

DICOM for Digital Pathology – Current Landscape

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Disclosures

Editor of the DICOM Standard (NEMA contract)

NCI FNL Leidos Essex sub-contractor (SME DICOM, de-identification)

NCI Imaging Data Commons (IDC) sub-contractor

Consult with various equipment manufacturers re-DICOM

Overview

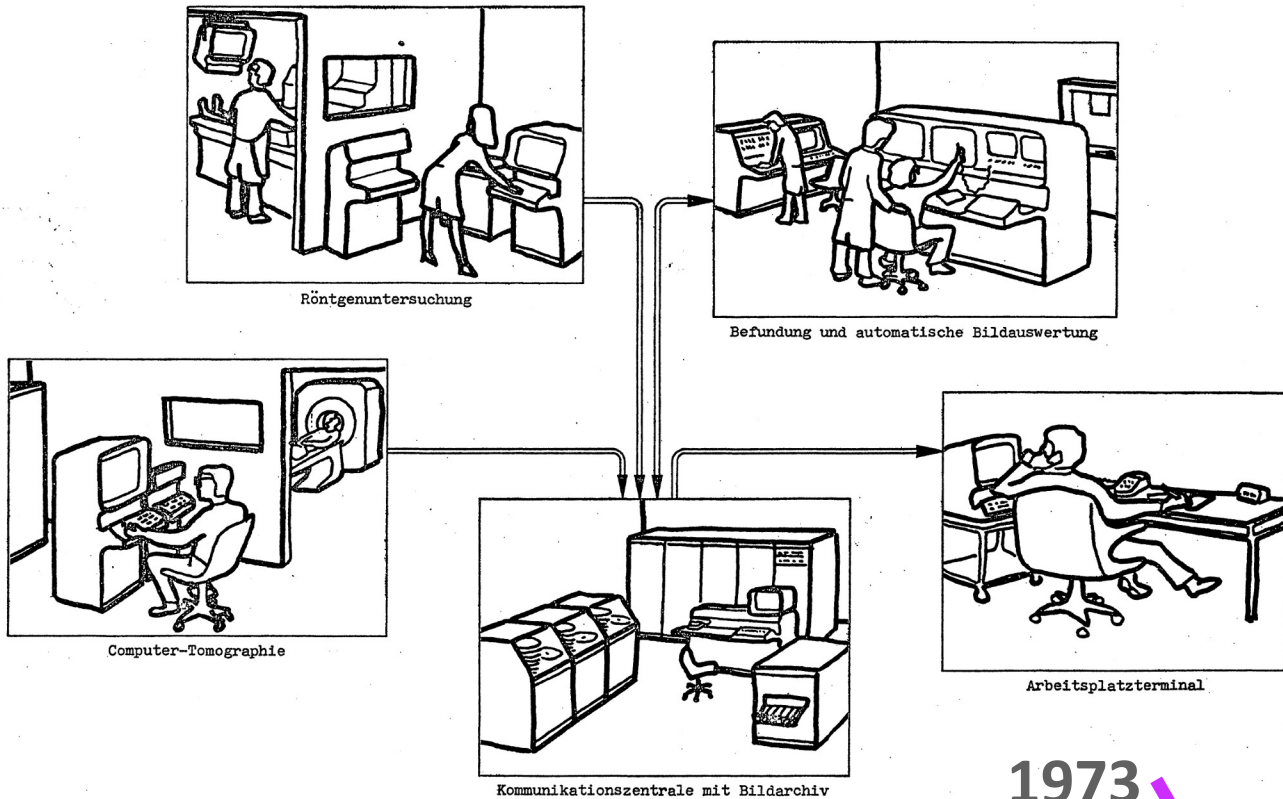
Introduction to DICOM for WSI

Connectathon overview (past and current)

DICOM, Imaging Data Commons (IDC) and Slim Viewer

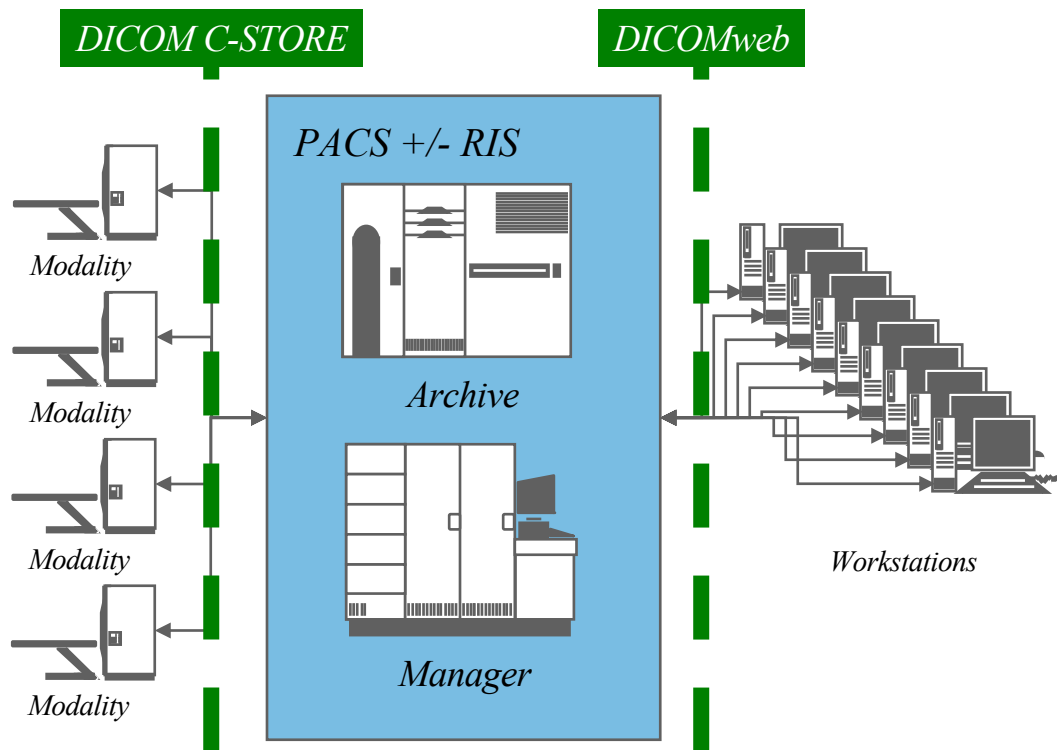
DICOM conformance tools (validators) and their utility to implementers

Updates on new activities

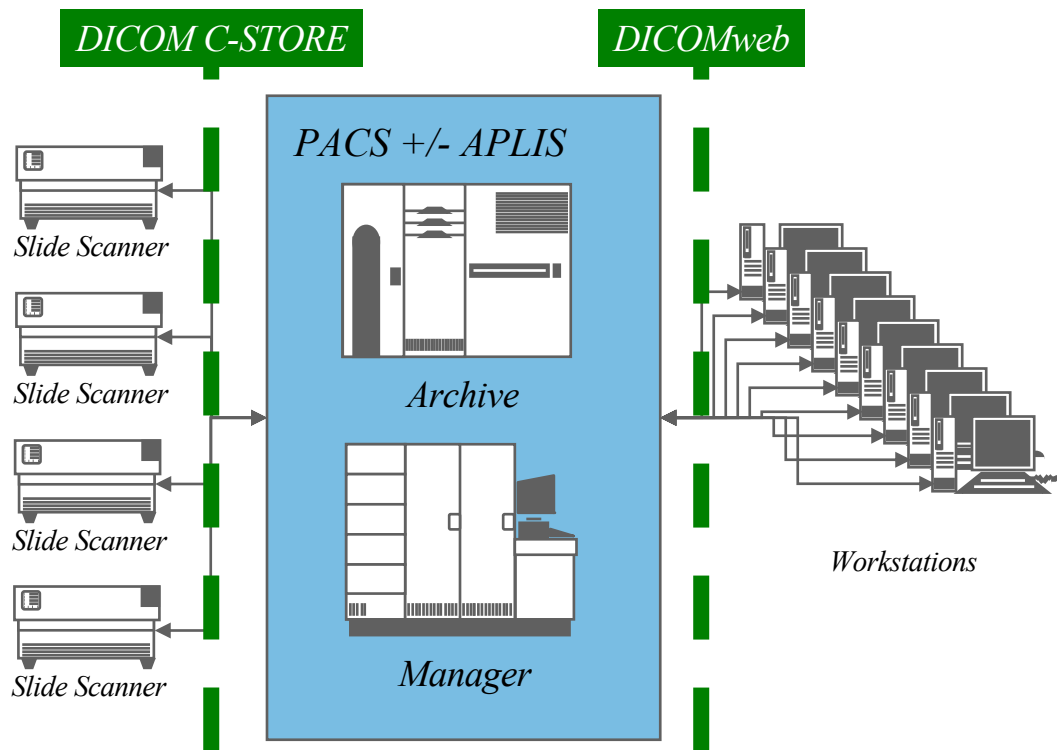


Meyer-Ebrecht D. [Electronic Archival System for X-Rays Images - Work proposal for a research project in the years 1974 and 1975] Elektronisches Archivierungssystem für Röntgenbilder – Arbeitsvorschlag für ein Forschungsprojekt in den Jahren 1974 und 1975. Hamburg, Germany: Philips Research Labs; 1973 Oct.

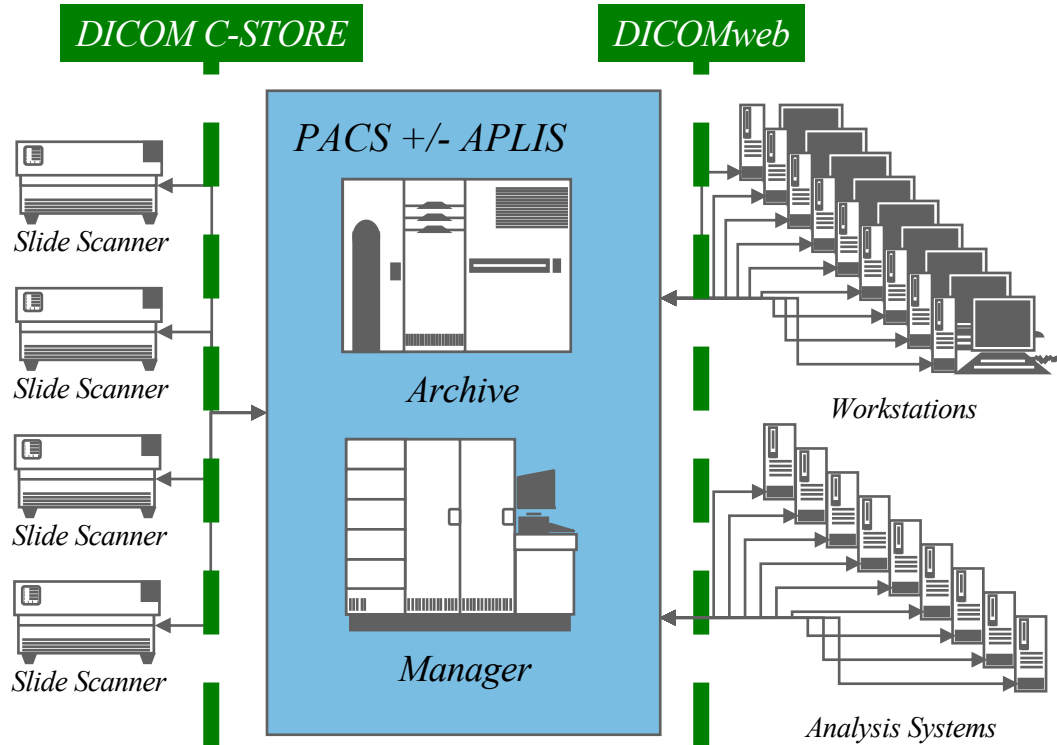
DICOM – Interoperability Boundaries – Commoditization



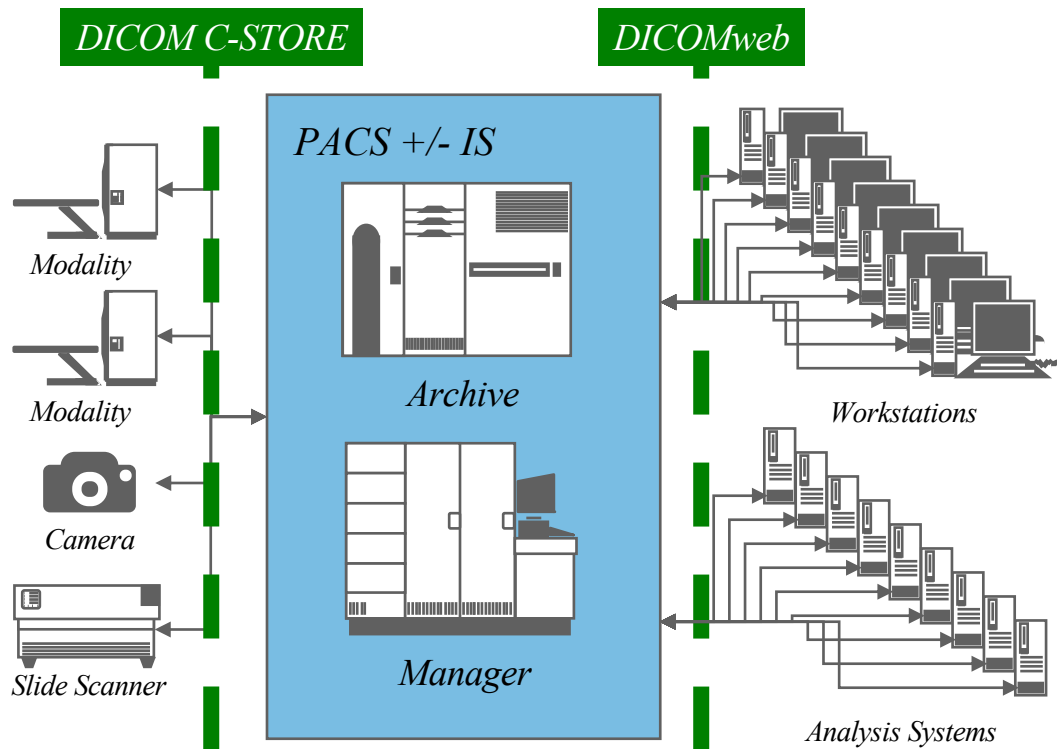
DICOM – Interoperability for Pathology



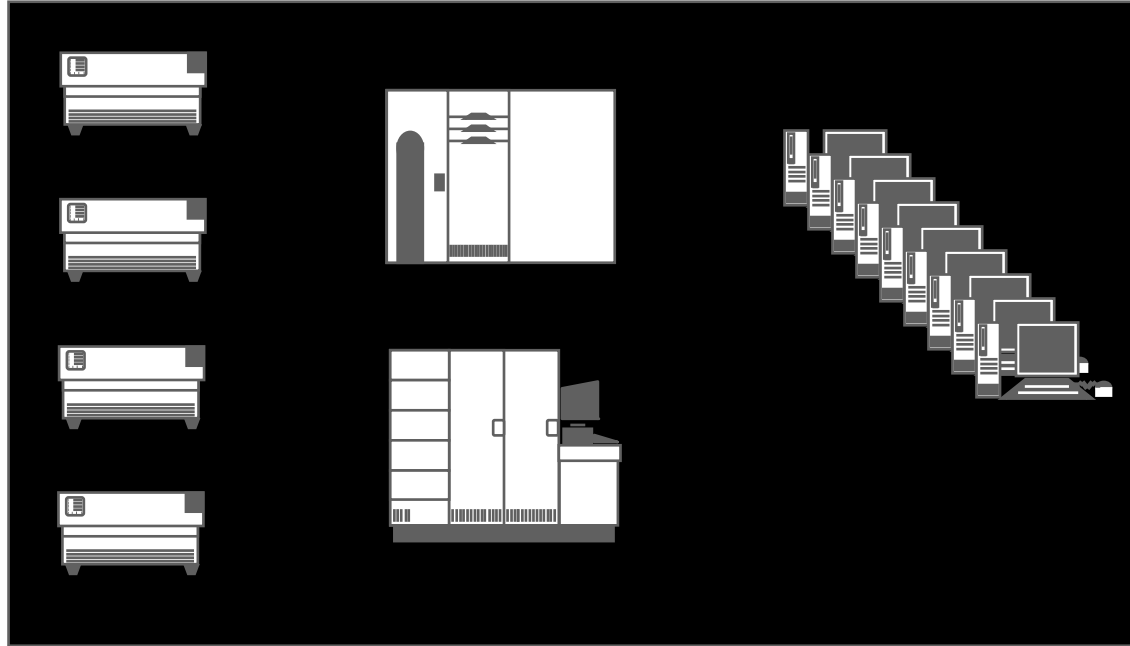
DICOM – Analysis Systems – Computational Pathology

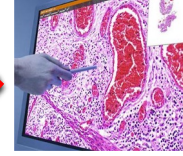
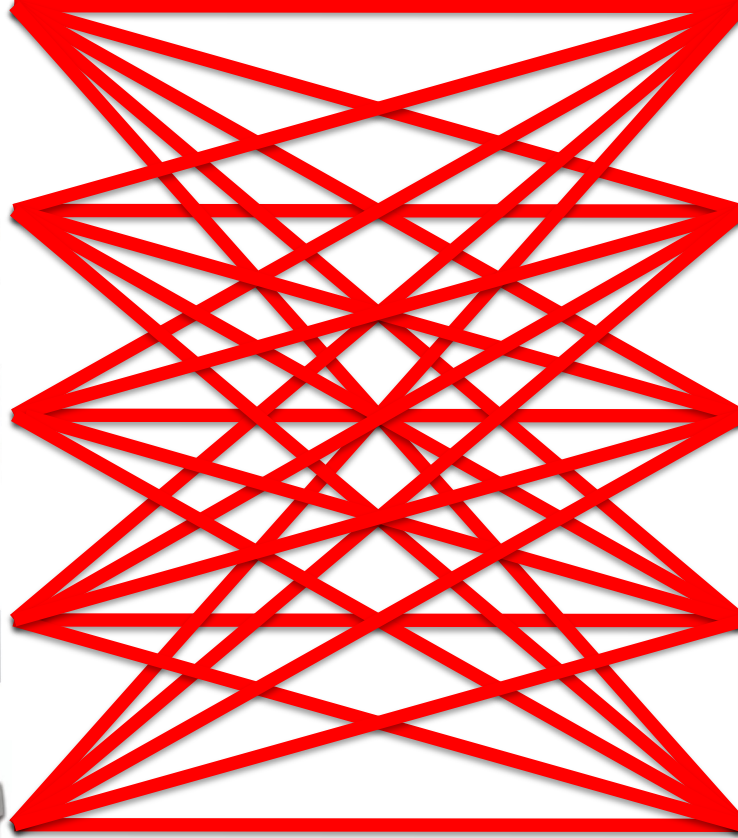
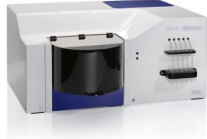


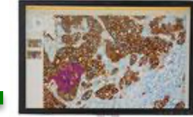
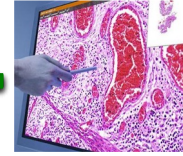
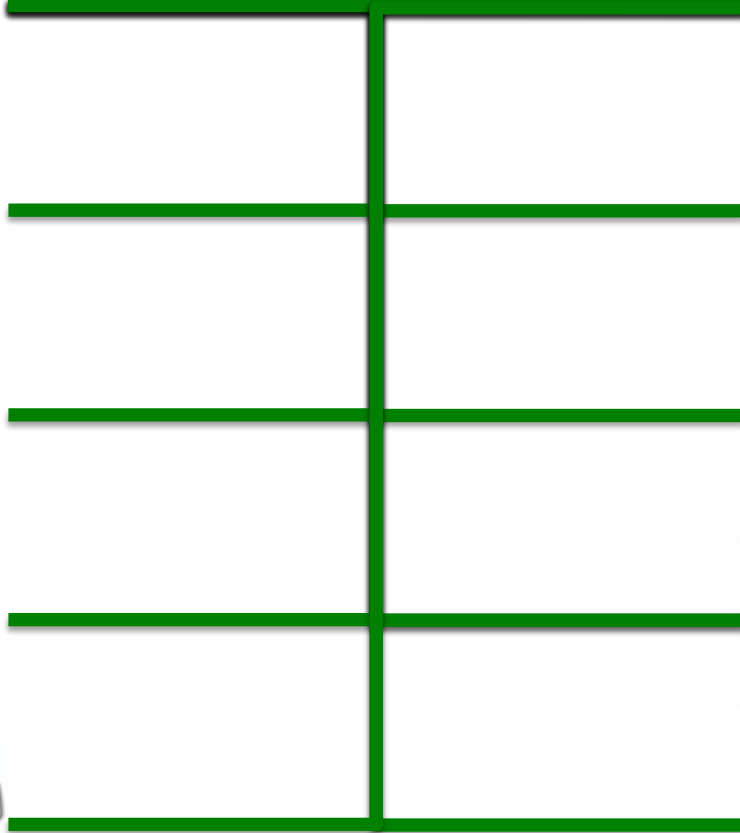
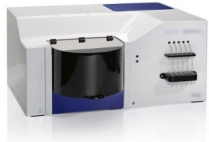
DICOM – Enterprise Imaging



FDA “Entire Pixel Pathway” – Non-interoperable Black Box







Interoperability boundaries for pathology imaging

Access to input data

images ✓ *DICOM WSMI (tiled pyramids)*

annotations ✓ *DICOM SEG, SR, ANN*

protocols ~ *DICOMweb query, metadata, frames*

Sharing of output data

images ✓ *DICOM parametric maps (tiled pyramids)*

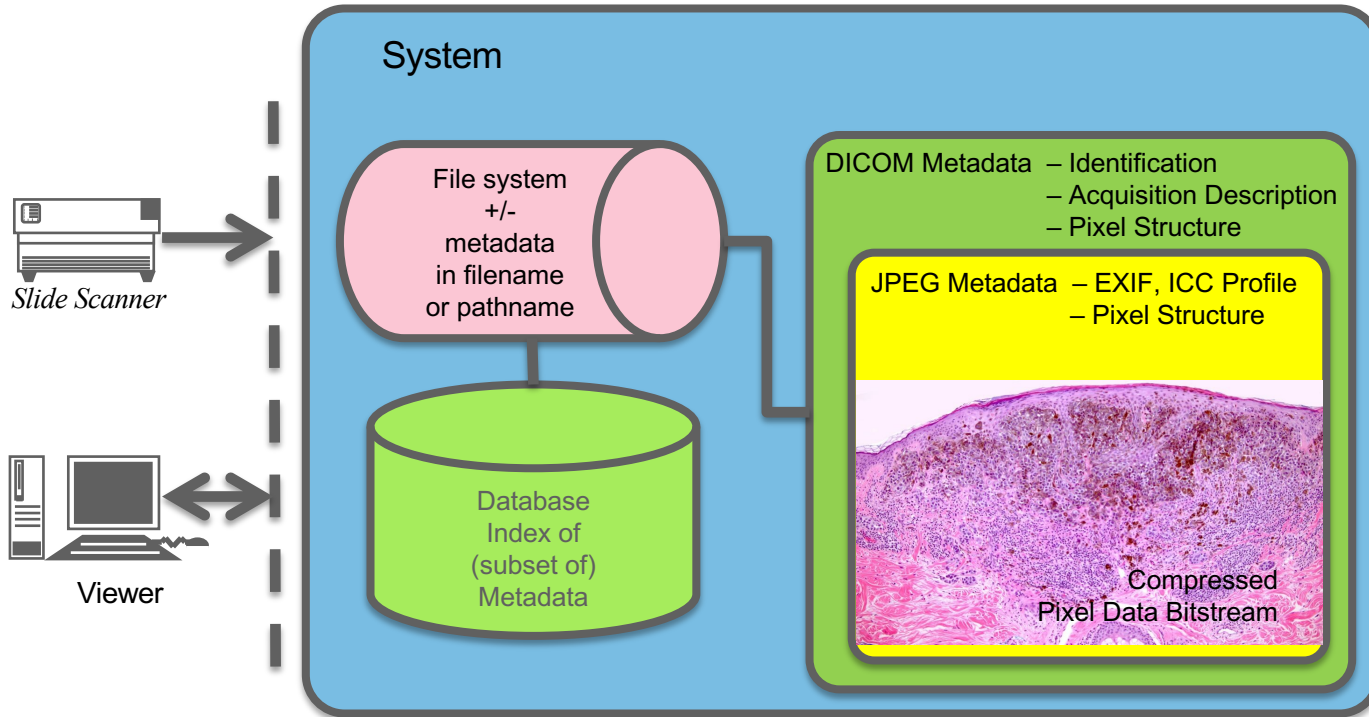
annotations ✓ *DICOM SEG, SR, ANN*

protocols ~ *DICOMweb STOW*

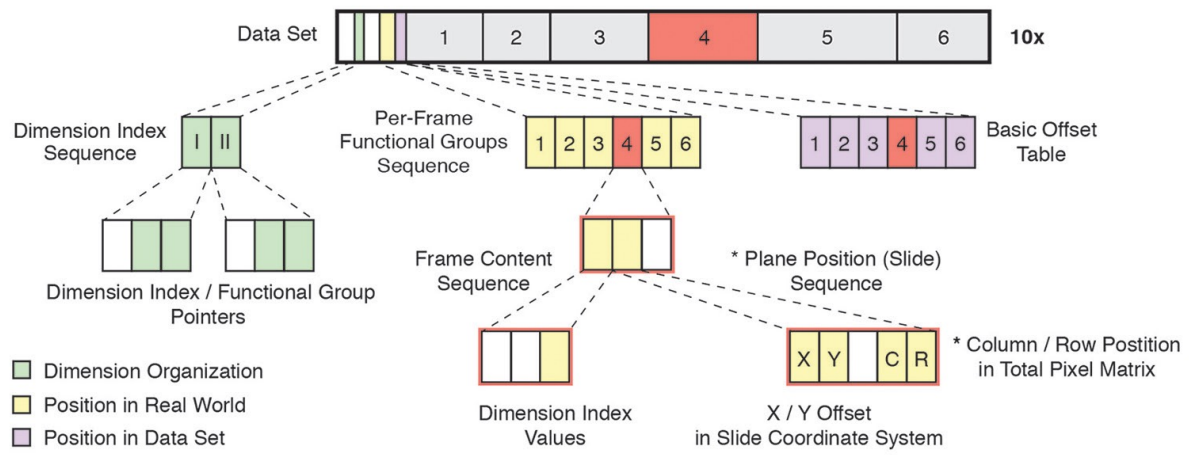
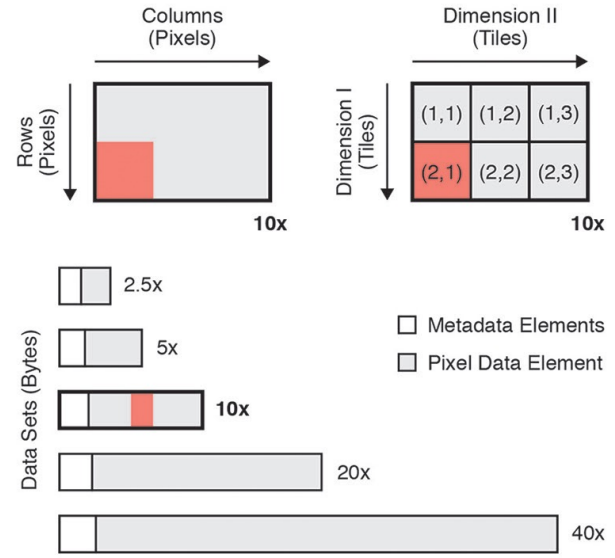
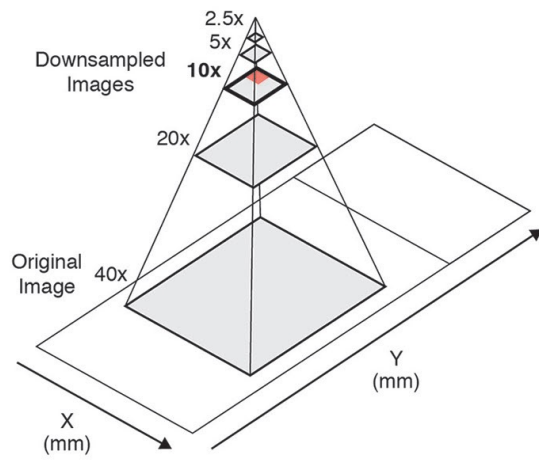
Management of workflow

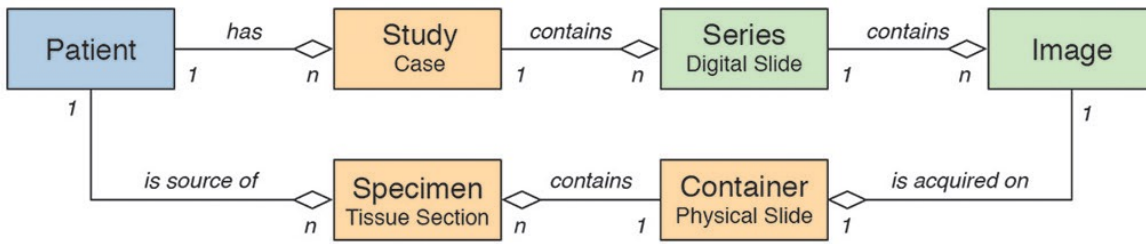
application selection ✗

application orchestration ~ *DICOMweb UPS*



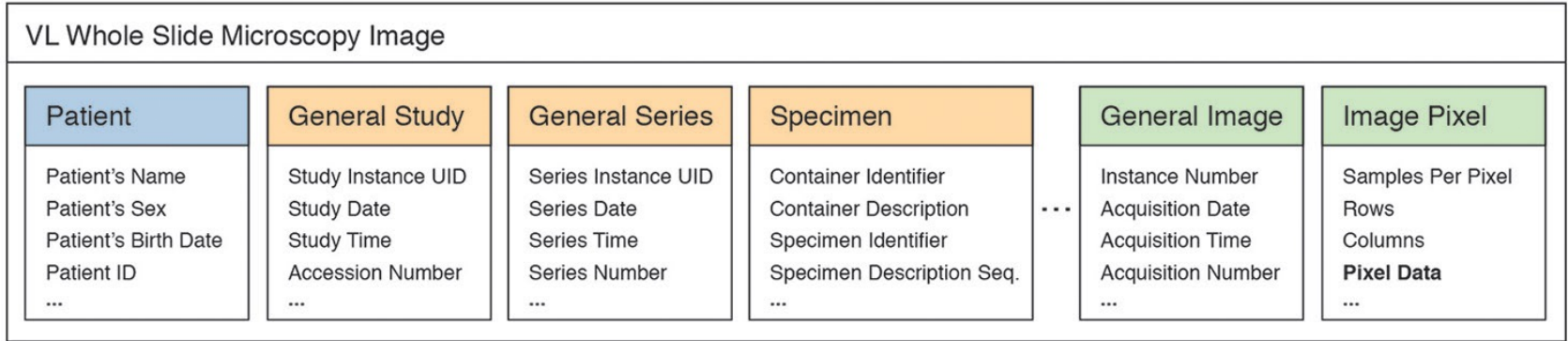
DICOM
Protocol





Information Source

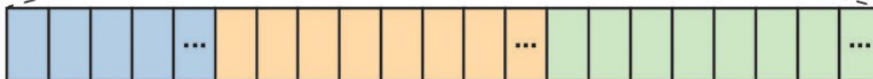
- Microscope
- Laboratory Information System
- Electronic Medical Record

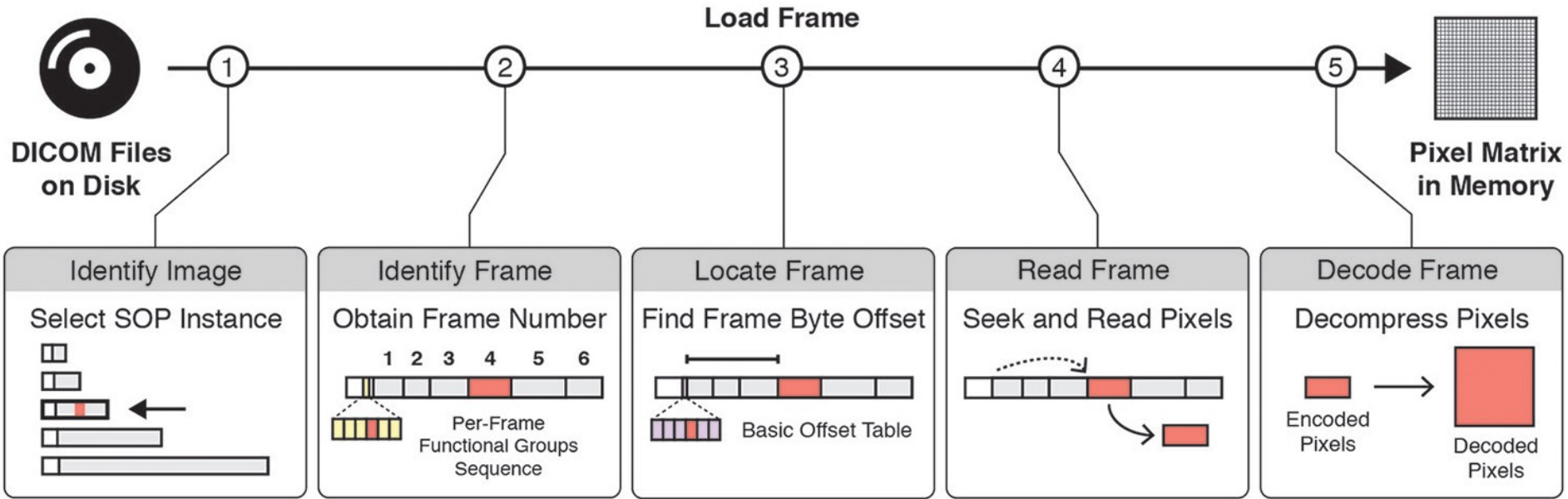


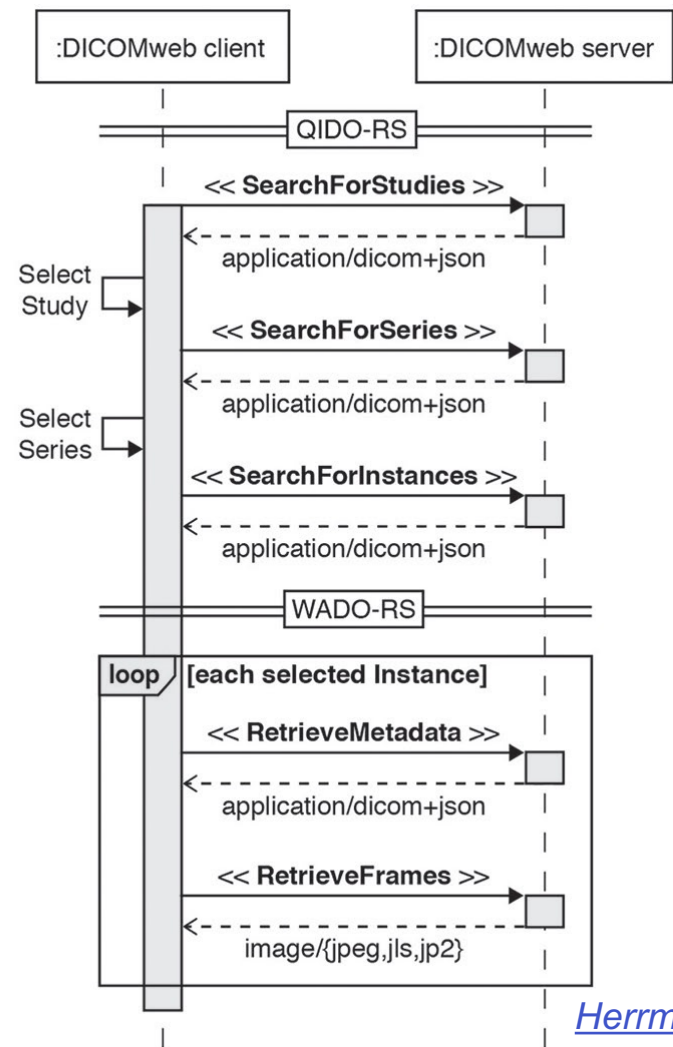
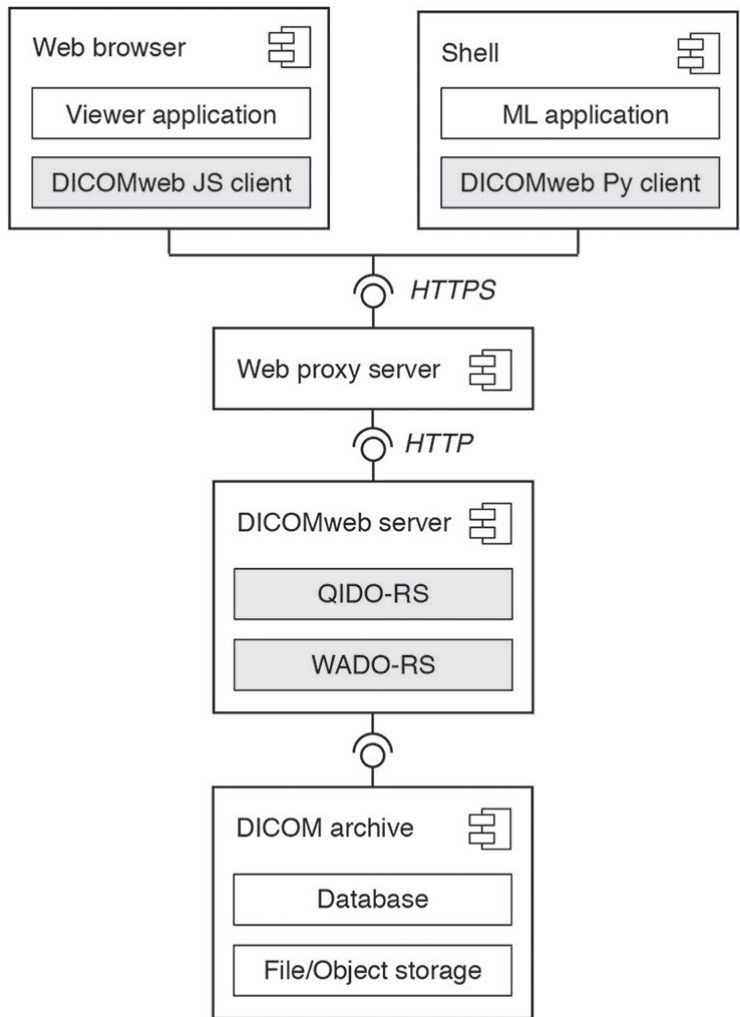
Pixel Data Element



Metadata Elements







So where are we at?

Most scanner vendors have implemented DICOM WSI

Demonstrated at successive Connectathons since 2017

Few have FDA clearance (at all, and to operate with DICOM)

Few sites are actually using the DICOM capability if present

Some very large sites are insisting on DICOM

Some converting proprietary formats to DICOM themselves

DICOM can have mathematically identical pixels

Two popular open-source libraries now support DICOM WSI

Testing annotations in recent Hackathons/Connectathons

DICOM, Imaging Data Commons and Slim Viewer

IDC is the imaging node of the NCI CBIIT Cancer Research Data Commons

Goal is to make images available in the Cloud for computing

Distinct from other archives that are not Cloud-based

Shares content from The Cancer Image Archive (TCIA) and other sources

Radiology and Pathology – both in DICOM format ONLY

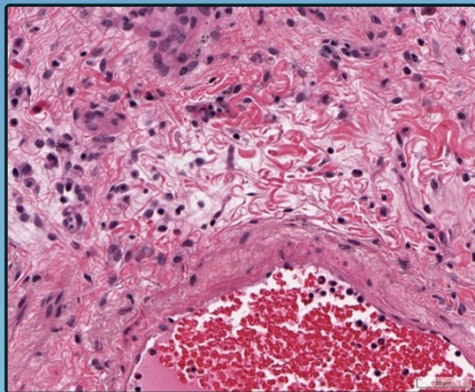
WSI converted to DICOM (has not yet received any native WSI DICOM)

IDC consists of DICOM files in Google and AWS buckets, Google DICOM Store and DICOM metadata automatically extracted to BigQuery

Application-appropriate DICOMweb viewers – radiology: OHIF, WSI: Slim Images, annotations, other DICOM objects (radiotherapy, etc.)

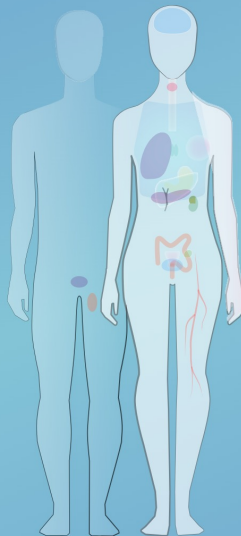
IDC Community Office Hours open to all every Tuesday 16:30 – 17:30 (New York) and Wednesday 10:30-11:30 (New York) via Google Meet at https://meet.google.com/xyt-vody-tvb.

Explore Images

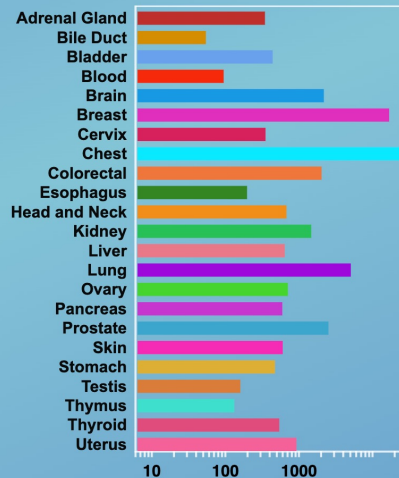


Slide Microscopy (SM) - Brightfield

Progress indicator dots



Cases by Major Primary Site



Data Portal Summary Data Release 18.0 March 19, 2024

143 Collections

65,698 Cases

66.38 TB Data Volume

897,106 Image Series

- Cancer Moonshot Biobank 0
- HTAN 0
- MIDI 0
- NLM 0
- QIBA 0

Analysis Results

Sort by: Count Alpha

Hide analysis results with 0 cases
show 11 more [Check All / Uncheck All](#)

- RMS-Mutation-Prediction-Expert-Annotations 95
- None 308
- TotalSegmentator-CT-Segmentations 0
- BAMF-AIMI-Annotations 0
- nnU-Net-BPR-annotations 0

Search Configuration

Hide attribute values with 0 cases

ORIGINAL DERIVED RELATED

Primary Site Location

Sort by: Count Alpha

show 40 more [Check All / Uncheck All](#)

- Various 95
- Chest 0
- Breast 0
- Lung 0
- Prostate 0

Cancer Type

Collection Name	Total # of Cases	# of Cases(this cohort)
<input checked="" type="checkbox"/> RMS-Mutation-Prediction	403	95

Selected Cases

Showing 1 to 10 of 95 entries Show entries Page Go Previous 1 2 3 4 5 ... 10 Next Find by Case ID: Go

<input type="checkbox"/> <input checked="" type="checkbox"/>	Collection Name	Case ID	Total # of Studies	Total # of Series
<input type="checkbox"/>	RMS-Mutation-Prediction	RMS2150	1	2
<input checked="" type="checkbox"/>	RMS-Mutation-Prediction	RMS2152	1	2
<input type="checkbox"/>	RMS-Mutation-Prediction	RMS2153	1	2
<input type="checkbox"/>	RMS-Mutation-Prediction	RMS2154	1	2
<input type="checkbox"/>	RMS-Mutation-Prediction	RMS2155	1	2
<input type="checkbox"/>	RMS-Mutation-Prediction	RMS2202	1	2
<input type="checkbox"/>	RMS-Mutation-Prediction	RMS2203	1	2
<input type="checkbox"/>	RMS-Mutation-Prediction	RMS2204	1	2
<input type="checkbox"/>	RMS-Mutation-Prediction	RMS2206	1	2
<input type="checkbox"/>	RMS-Mutation-Prediction	RMS2207	1	2

Selected Studies

Showing 1 to 1 of 1 entries Show entries Page Go Previous 1 Next Find by Study Instance UID: Go

<input type="checkbox"/> <input checked="" type="checkbox"/>	Case ID	Study Instance UID	Study Date	Study Description	# of Series	View
<input type="checkbox"/>	RMS2152	2.25.155...94838876	10-31-2018	Histopathology	2	

Patient ^

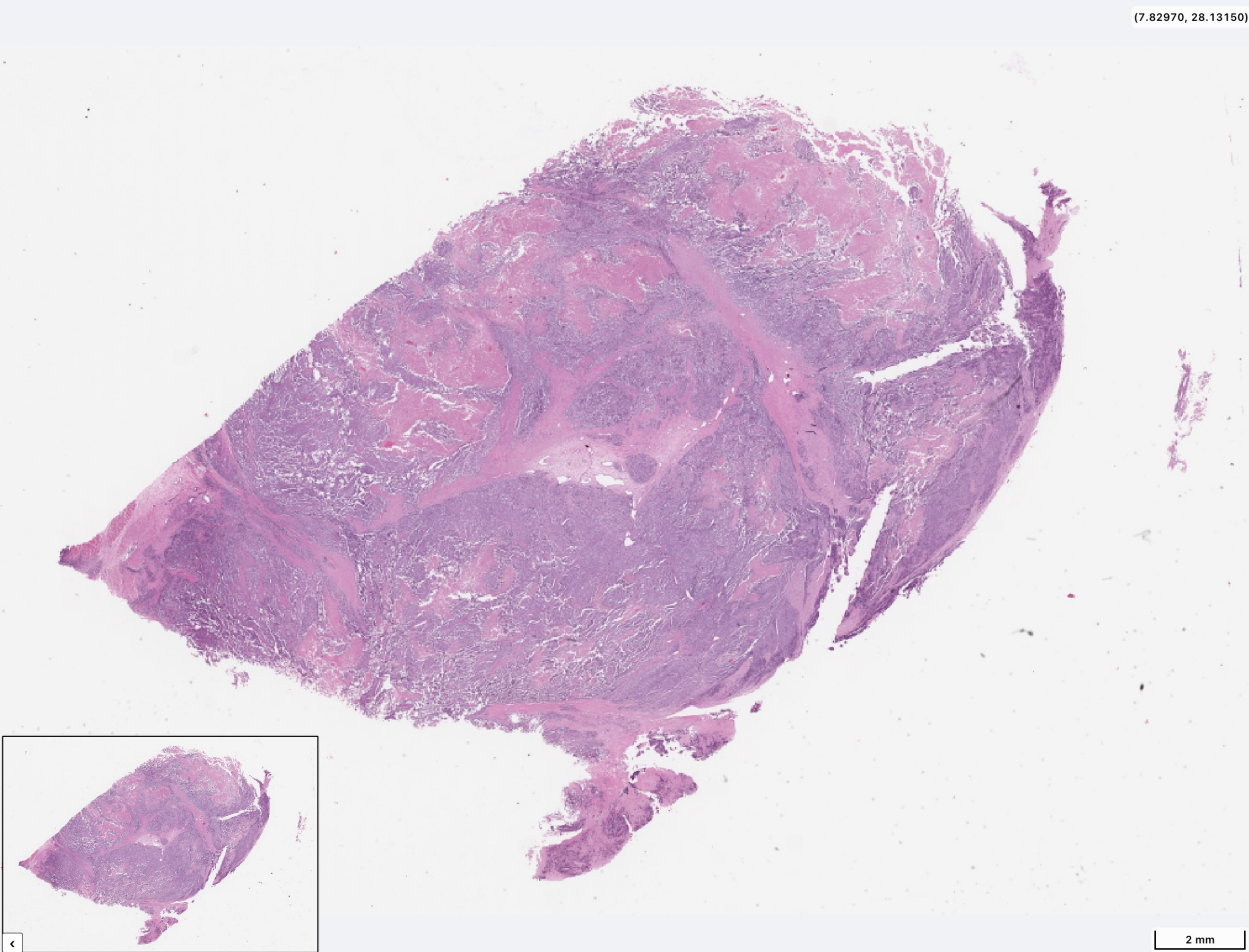
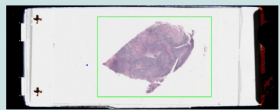
ID: RMS2152
Name: RMS2152
Gender: Male
Birthdate:

Study ^

Accession #: RMS2152
ID: RMS2152
Date: 2018-10-31
Time: 16:31:25

Slides ^

PAPJAD-OBGUTB



Slide label v

Specimens ^

PAPJAD-OBGUTB

Description:

FFPE HE

Anatomical structure:
Thigh

Tissue fixative:
Formalin

Tissue embedding medium:
Paraffin wax

Equipment v

Optical Paths ^

1

Tissue stain:
hematoxylin stain

Tissue stain:
water soluble eosin stain

Annotations ^

ROI 1

Property category:
Morphologic abnormality

Property type:
Alveolar rhabdomyosarcoma

ROI 2

Property category:
Body substance

Property type:
Connective tissue

Patient ^

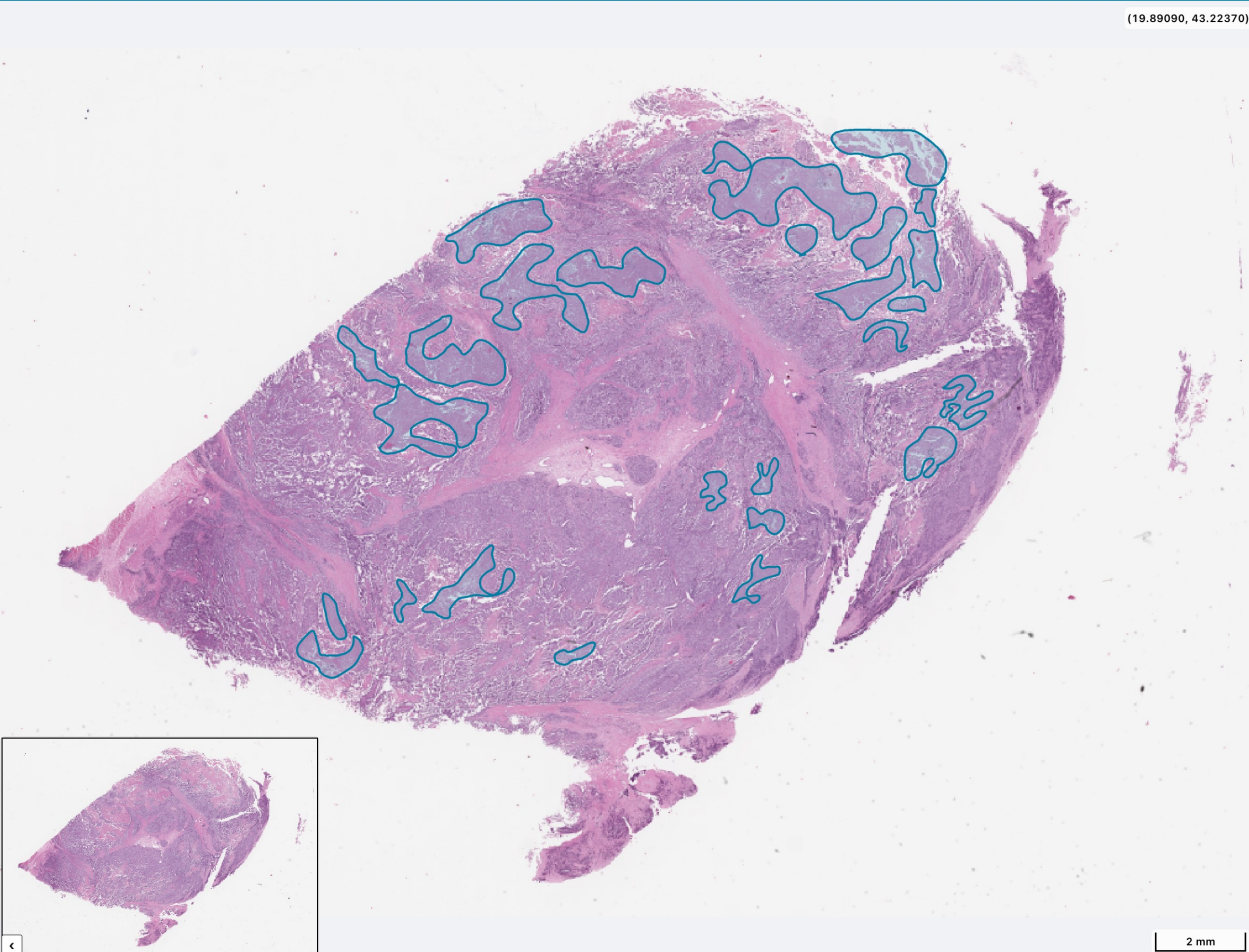
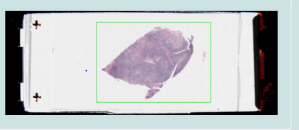
ID: RMS2152
Name: RMS2152
Gender: Male
Birthdate:

Study ^

Accession #: RMS2152
ID: RMS2152
Date: 2018-10-31
Time: 16:31:25

Slides ^

PAPJAD-0BGUTB



Optical Paths ^

1

Tissue stain:
hematoxylin stain
Tissue stain:
water soluble eosin stain

Annotations ^

ROI 1

Property category:
Morphologic abnormality
Property type:
Alveolar rhabdomyosarcoma

ROI 2

Property category:
Body substance
Property type:
Connective tissue

ROI 3

Property category:
Morphologic abnormality
Property type:
Necrosis

ROI 4

Property category:
Morphologic abnormality
Property type:
Necrosis

ROI 5

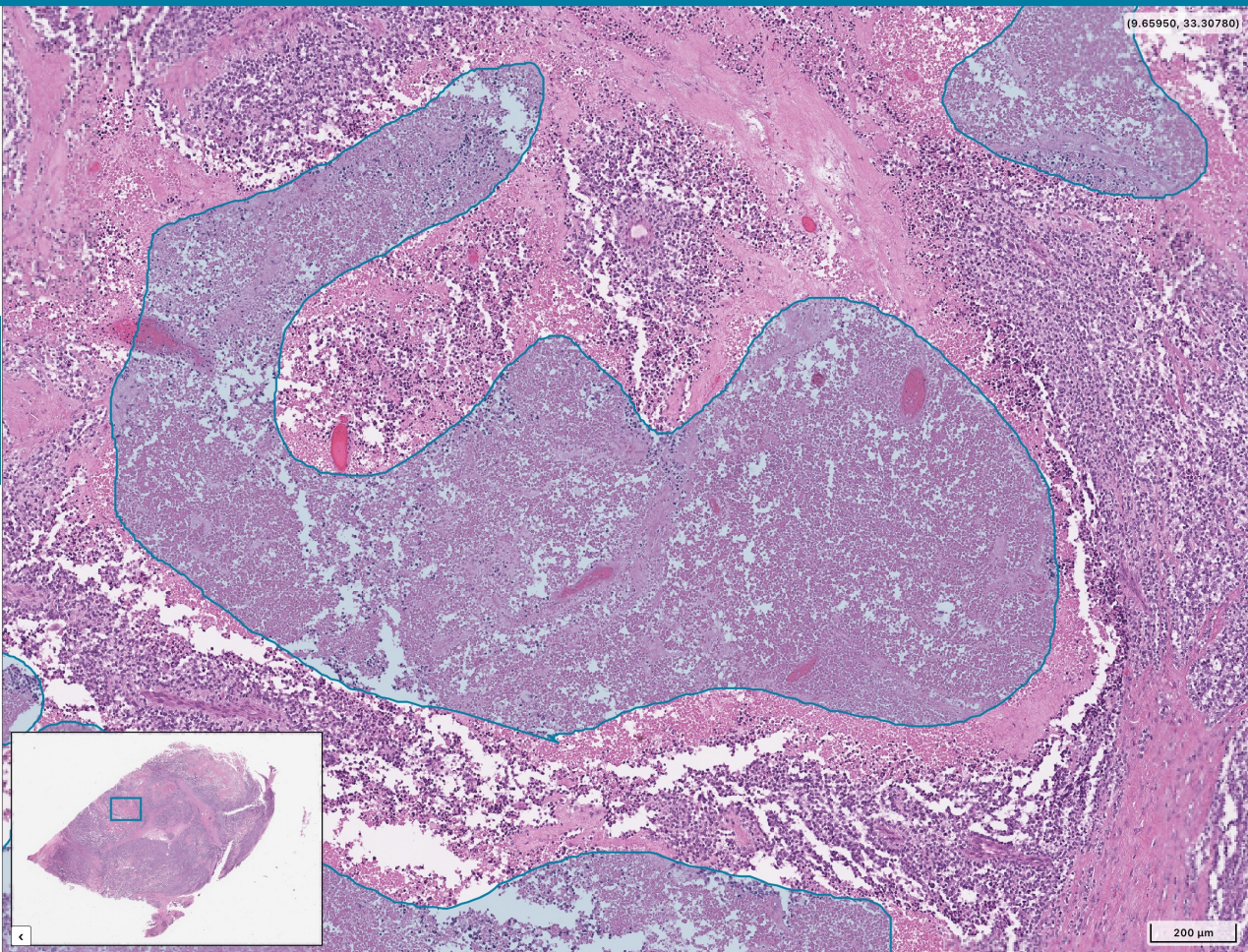
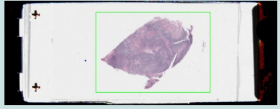
Patient
ID: RMS2152
Name: RMS2152
Gender: Male
Birthdate:

Study

Accession #: RMS2152
ID: RMS2152
Date: 2018-10-31
Time: 16:31:25

Slides

PAPJAD-0BGUTB



Optical Paths

1

Tissue stain:
hematoxylin stain
Tissue stain:
water soluble eosin stain

Annotations

ROI 1

Property category:
Morphologic abnormality
Property type:
Alveolar rhabdomyosarcoma

ROI 2

Property category:
Body substance
Property type:
Connective tissue

ROI 3

Property category:
Morphologic abnormality
Property type:
Necrosis

ROI 4

Property category:
Morphologic abnormality
Property type:
Necrosis

ROI 5

Patient

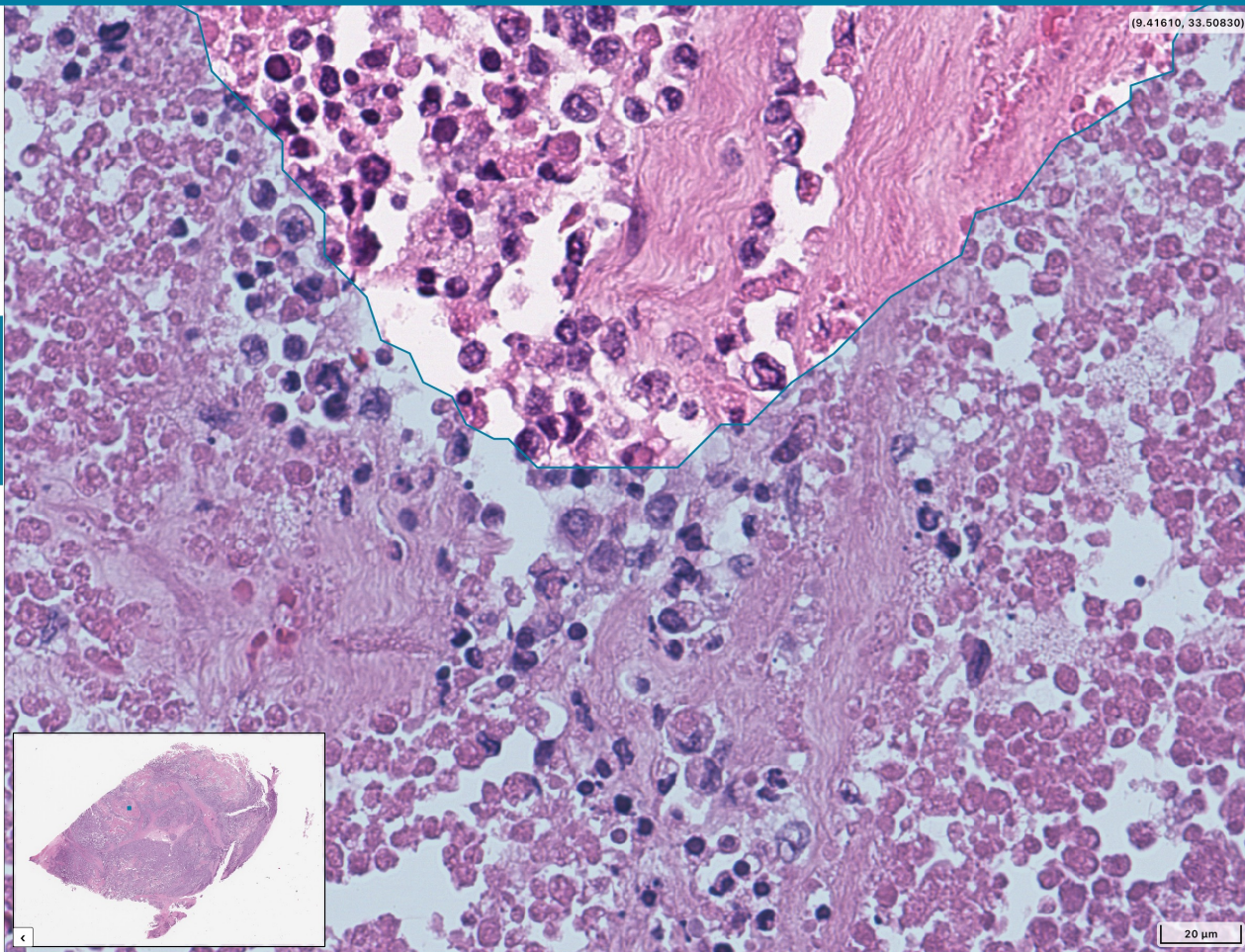
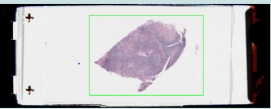
ID: RMS2152
Name: RMS2152
Gender: Male
Birthdate:

Study

Accession #: RMS2152
ID: RMS2152
Date: 2018-10-31
Time: 16:31:25

Slides

PAPJAD-0BGUTB



Optical Paths

1

Tissue stain:
hematoxylin stain
Tissue stain:
water soluble eosin stain

Annotations

ROI 1

Property category:
Morphologic abnormality
Property type:
Alveolar rhabdomyosarcoma

ROI 2

Property category:
Body substance
Property type:
Connective tissue

ROI 3

Property category:
Morphologic abnormality
Property type:
Necrosis

ROI 4

Property category:
Morphologic abnormality
Property type:
Necrosis

ROI 5

DICOM Conformance Tools (Validators)

The DICOM Standard describes metadata in meticulous detail

Structural, identifying and descriptive information for multiple entities

Patient, Study, Series, Equipment, Specimen, Preparation, Acquisition, ...

Some is required, some is optional, some specific values are required

Easy for implementors to make mistakes, omit critical information

Can assist them with mechanical tools

Hand-written or generated from the formal representation of the standard

Examples: *dciodvfy* and *dcenvfy* from [dicom3tools](#) package

dciodvfy: detects errors within a single file (instance)

dcenvfy: detects errors across a set of files (consistency between files)

Not a panacea: valid files may not “work”, invalid files may “work” (e.g., display)

Used routinely in Integrating the Healthcare Enterprise (IHE) & WG26 Connectathons

Table A.32.8-1. VL Whole Slide Microscopy Image IOD Modules

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Whole Slide Microscopy Series	C.8.12.3	M
	Clinical Trial Series	C.7.3.2	U
Frame of Reference	Frame of Reference	C.7.4.1	M
Equipment	General Equipment	C.7.5.1	M
	Enhanced General Equipment	C.7.5.2	M
Acquisition	General Acquisition	C.7.10.1	M
Multi-Resolution Pyramid	Multi-Resolution Pyramid	C.7.11.1	U - Shall be present only if Image Type Value 3 is VOLUME or THUMBNAIL.
Image	General Image	C.7.6.1	M
	General Reference	C.12.4	U
	Microscope Slide Layer Tile Organization	C.8.12.14	M
	Image Pixel	C.7.6.3	M
	Acquisition Context	C.7.6.14	M
	Multi-frame Functional Groups	C.7.6.16	M
	Multi-frame Dimension	C.7.6.17	M
	Specimen	C.7.6.22	M
	Whole Slide Microscopy Image	C.8.12.4	M
	Optical Path	C.8.12.5	M
	Slide Label	C.8.12.8	C - Required if Image Type (0008,0008) Value 3 is LABEL; may be present otherwise
	SOP Common	C.12.1	M
	Common Instance Reference	C.12.2	M
	Frame Extraction	C.12.3	C - Required if the SOP Instance was created in response to a Frame-Level retrieve request

Table C.8.12.14-1. Microscope Slide Layer Tile Organization Module Attributes

Attribute Name	Tag	Type	Attribute Description
Total Pixel Matrix Columns	(0048,0006)	1	Total number of columns in pixel matrix; i.e., width of total imaged volume in pixels. See Section C.8.12.14.1.1
Total Pixel Matrix Rows	(0048,0007)	1	Total number of rows in pixel matrix; i.e., height of total imaged volume in pixels. See Section C.8.12.14.1.1
Total Pixel Matrix Focal Planes	(0048,0303)	1C	<p>Total number of focal planes (Z locations) in the pixel matrix; i.e., depth of total imaged volume in pixels. See Section C.8.12.14.1.1</p> <p>Required if Dimension Organization Type (0020,9311) is present with a value of TILED_FULL. May be present otherwise.</p> <p>Note <i>Total Pixel Matrix Focal Planes (0048,0303) describes the number of focal planes separately encoded, and is distinct from Number of Focal Planes (0048,0013), which describes in what manner different focal planes were combined into a single encoded plane (focus stacking).</i></p>
Total Pixel Matrix Origin Sequence	(0048,0008)	1	<p>Location of pixel 1\1 of the total pixel matrix in the Slide Coordinate System Frame of Reference.</p> <p>Only a single Item shall be included in this Sequence.</p> <p>See Section C.8.12.14.1.2 and Section C.8.12.2.1.1 for further explanation.</p>
>X Offset in Slide Coordinate System	(0040,072A)	1	The X offset in millimeters from the Origin of the Slide Coordinate System.
>Y Offset in Slide Coordinate System	(0040,073A)	1	The Y offset in millimeters from the Origin of the Slide Coordinate System.
>Z Offset in Slide Coordinate System	(0040,074A)	1C	<p>The Z offset in μm from the image substrate reference plane (i.e., utilized surface of a glass slide).</p> <p>Required if the Z offset is not zero. May be present otherwise.</p> <p>Note <i>The conditional requirement is used because, historically, this Attribute was not present.</i></p>
Image Orientation (Slide)	(0048,0102)	1C	<p>The direction cosines of the first row and the first column of the total pixel matrix with respect to the Slide Coordinate System Frame of Reference. See Section C.8.12.14.1.2.</p> <p>Required if Plane Position (Slide) Sequence (0048,021A) is present within a Functional Group Sequence or Dimension Organization Type (0020,9311) is present with a value of TILED_FULL. May be present otherwise.</p> <p>Note <i>This condition will always be satisfied when this Module is included in the Whole Slide Microscopy Image IOD.</i></p>

```
% dcmjvfy compressed_instance_3_6.dcm
(0x0048,0x0105) SQ Optical Path Sequence - Error - Bad Value Length - not a multiple of 2 - VL is 0xc9 should be 0xca
(0x0028,0x2000) OB ITC Profile - Error - Bad Value Length - not a multiple of 4 - VL is 0x3 should be 0x4
(0x1002,0x1001) ? - Warning - Unrecognized tag - assuming explicit value representation OK
Error - DICOM dataset read failed
Error - Illegal root for UID - "870896693490043133834121745960504521625957166000" in (0x0040,0x0554) Specimen UID
Warning - Missing attribute or value that would be needed to build DICOMDIR - Study ID
Warning - Missing attribute or value that would be needed to build DICOMDIR - Instance Number
Error - Value invalid for this VR - (0x0002,0x0003) UI Media Storage SOP Instance UID UI [1] = <1.2.416.0.0010.3.1.4.537.1.17438.870896693490043133834121745960504521625957166000.3.1.1.1.1.1.1> - Length invalid for this VR = 95, expected <= 64
Error - Value invalid for this VR - (0x0002,0x0003) UI Media Storage SOP Instance UID UI [1] = <1.2.416.0.0010.3.1.4.537.1.17438.870896693490043133834121745960504521625957166000.3.1.1.1.1.1.1> - Leading zeroes in embedded numeric component(s)
Error - Value invalid for this VR - (0x0008,0x0018) UI SOP Instance UID UI [1] = <1.2.416.0.0010.3.1.4.537.1.17438.870896693490043133834121745960504521625957166000.3.1.1.1.1.1.1> - Length invalid for this VR = 95, expected <= 64
Error - Value invalid for this VR - (0x0008,0x0018) UI SOP Instance UID UI [1] = <1.2.416.0.0010.3.1.4.537.1.17438.870896693490043133834121745960504521625957166000.3.1.1.1.1.1.1> - Leading zeroes in embedded numeric component(s)
Warning - Value dubious for this VR - (0x0008,0x0090) PN Referring Physician's Name PN [1] = <SOME-PHYSICIAN> - Retired Person Name form
Warning - Value dubious for this VR - (0x0010,0x0010) PN Patient's Name PN [1] = <DCM_4_7c-12c> - Retired Person Name form
Error - Value invalid for this VR - (0x0020,0x000d) UI Study Instance UID UI [1] = <1.2.416.0.0010.3.1.2.537.1.17433.870896693490043133834121745960504521625957166000> - Length invalid for this VR = 81, expected <= 64
Error - Value invalid for this VR - (0x0020,0x000d) UI Study Instance UID UI [1] = <1.2.416.0.0010.3.1.2.537.1.17433.870896693490043133834121745960504521625957166000> - Leading zeroes in embedded numeric component(s)
Error - Value invalid for this VR - (0x0020,0x000e) UI Series Instance UID UI [1] = <1.2.416.0.0010.3.1.3.537.1.17433.870896693490043133834121745960504521625957166000.3> - Length invalid for this VR = 83, expected <= 64
Error - Value invalid for this VR - (0x0020,0x000e) UI Series Instance UID UI [1] = <1.2.416.0.0010.3.1.3.537.1.17433.870896693490043133834121745960504521625957166000.3> - Leading zeroes in embedded numeric component(s)
Error - Value invalid for this VR - (0x0028,0x2002) CS Color Space CS [1] = <SRGB> - Character invalid for this VR = 's' (0x73)
Error - DICOM dataset contains invalid data values for Value Representations
VLMHoleslideMicroscopyImage
Error - Missing attribute Type 2 Required Element=<PatientBirthDate> Module=<Patient>
Error - Missing attribute Type 2 Required Element=<StudyID> Module=<GeneralStudy>
Error - Empty attribute (no value) Type 1 Required Element=<Manufacturer> Module=<EnhancedGeneralEquipment>
Error - Missing attribute Type 1 Required Element=<ManufacturerModelName> Module=<EnhancedGeneralEquipment>
Error - Missing attribute Type 1 Required Element=<DeviceSerialNumber> Module=<EnhancedGeneralEquipment>
Error - Missing attribute Type 1 Required Element=<SoftwareVersions> Module=<EnhancedGeneralEquipment>
Error - Missing attribute Type 2 Required Element=<InstanceNumber> Module=<GeneralImage>
Error - Attribute present when condition unsatisfied (which may not be present otherwise) Type 1C Conditional Element=<ImageOrientationSlide> Module=<MicroscopeSlideLayerTileOrganization>
Error - Missing attribute Type 1 Required Element=<InstanceNumber> Module=<MultiFrameFunctionalGroupsCommon>
Error - Missing attribute Type 1 Required Element=<PlanePositionSlideSequence> Module=<PlanePositionSlideMacro>
Error - Missing attribute Type 1 Required Element=<WholeSlideMicroscopyImageFrameTypeSequence> Module=<WholeSlideMicroscopyImageFrameTypeMacro>
Error - Required unless DimensionOrganizationType is TILED_FULL - attribute <PerFrameFunctionalGroupsSequence>
Warning - CodingSchemeDesignator is deprecated - attribute <CodingSchemeDesignator> = <SRT>
Warning - Attribute is not present in standard DICOM IOD - (0x0008,0x9007) CS Frame Type
Warning - Attribute is not present in standard DICOM IOD - (0x0040,0x0710) SQ Whole Slide Microscopy Image Frame Type Sequence
Error - Attribute with an even group number is not a recognized standard attribute - (0x1002,0x1001) ?
Warning - Attribute is not present in standard DICOM IOD - (0x1002,0x1001) ?
Warning - DICOM dataset contains attributes not present in standard DICOM IOD - this is a Standard Extended SOP Class
```

```
% dcmjvfy *.dcm
Error - String attribute has different value - Element=<Manufacturer> IE=<Equipment> for file <f6ec15e1-56e3-45c4-ad53-91be8df1d90a.dcm> versus <fcc7af34-713d-41a6-869e-0ed1c215090d.dcm> Value 1 <Hamamatsu> versus <Leica Biosystems>
Error - String attribute has different value - Element=<ManufacturerModelName> IE=<Equipment> for file <f6ec15e1-56e3-45c4-ad53-91be8df1d90a.dcm> versus <fcc7af34-713d-41a6-869e-0ed1c215090d.dcm> Value 1 <NanoZoomer converted by com.pixelmed.convert.TIFFToDicom> versus <Aperio converted by com.pixelmed.convert.TIFFToDicom>
Error - String attribute has different value - Element=<DeviceSerialNumber> IE=<Equipment> for file <f6ec15e1-56e3-45c4-ad53-91be8df1d90a.dcm> versus <fcc7af34-713d-41a6-869e-0ed1c215090d.dcm> Value 1 <9717418a2280805d-70165c05:1812a251412-7ffe> versus <9717418a2280805d-70165c05:1812a251412-7ffe>
Error - String attribute has different value - Element=<DeviceSerialNumber> IE=<Equipment> for file <e27cda16-a70e-40b4-959b-f443ecccce74.dcm> versus <fcc7af34-713d-41a6-869e-0ed1c215090d.dcm> Value 1 <9717418a2280805d-70165c05:1812a251412-7ffe> versus <9717418a2280805d-70165c05:1812a251412-7ffe>
Error - String attribute has different value - Element=<Manufacturer> IE=<Equipment> for file <db50117c-dcdc-4987-8f54-dc1e83b991de.dcm> versus <fcc7af34-713d-41a6-869e-0ed1c215090d.dcm> Value 1 <Hamamatsu> versus <Leica Biosystems>
Error - String attribute has different value - Element=<ManufacturerModelName> IE=<Equipment> for file <db50117c-dcdc-4987-8f54-dc1e83b991de.dcm> versus <fcc7af34-713d-41a6-869e-0ed1c215090d.dcm> Value 1 <NanoZoomer converted by com.pixelmed.convert.TIFFToDicom> versus <Aperio converted by com.pixelmed.convert.TIFFToDicom>
Error - String attribute has different value - Element=<DeviceSerialNumber> IE=<Equipment> for file <db50117c-dcdc-4987-8f54-dc1e83b991de.dcm> versus <fcc7af34-713d-41a6-869e-0ed1c215090d.dcm> Value 1 <9717418a2280805d-70165c05:1812a251412-7ffe> versus <9717418a2280805d-70165c05:1812a251412-7ffe>
Error - String attribute has different value - Element=<DeviceSerialNumber> IE=<Equipment> for file <74b9b980-Sc11-40b9-8762-e7f35034e656.dcm> versus <fcc7af34-713d-41a6-869e-0ed1c215090d.dcm> Value 1 <9717418a2280805d-70165c05:1812a251412-7ffe> versus <9717418a2280805d-70165c05:1812a251412-7ffe>
```

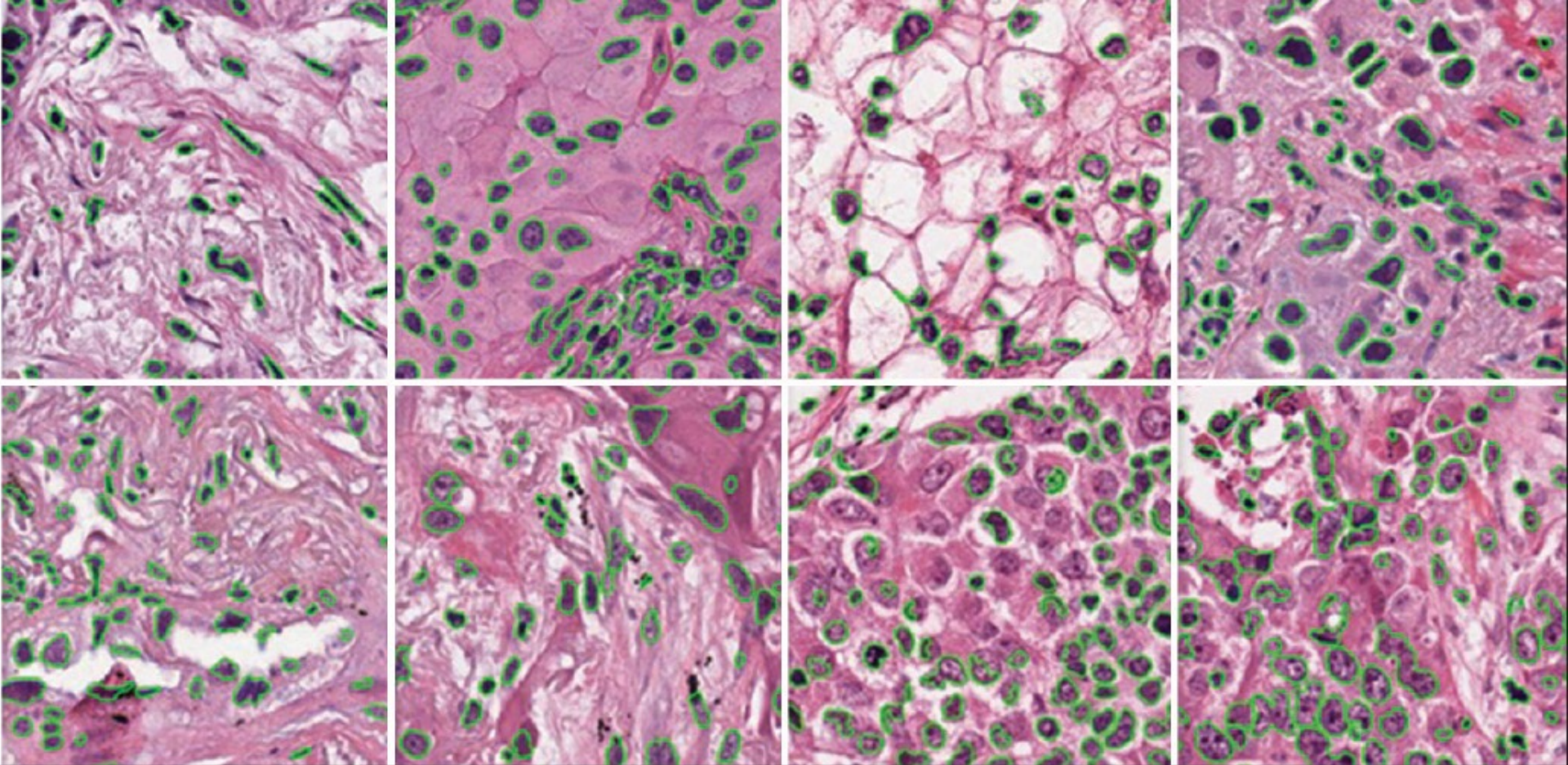
Updates on new pathology-related activities in DICOM

Annotations

Color management – already present but needs more testing

New compression schemes – JPEG-XL, Deflate for bitmaps

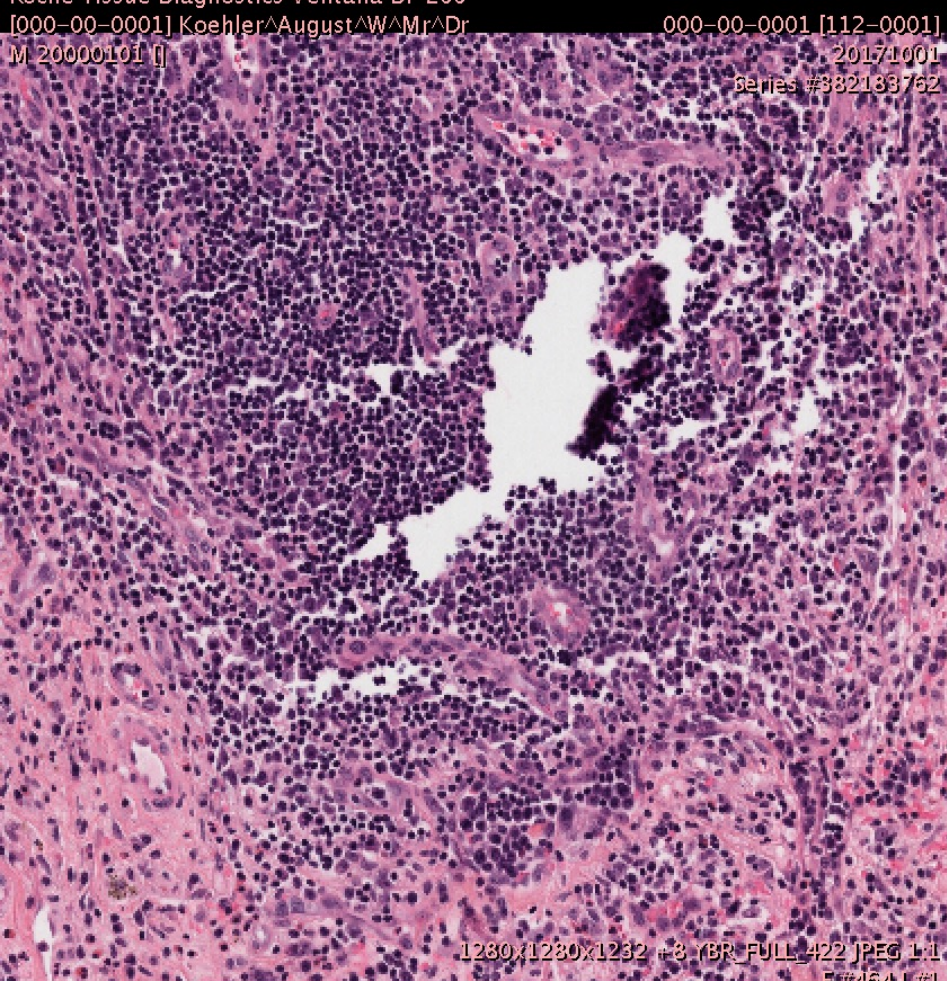
More web-based API – e.g., spatial queries (esp. annotations)



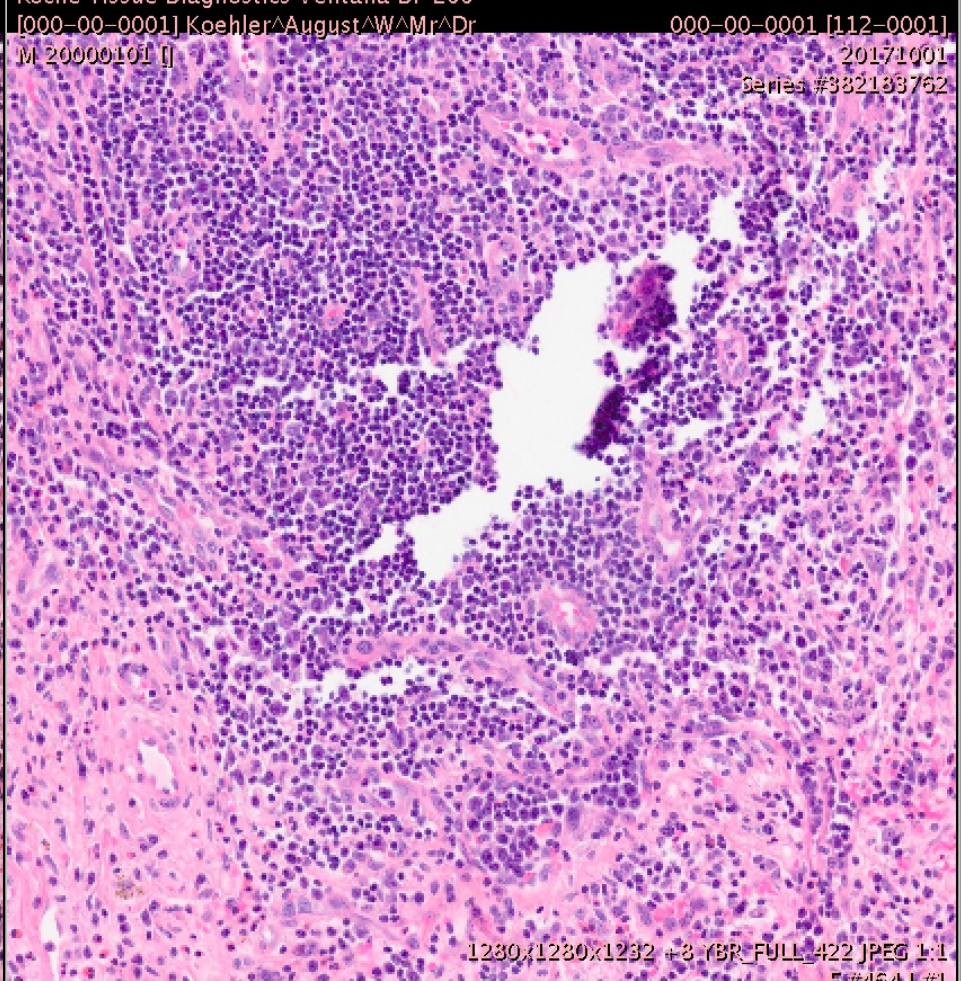
Wen et al. A methodology for texture feature-based quality assessment in nucleus segmentation of histopathology image. JPI. 2017.

DICOM WSI Annotations

- Use cases: human generated (few) vs. machine generated (millions)
- Standard supports vector or rasterized (bit mask, soon label map)
- Supports overlapping and non-overlapping segmentations
- Coded classification for semantic interoperability (SNOMED CT)
- Anatomy & property (category/type) (e.g., brain, abnormal structure/necrosis)
- Hackathons, Connectathons for testing are underway (ECDP 2024)
- Some use cases, representations & optimizations yet to be explored
- Considering performance issues with different levels of zoom
- Spatial query API is probably needed (e.g., annotations that intersect a tile)



No ICC Profile Applied



With ICC Profile Applied

DICOM WSI Color Management

Goal is color consistency throughout pixel pathway

Color “improvement” (normalization) outside DICOM’s scope

Depends on International Color Consortium (ICC) profiles

Consistent with approach adopted by scanner vendors

All DICOM WSI require presence of an ICC profile

IFF downstream systems are calibrated, consistency possible

DICOMweb – client or server may apply profile

Web-browser-based clients have distinct limits in this respect

DICOM WSI Compression

State of the art is modest level of lossy compression of WSI

Mostly using baseline JPEG, some JPEG 2000

Possibility of doing better with new JPEG-XL

More flexible (effective, complex) than baseline JPEG

Can re-encode existing JPEG images without further loss

Potentially save > 30% in size

For segmentation bit masks, need compression, since sparse

Considering use of Deflate (zip), in future maybe JBIG2

DICOM and FDA

Recognized consensus standard – what does that “mean”?
Understanding when pixel data is mathematically the same
... as the manufacturer’s proprietary format already cleared
... as what will be displayed to the user (vs. already cleared)

Compression (JPEG) is independent of wrapper (DICOM)

What role does color management (ICC in DICOM) play?

Are there any display-specific standard issues (like GSDF)?

Analogy of plain X-Ray vs. mammography in radiology (relative perceived risk and classification) – eventually relaxed to “5MP”, no processing, requirements, mix-and-match but not DICOM-related