

## Medical Image Processing

### PACS and DICOM

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## Who am I?

- Master of Science in computer engineering
- PhD medical image analysis and modelling
- Worked in hospital environment for 20 years
- Senior member of Lund Cardiac MR Group
- Founder of Medviso AB
- CTO for Imacor AB

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## Why bother?

- Almost ALL medical images are stored in DICOM format.
- All hospitals use PACS (Picture Archive and Communication Systems)
- If you ever will work with medical images in real life you need to understand basics of the DICOM standard.
- Reading DICOM images is part of the fourth hand-in assignment...

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## Knowledge expectations

- Being able to write minimalistic DICOM reader (part of assignment 4)
- Understand the basics of the DICOM standard and PACS systems
- Understand the basics on how to display medical images

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## Basics

- **D**igital Imaging and **C**ommunication in **M**edicine
- Both an image format & network protocol
- Huge standard (20 volumes, ~8000 pages)
- Bad standard...

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## Supported Imaging Modalities

- Magnetic Resonance Imaging
- Nuclear Medicine
- Computed Tomography
- Positron Emission Tomography
- Ultrasound
- Digital X-Ray & X-Ray Angiography
- Electron Microscope
- Digital Microscopy
- ...

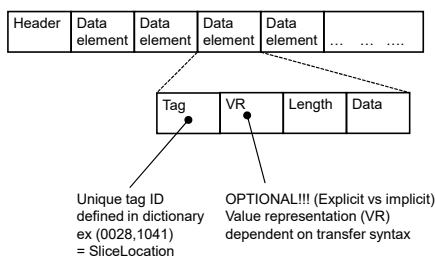
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## DICOM file format

- Header and image data stored together
- Stores data about the patient, machine, and data acquisition
- Implemented by the manufacturers
- Generally one slice per file

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## DICOM encoding



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## Value representations

- AS AgeString (4 bytes fixed)
- DA Date (8 bytes fixed)
- DS DecimalString (16 bytes maximum)
- DT DateTime (26 bytes maximum)
- FL FloatingPoint (4 bytes fixed)
- IS IntegerString (12 bytes maximum)
- ...
- UN Unknown (Unlimited)
- UT UnlimitedText (Unlimited)

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## Transfer syntax (examples)

Transfer Syntax UID	Transfer Syntax name
1.2.840.10008.1.2	Implicit VR Endian: Default Transfer Syntax for DICOM
1.2.840.10008.1.2.1	Explicit VR Little Endian
1.2.840.10008.1.2.1.99	Deflated Explicit VR Big Endian
1.2.840.10008.1.2.2	Explicit VR Big Endian
1.2.840.10008.1.2.4.50	JPEG Baseline (Process 1):
1.2.840.10008.1.2.4.51	JPEG Baseline (Processes 2 & 4):
1.2.840.10008.1.2.4.52	JPEG Extended (Processes 3 & 5) Retired
1.2.840.10008.1.2.4.53	.....
1.2.840.10008.1.2.4.56	JPEG Lossless, Nonhierarchical (Process 29) Retired
1.2.840.10008.1.2.4.70	JPEG Lossless, Nonhierarchical, First-Order Prediction
1.2.840.10008.1.2.4.80	JPEG-LS Lossless Image Compression
1.2.840.10008.1.2.4.81	JPEG-LS Lossy (Near-Lossless) Image Compression
1.2.840.10008.1.2.4.90	JPEG 2000 Image Compression (Lossless Only)
1.2.840.10008.1.2.4.91	JPEG 2000 Image Compression
1.2.840.10008.1.2.4.92	JPEG 2000 Part 2 Multicomponent Image Compression (Lossless Only)
1.2.840.10008.1.2.4.93	JPEG 2000 Part 2 Multicomponent Image Compression
1.2.840.10008.1.2.4.94	JPIP Referenced
1.2.840.10008.1.2.4.95	JPIP Referenced Deflate
1.2.840.10008.1.2.5	RLE Lossless
1.2.840.10008.1.2.6.1	RFC 2557 MIME Encapsulation
1.2.840.10008.1.2.4.100	MPEG2 Main Profile Main Level
1.2.840.10008.1.2.4.102	MPEG-4 AVC/H.264 High Profile / Level 4.1
1.2.840.10008.1.2.4.103	MPEG-4 AVC/H.264 BD-compatible High Profile / Level 4.1

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## Surprises

- Tags are of variable length
- Fields are generally optional
- You never know what fields will be there
- Headers have to be read sequentially
- Coding DICOM support is full of surprises

*General advice: Trust nobody! Most of the answers are found in discussion forums, not plowing the standard.*

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## Important tags

- “Image information”
  - (0018, 0050) **Slice Thickness**
  - (0018, 0088) **Spacing Between Slices**
  - (0018, 1060) Trigger Time
  - (0020, 1041) Slice Location
  - (0020, 0032) Image Position
  - (0020, 0037) Image Orientation

Red = extra important for the assignment...

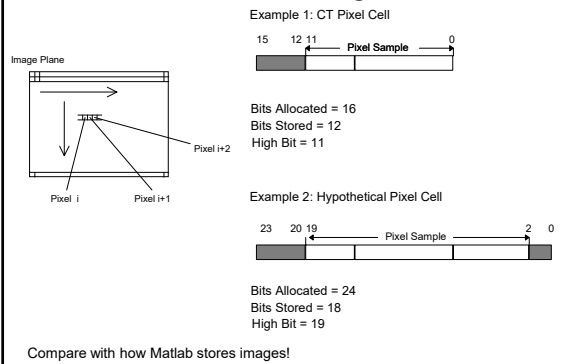
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## Important tags

- How & where the image data is stored
  - (0028, 0010) **Rows**
  - (0028, 0011) **Columns**
  - (0028, 0030) **Pixel Spacing**
  - (0028, 0100) **Bits Allocated**
  - (0028, 0101) **Bits Stored**
  - (0028, 0102) High Bit
  - (0028, 1052) **Rescale Intercept**
  - (0028, 1053) **Rescale Slope**
  - (7ef0, 0010) **Pixel Data**

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## Pixel storage



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## Less important tags...

- Birth time (0010, 0032)
- Patient Insurance Plane Seq (0010, 0050)
- Mother's Birth Name (0010, 1060)
- Military Rank (0010, 1080)
- Smoking Status (0010, 21A0)
- Patient Sex Neutered (0010, 2203)
- Religious Preference (0010, 21F0)
- Breed Description (0010, 2292)
- ...

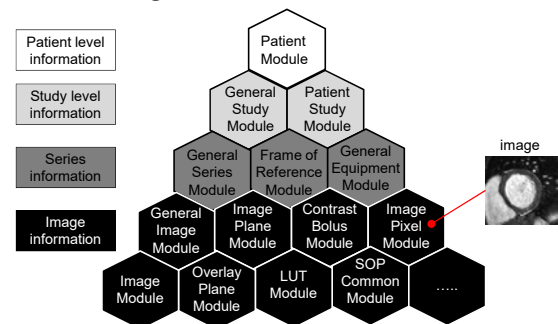
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## Picture Archive and Communication System (PACS)

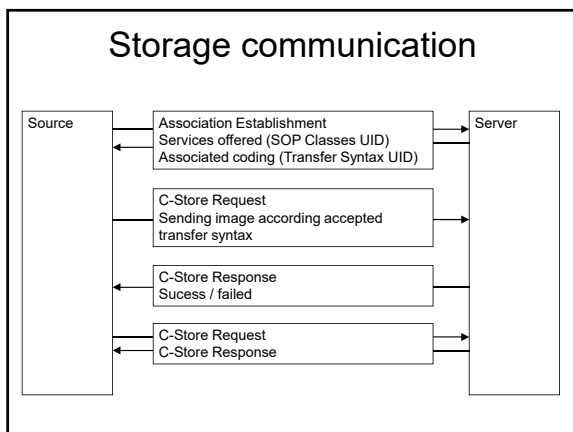
- All image storage in hospitals today are done in PACS systems.
- In one hospital several PACS systems may be used to store images from different departments.
- In Sweden there is growing possibilities to send images between hospitals (and Counties).

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## Image Information Model



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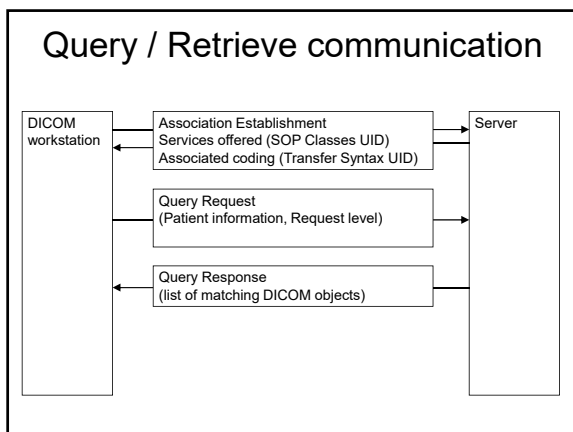


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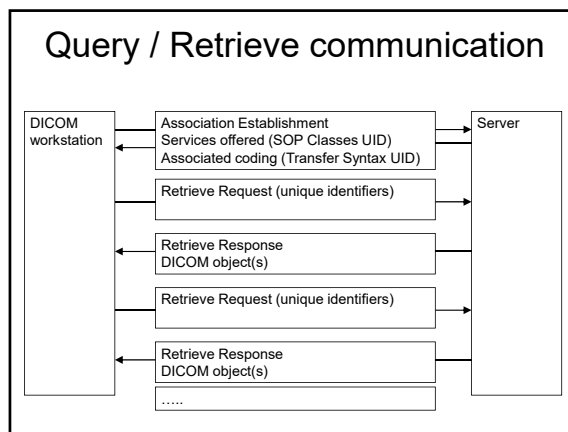
### Response

- The response contains type of the data that server can accept. It can be an acknowledge or a reject. If the request is not understood or can not be properly answered, it's rejected.

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### What is needed to set up communication?

- "Client" (scanner/workstation) needs to know server: AETitle, IP address, port
- "Server" (PACS system) generally needs to know AETitle (of client)
- Permission to Query / Retrieve images may be set on IP address

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### Challenges

- Large complex format -> difficult to implement support
- Each implementation has a different level of completeness -> difficult to predict which tags and services will be available
- Most scanners add custom proprietary tags to the header
- One slice per file is lame

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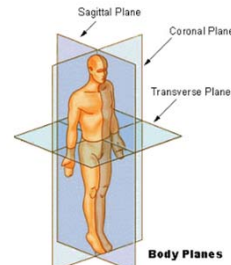
## DICOM conformance statement

- Details what transfer syntaxes that are supported
- Required DICOM attributes
- For some tags vendor make own decisions on interpretation

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## Presentation of medical images

- It is key to not mix right / left in images
- Take physical pixel size into account
- Standardized views
  - **Transversal**  
as seen from the feet
  - **Coronal**  
as seen from the nose
  - **Sagittal**  
nose to the left



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## Scaling displaying pixels

- The scanner (CT, MRI, PET...) may output "arbitrary" pixel values that needs to be interpreted in order to be displayed.
- For CT the unit is usually in Hounsfield units.
- For MR the unit is arbitrary or in some case quantitative in cm/s or ms etc.
- For PET/SPECT the unit is often in counts.

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## Scaling displaying pixels

- Prior to displaying the pixel value it needs to be rescaled (using the tags RescaleIntercept and RescaleSlope)
- After rescaled the developer needs to figure out which greyscale should be connected to which value.

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## Knowledge review



<http://m.voto.se/FMNA30-DICOM>

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