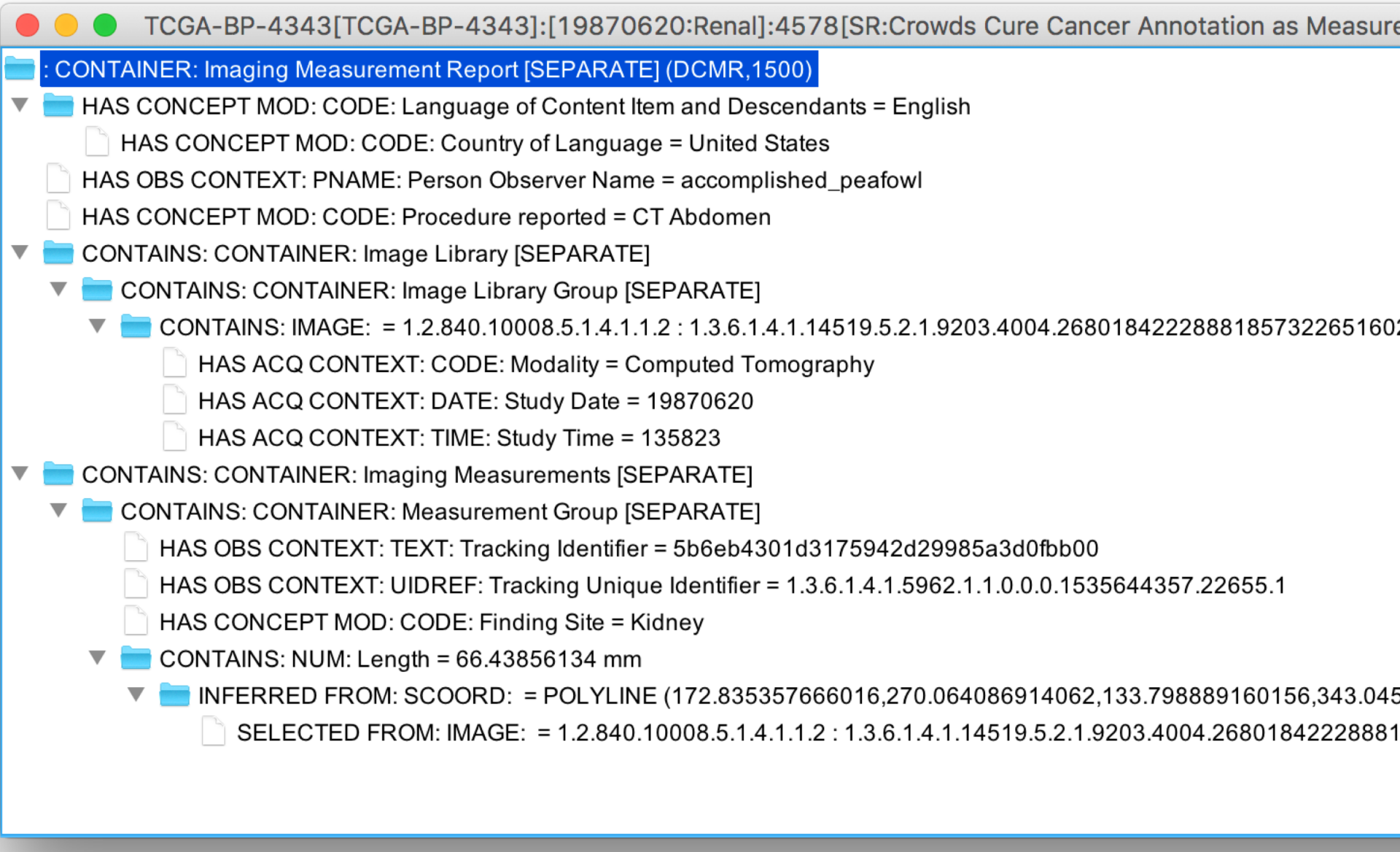

```
Report")  [SEPARATE] (DCMR,1500)
"Language of Content Item and Descendants")  = (eng,RFC5646,"Engl
121046,DCM,"Country of Language")  = (US,ISO3166_1,"United States
,"Person Observer Name")  = "accomplished_peafowl"
"Procedure reported")  = (41806-1,LN,"CT Abdomen")
mage Library")  [SEPARATE]
6200,DCM,"Image Library Group")  [SEPARATE]
GE:  = (1.2.840.10008.5.1.4.1.1.2,1.3.6.1.4.1.14519.5.2.1.9203.40
S ACQ CONTEXT: CODE: (121139,DCM,"Modality")  = (CT,DCM,"Computed
S ACQ CONTEXT: DATE: (111060,DCM,"Study Date")  = "19870620"
S ACQ CONTEXT: TIME: (111061,DCM,"Study Time")  = "135823"
maging Measurements")  [SEPARATE]
5007,DCM,"Measurement Group")  [SEPARATE]
XT: TEXT: (112039,DCM,"Tracking Identifier")  = "5b6eb4301d317594
XT: UIDREF: (112040,DCM,"Tracking Unique Identifier")  = "1.3.6.1
OD: CODE: (G-C0E3,SRT,"Finding Site")  = (T-71000,SRT,"Kidney")
: (G-D7FE,SRT,"Length")  = 66.43856134 (mm,UCUM,"mm")
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```

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,"Person Observer Name")  = "accomplished_peafowl"
"Procedure reported")  = (41806-1,LN,"CT Abdomen")
mage Library")  [SEPARATE]
6200,DCM,"Image Library Group")  [SEPARATE]
GE:  = (1.2.840.10008.5.1.4.1.1.2,1.3.6.1.4.1.14519.5.2.1.9203.40
S ACQ CONTEXT: CODE: (121139,DCM,"Modality")  = (CT,DCM,"Computed
S ACQ CONTEXT: DATE: (111060,DCM,"Study Date")  = "19870620"
S ACQ CONTEXT: TIME: (111061,DCM,"Study Time")  = "135823"
maging Measurements")  [SEPARATE]
5007,DCM,"Measurement Group")  [SEPARATE]
XT: TEXT: (112039,DCM,"Tracking Identifier")  = "5b6eb4301d317594
XT: UIDREF: (112040,DCM,"Tracking Unique Identifier")  = "1.3.6.1
OD: CODE: (G-C0E3,SRT,"Finding Site")  = (T-71000,SRT,"Kidney")
: (G-D7FE,SRT,"Length")  = 66.43856134 (mm,UCUM,"mm")
FERRED FROM: SCOORD:  = POLYLINE {172.835357666016,270.0640869140
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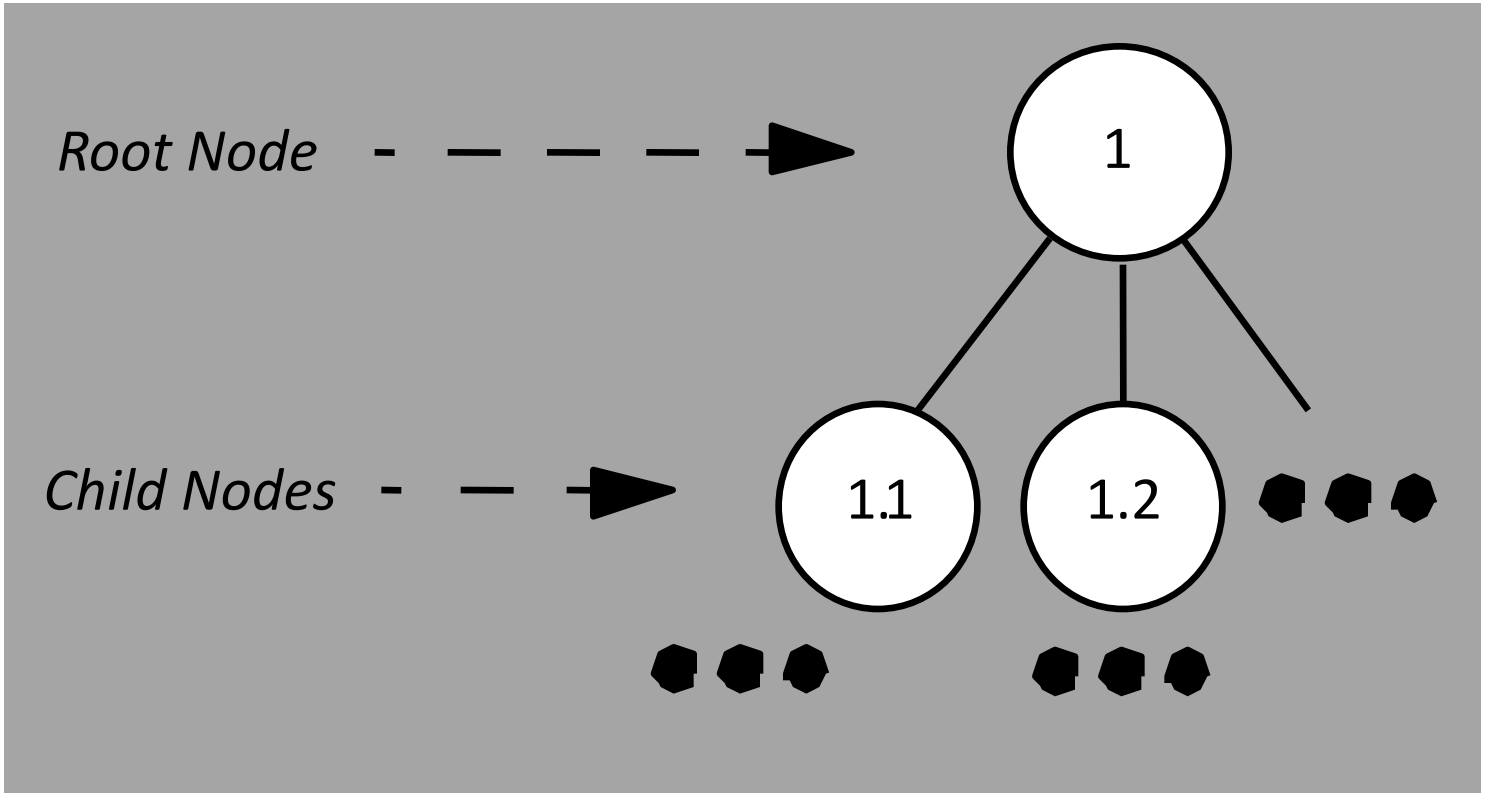
```

SR Content is a Tree

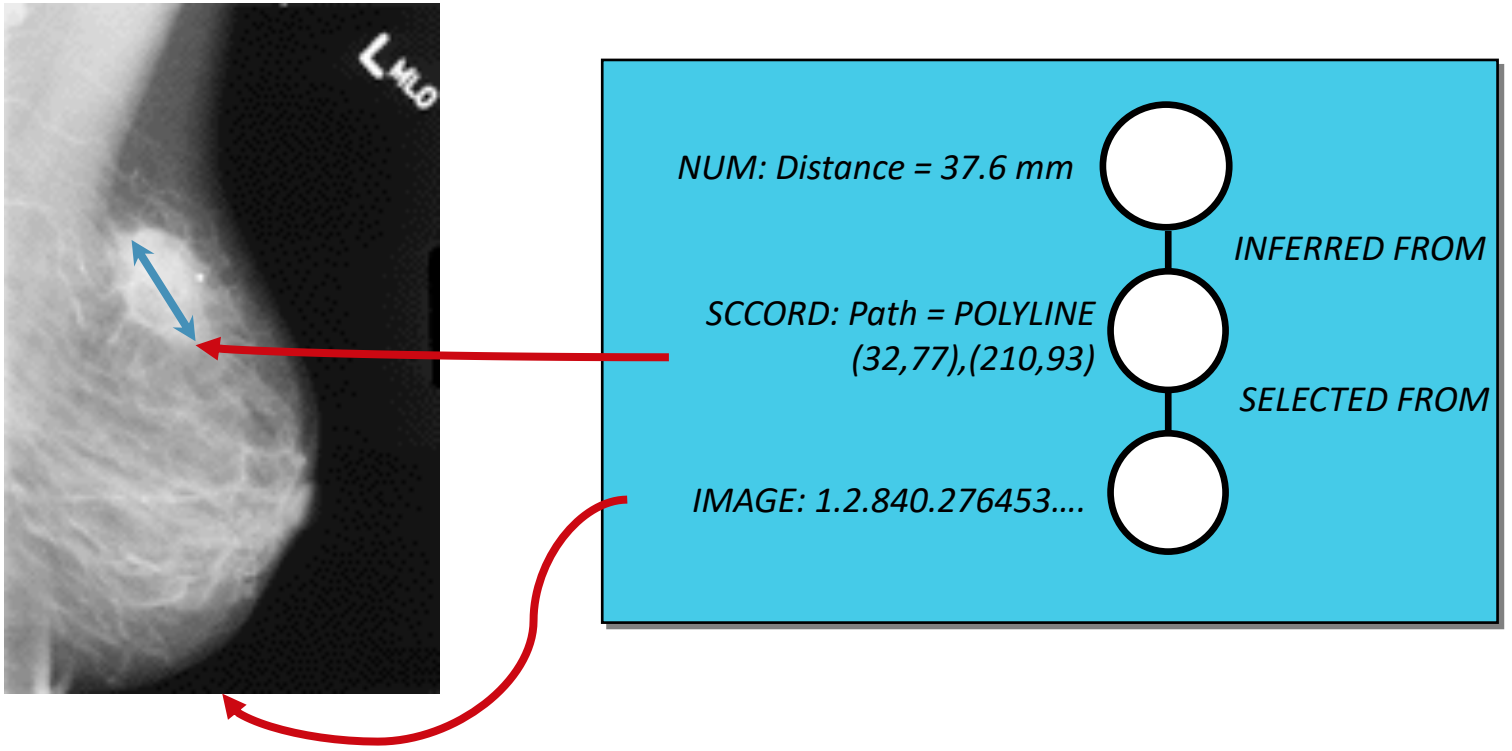


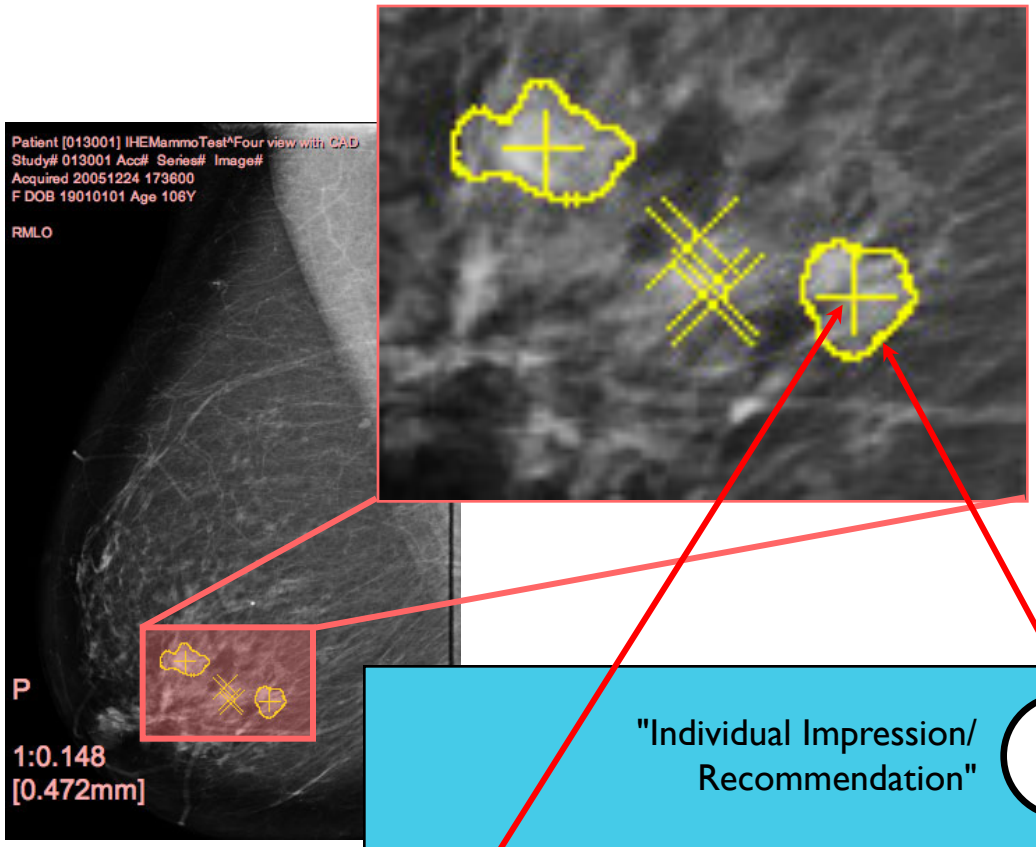
Each Node (Content Item)

- Is a "name-value" pair
  - e.g. "finding" = "mass"
- Concept "name" is always coded
  - e.g. (121071, DCM, "Finding")
- "Value" may be one of several "value types"
- "Value" may be coded too
  - e.g. (M-37000, SRT, "Hemorrhage")
  - e.g. 37.2 (mm2, UCUM, "square millimeters")

Value Types

- TEXT
- CODE
- NUM
- PNAME
- DATE
- TIME
- DATETIME
- CONTAINER
- UIDREF
- COMPOSITE
- IMAGE
- WAVEFORM
- SCOORD(3D)
- TCOORD


L MLO
NUM: Distance = 37.6 mm
INFERRED FROM
SCCORD: Path = POLYLINE
(32,77),(210,93)
SELECTED FROM
IMAGE: 1.2.840.276453….



CONTAINER: "Mammo CAD Report"

CODE: "Summary" = "Succeeded with Findings"

• • •

CONTAINER: "Individual Impression/ Recommendation"

"Individual Impression/ Recommendation"

CONTAINS

CODE: "Single Image Finding" = "Mammography breast density"

HAS PROPERTIES

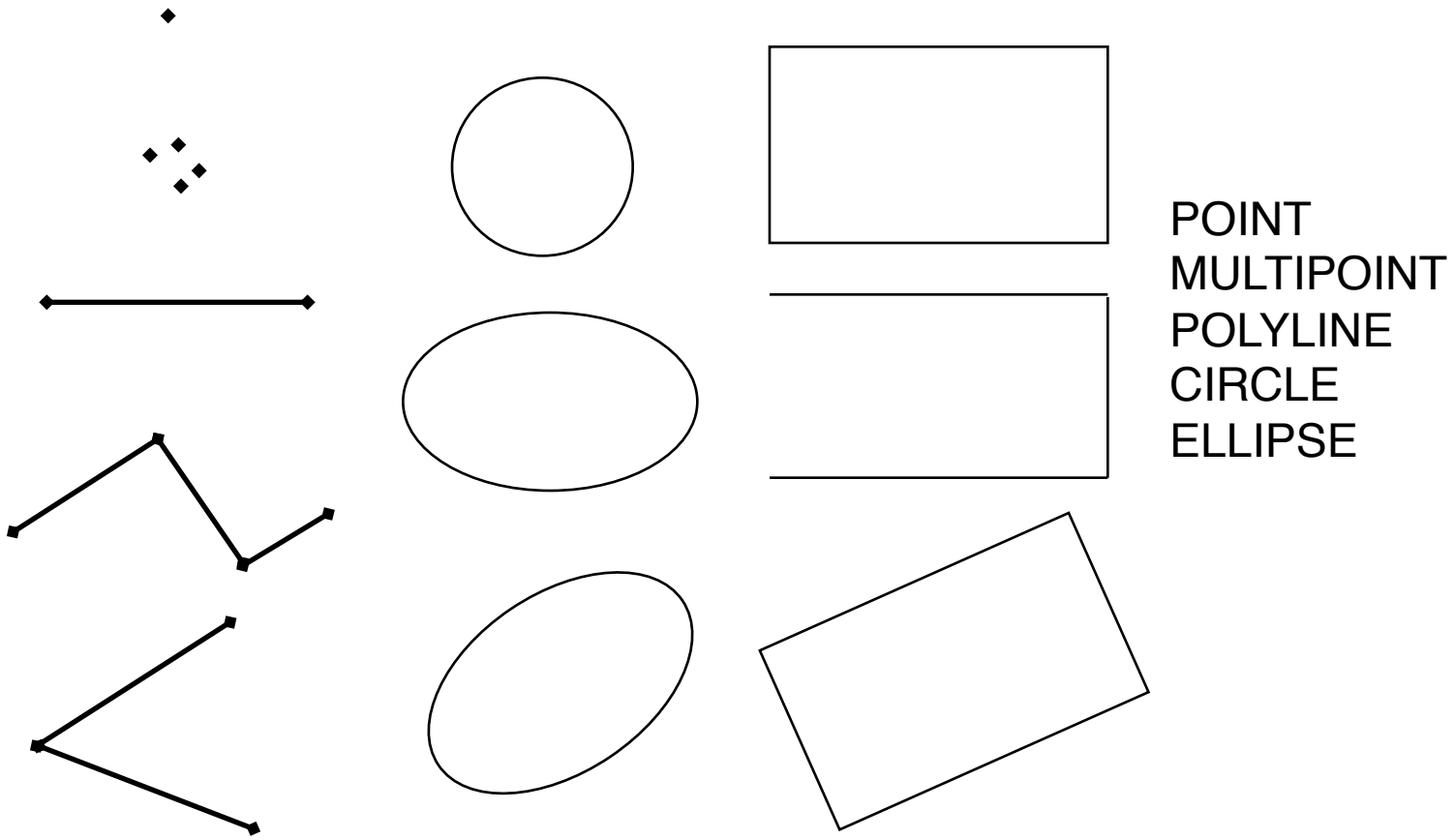
SCOORD: "Center" = POINT {2505,2168}

SCOORD: "Outline" = POLYLINE {2531,2114,2537, 2114,..,2525,2114,2531,2114}

SELECTED FROM

IMAGE: 1.2.840.276453....

Spatial Coordinates



Temporal Coordinates

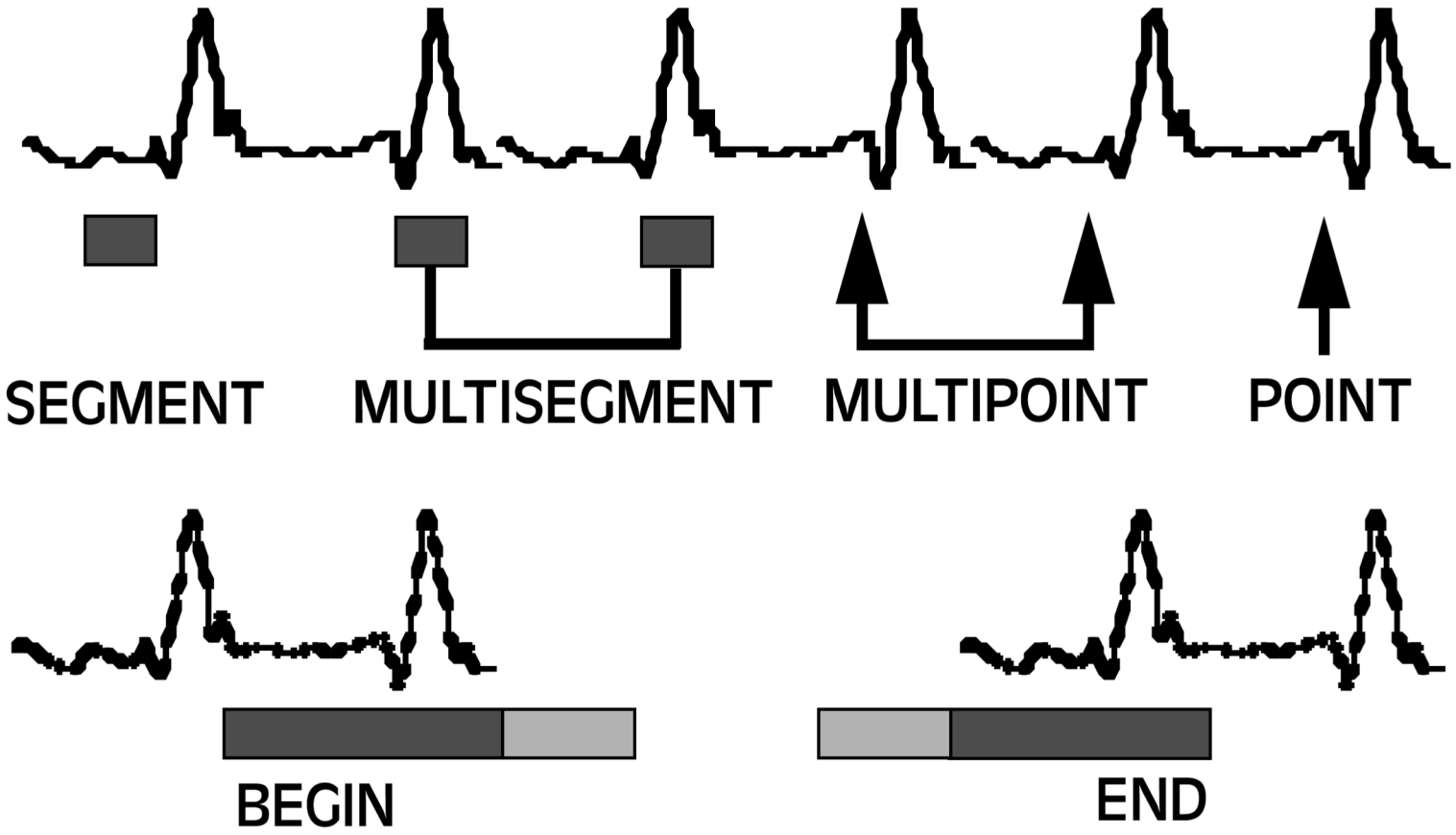
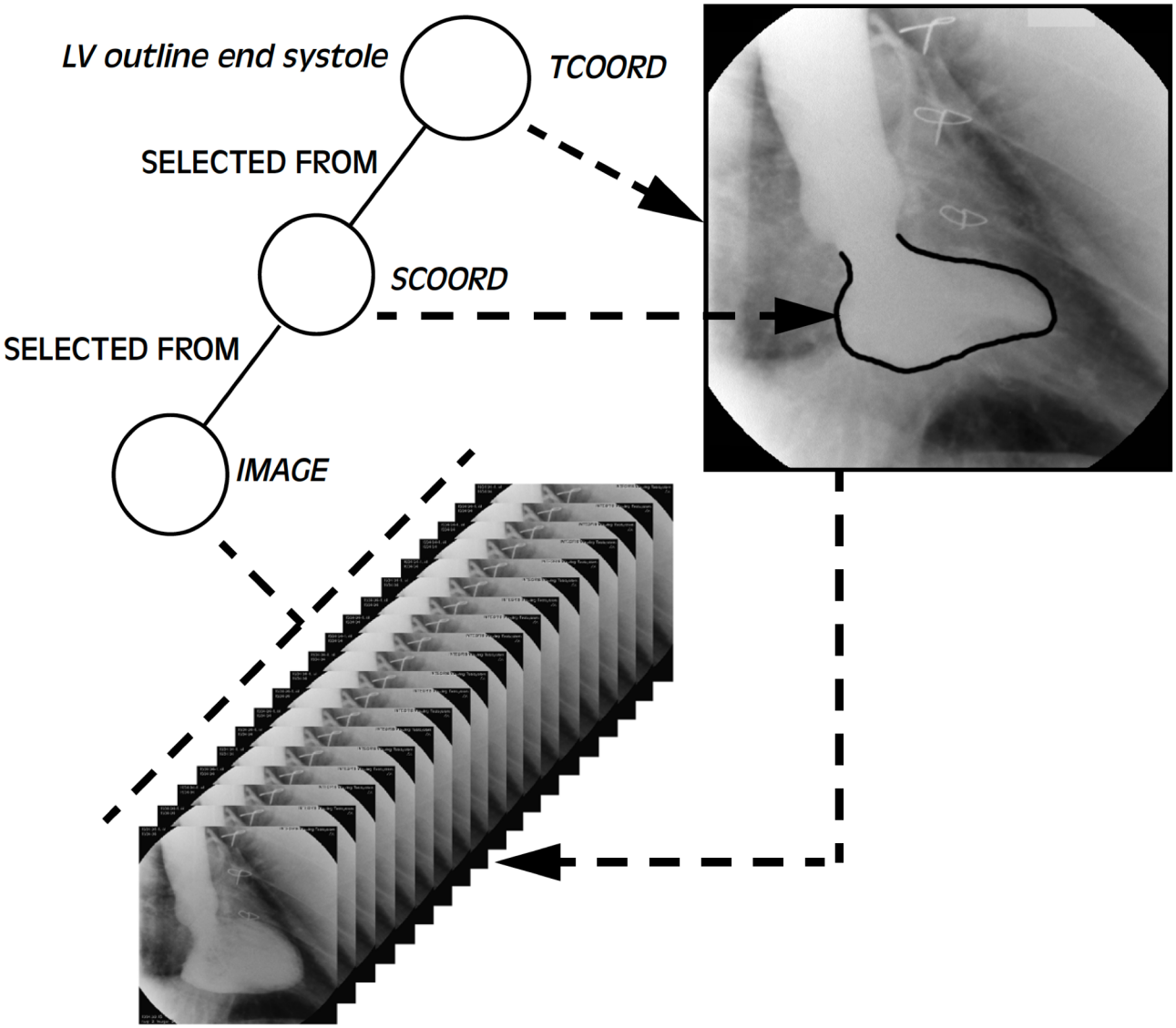
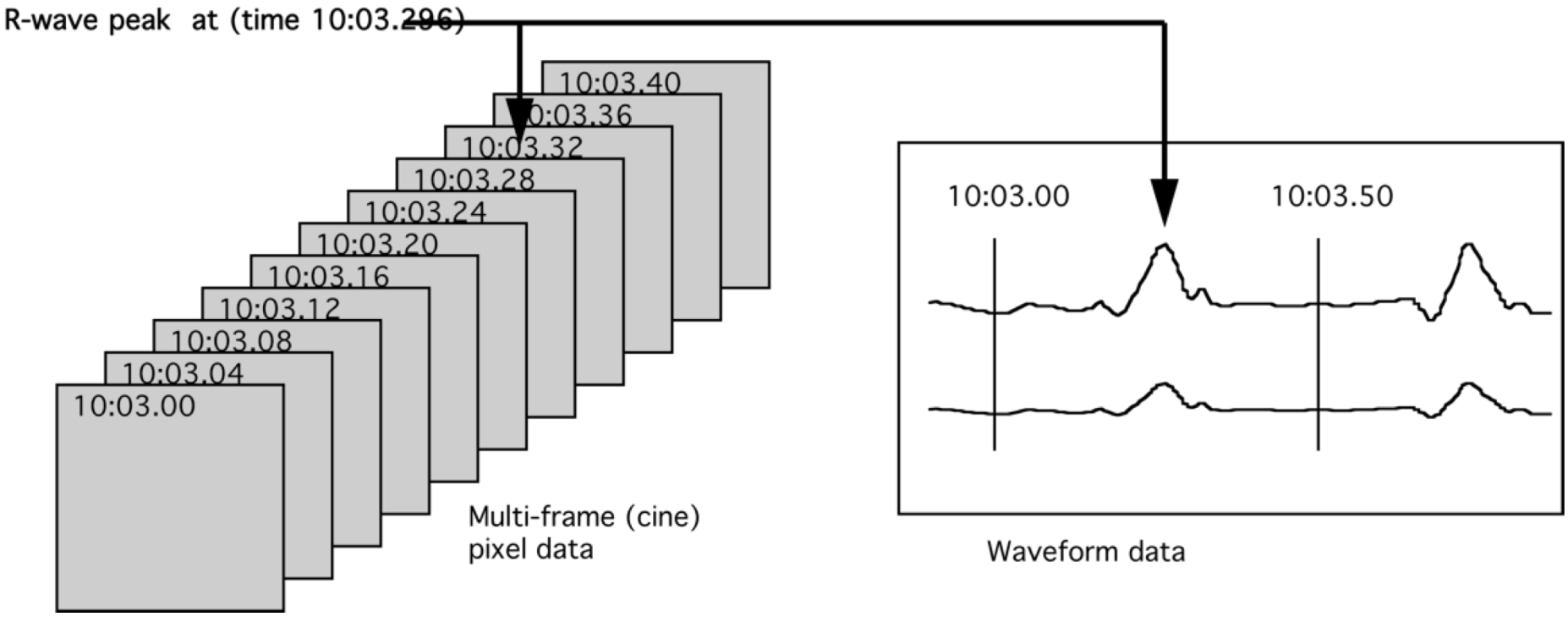


Image Temporal and Spatial Coordinates



Temporal Coordinates applied to both Images and Waveforms



What about Codes?

- DICOM uses external lexicons
  - SNOMED
  - LOINC
  - RADLEX
  - defines DCM codes & definitions if no other good scheme
- EHR push towards more reliable codes
  - e.g., EHR interoperability and common data elements
  - RIS, modalities and PACS implementations could do better
  - institutions need to standardize internal procedure codes
  - harmonize/bridge imaging/EHR codes

Codes for Structured Reports

- Codes needed for
  - entities, e.g., lesions, tumors, tissue types
  - location, e.g., anatomic site
  - characteristics, e.g., edges, enhancement
  - measurements, e.g., volume, sum of areas, mean
  - units, e.g., HU, mm
- Availability
  - many already - SNOMED, LOINC, RADLEX, DCM, NCI, UCUM
  - more being defined every day
  - vendors also use private codes
  - need to anticipate code evolution (configurable producer/consumer)

ROI and Segmentation Codes

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Table CID 7150. Segmentation Property Categories

Coding Scheme Designator	Code Value	Code Meaning	SNOMED-CT Concept ID	UMLS Concept Unique ID	Segmentation Property Type Context Group
SRT	T-D0050	Tissue	85756007	C0040300	CID 7191 “Tissue Segmentation Property Types”
SRT	T-D000A	Anatomical Structure	123037004	C1268086	CID 7192 “Anatomical Structure Segmentation Property Types”
SRT	A-00004	Physical object	260787004	C0085089	CID 7193 “Physical Object Segmentation Property Types”
SRT	M-01000	Morphological Abnormal Structure	49755003	C0221198	CID 7194 “Morphological Abnormal Structure Segmentation Property Types”
SRT	R-42019	Function	246464006	C0542341	CID 7195 “Function Segmentation Property Types”
SRT	R-42018	Spatial and Relational Concept	309825002	C0587374	CID 7196 “Spatial and Relational Concept Segmentation Property Types”
SRT	T-D0080	Body Substance	91720002	C0504082	CID 7197 “Body Substance Segmentation Property Types”
SRT	F-61002	Substance	105590001	C0439861	CID 7198 “Substance Segmentation Property Types”

ROI and Segmentation Codes

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Table CID 7153. CNS Segmentation Types

Coding Scheme Designator	Code Value	Code Meaning	SNOMED-CT Concept ID	UMLS Concept Unique ID
SRT	T-B1100	Adenohypophysis	62818001	C0032008
SRT	T-A3230	Amygdala	4958002	C0002708
SRT	T-A1220	Arachnoid	75042008	C0003707
FMA	276650	Arcuate Fasciculus		C2329633
SRT	T-A0100	Brain	12738006	C0006104
SRT	T-A0109	Brain cerebrospinal fluid pathway	280371009	C0459387
SRT	T-D0558	Brain stem	119238007	C1268144
SRT	T-A1600	Brain ventricle	35764002	C0007799
SRT	T-A3200	Caudate nucleus	11000004	C0007461
SRT	T-A0090	Central nervous system	21483005	C0927232
SRT	T-A6080	Cerebellar white matter	33060004	C0152381
SRT	T-A1800	Cerebral aqueduct	80447000	C0007769
SRT	T-A2020	Cerebral cortex	40146001	C0007776

Constrained by Templates

- Generic tree of content items has unbounded complexity, so need constraints
- Templates for interoperability for specific use cases
  - e.g., Mammography CAD
- Templates for entire structure
  - "root level"
- Templates for parts of structure – re-usable
  - e.g., Volumetric ROI Measurements
- Defined in PS3.16, follow pattern similar to Module tables in PS3.3
  - (coded) name of content item
  - requirement type
  - multiplicity
  - conditions
  - value set for coded values
  - coded units for numeric values

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	

Key Object Selection Document

- Specialized form of DICOM Structured Report
  - SOP Class constrains to specific template
- Essentially
  - list of images and other DICOM objects (“manifest”)
  - coded Document Title, e.g., “For Clinical Trial Export”
  - text description
- Used in IHE as
  - Key Image Note profile
  - manifest for XDS-I profile

Presentation States relatively useless

- DICOM Presentation States are great for capturing state of rendering to human
  - zoom/pan, window center/width, …
  - but limited text and graphic annotations
  - no semantics
  - not even linkage of graphics and text
  - can be referenced from SR to set appropriate viewing conditions for referenced images
- Unfortunately are very popular with PACS due to their simplicity
  - better than no DICOM capture of annotations at all of course
  - means product managers not motivated to add SR support
- Ideally, all PACS viewers would support displaying any kind of SR
  - not just tabulating/rendering hierarchical content as text
  - not just jumping to reference image
  - but also displaying all coordinates/SEG references overlaid on images
  - preferably with local context from the tree such as finding, measurements and units

DICOM SR Nirvana!

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