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A Data Model for Handling Whole Slide Microscopy Images in Picture Archiving and Communication Systems (PACS)

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EURO-TELEPATH
"Telepathology Network in Europe"

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Objectives

- PACS'es and DICOM (de-facto interoperability standard for PACS and medical imaging modalities) initially were designed for handling of radiological images (still, 3D stacks, movies).
  - PACS'es are widely used in healthcare institutions
- New modalities, as Virtual Microscopy (Whole Slide Imaging) can not be easily integrated into off-the-shelf PACS'es.

The WSI Problem

DICOM WG-26: Pathology

WSI = Whole Slide Imaging

- Image dimensions, data size
  - Typical:
    20mm x 15mm @ .5mpp (“20X”) =
    40,000 x 30,000 pixels = 1.2Gp = 3.6GB **(uncompressed)**
    20mm x 15mm @ .25mpp (“40X”) =
    80,000 x 60,000 pixels = 4.8Gp = 14.4GB
  - Extreme: 50mm x 25mm @ .1mpp (“100X”) =
    500,000 x 250,000 pixels = 125Gp = 375GB
    - x 10 Z-planes => 3.75TB

DICOM limitations

- Embedded binary object
  - an unsigned long (32 bit) integer for the data size

  size $\leq 2^{32}-2 \approx 4$ Gbyte
- Image co-ordinates (X,Y)
  - unsigned short (16 bits) integers to specify image dimensions

  value $\leq 2^{16}-2 = 65\ 534$

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Image Data Organisation

Image		mage2) GByte	Tile Size
Label			
Macro	1280 x 446		
Thumbnail			
Intermediate 1			
Intermediate 2			
Hi-Res1 (20x/10x)			
Hi-Res2 (40x)			

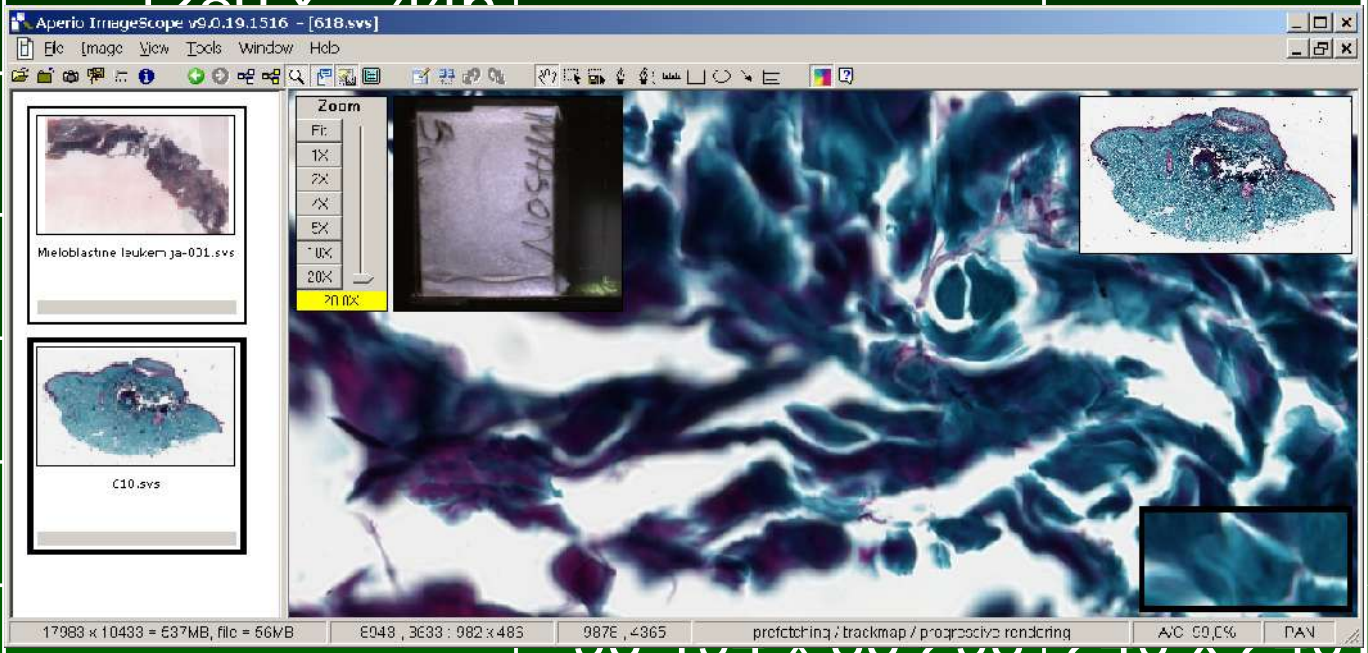


Image Data Organisation

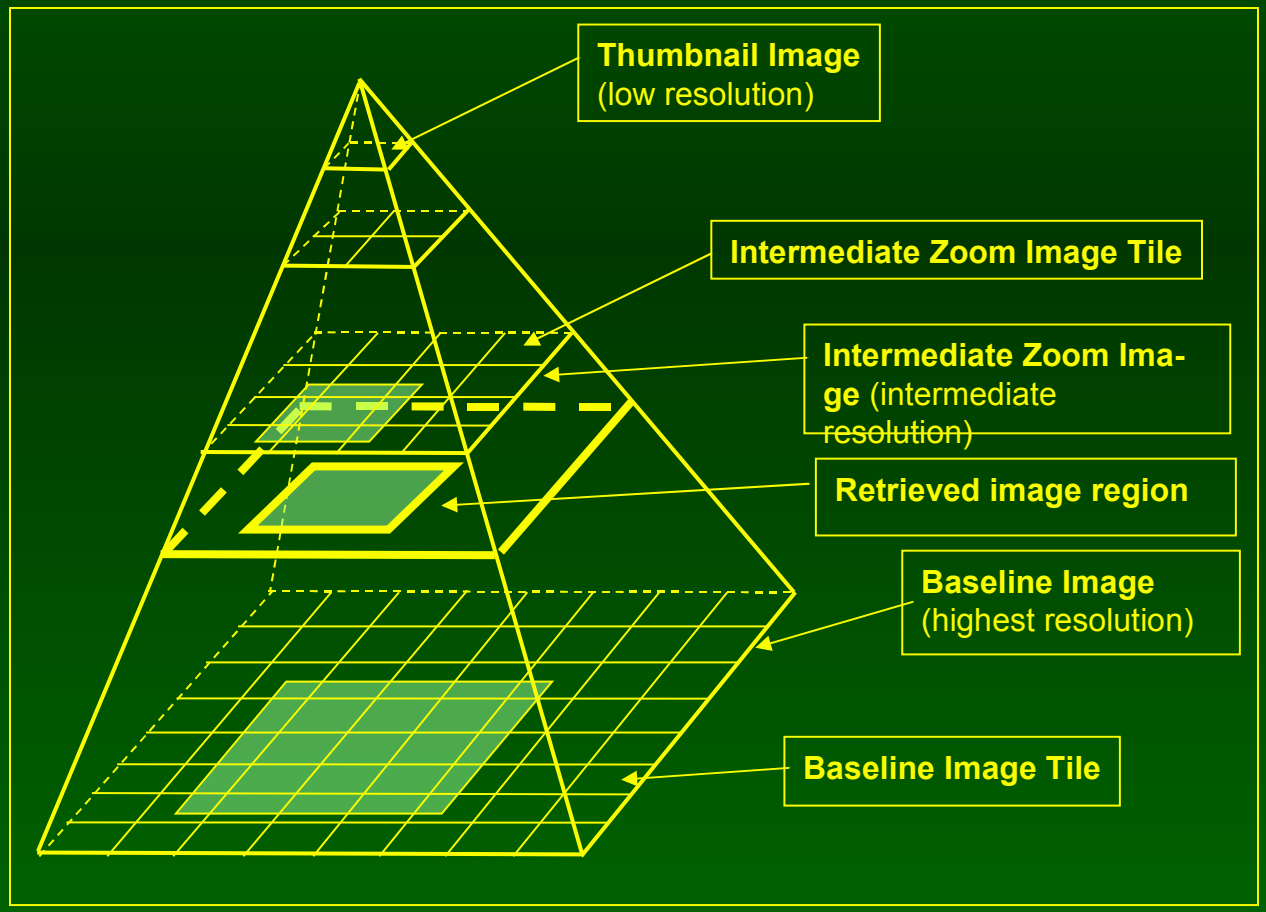
Image	Size(Image1) 0.56 GByte	Size(Image2) 23.8 GByte	Tile Size
Label	539 x 507		
Macro	1280 x 446		
Thumbnail	1024 x 641	839 x 768	
Intermediate 1	3247 x 2033	2 912 x 2 665	240 x 240
Intermediate 2	6 494 x 4 066	5 824 x 5 331	240 x 240
Hi-Res1 (20x/10x)	25 976 x 16 264	23 298 x 21 324	240 x 240
Hi-Res2 (40x)		93 194 x 85 298	240 x 240

Description of Problem
Characteristics of WSI

Pyramid addresses zooming

~JPEG2000

Ratio?

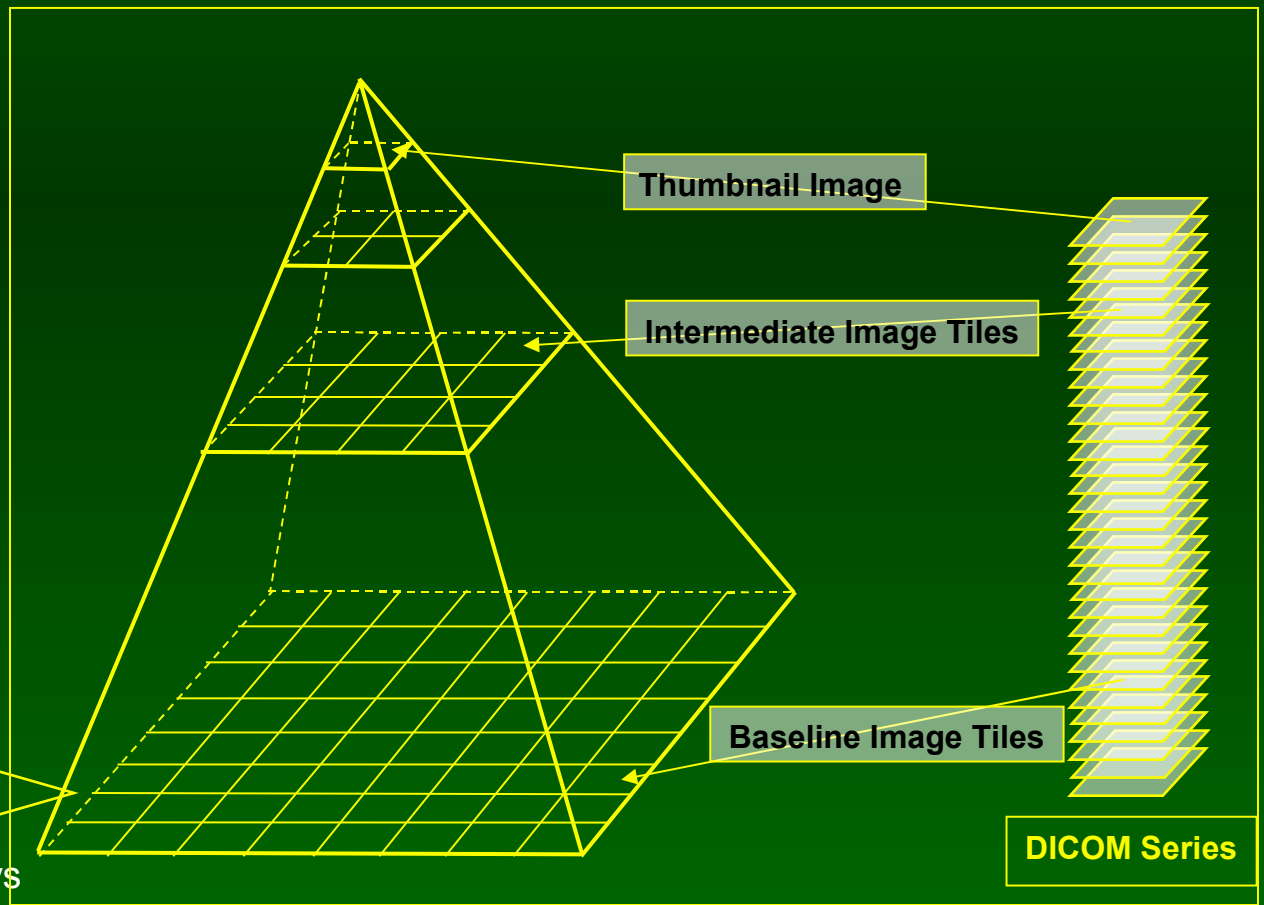


Handling WSI in PACS

- Tiled DICOM images
  - Implementable now (workaround for coordinates – still an open question…)
- Using JPIP (JPEG2000 Interactive Protocol)
  - Partial Image Retrieval of specified size at specified resolution and quality
  - Not yet implemented in any ”COTS” PACS
  - DICOM + JPIP => 2 alternative interfaces and partially overlapping data sets

Description of Proposed Solution
Store WSI Pyramid as DICOM Series

Each “tile” of each level of each plane of WSI corresponds to image in series



JPIP:
part of an image @ specified resolution

PACS client for WSI

- "Normal" approach in PACS design
  - e.g. Mammography, fMRI, 3D analysis PACS clients
  - Same (?) vendor: PACS, microscope, viewer
- Retrieving the necessary part of VM image
  - Using DICOM Q/R by UID of necessary Tiles, pre-fetching possible (widely implemented in PACS)
  - *JPIP = JPEG2000 Interactive Protocol*

What about tile size?

Image	Size(Image1) 0.56 GByte	Size(Image2) 23.8 GByte	Tile Size
Label	539 x 507		
Macro	1280 x 446		
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Choosing the tile size

- Goal – to fit the compressed data into a single data container – protocol data unit (PDU) - rationally
  - PDU size is constant (“negotiated”) for the whole DICOM session (association)
  - maximum even value of 32-bit unsigned integer (2^{32}-2)
  - in practice the maximum PDU size is set to 8, 16 (most frequently) or 32 kilobytes (8192 16384 or 32768 bytes)
  - E.g.:
    240x240xRGB / 10 (compr.) = 16.8kByte => 2 PDUs
    224x224xRGB / 10 = 14.7kByte => 1 PDU (92%)

Optimising Tile Size ?

$$\beta = \frac{1}{N(M-1)} \sum_{j=1}^{N} \sum_{i=1}^{M-1} \left| \mathbf{X}(i,j) - \mathbf{X}(i,j+1) \right|$$

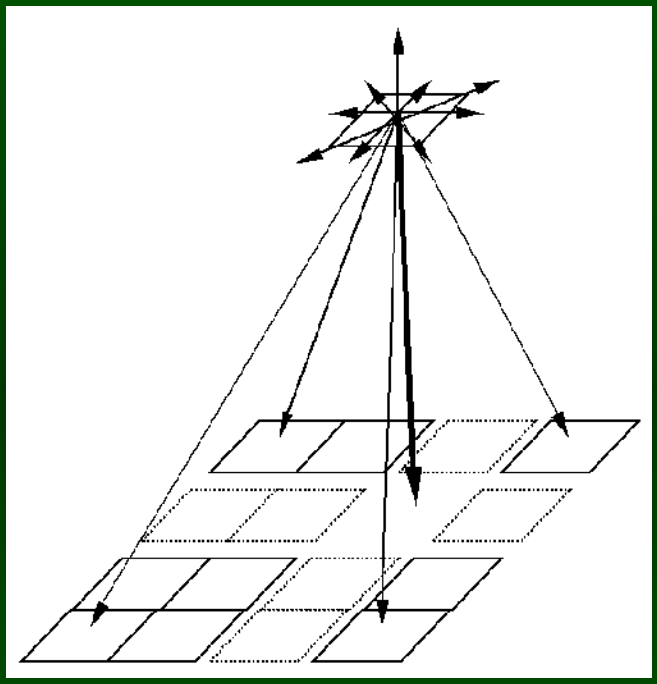
- The image content complexity measure could be calculated for relatively small non-overlapping image areas (e.g. 32x32 or 64x64 pixels) before the division of an image into tiles and carrying out their compression. The smaller is the value computed, the greater is the tile size.

Conclusions

- The construction of the map on the image content complexity measure has been suggested to predict possible compression ratios and to carry out the estimation of an image tile size.
- The requirements for links between tile images in the data model have been defined having in mind the possible user needs for navigation within the image pyramid.
- A tile of an intermediate level, as a more general case, includes following features:
  - …

Conclusions

- A tile of an intermediate level as more general case, includes following features:
  - It has a link to a lower magnification image (up in the pyramid). The link might be null, if the image is of the highest level of the pyramid.
  - It has 8 links to neighbour images of the same magnification. These links might be utilised for image pre-fetching from the DICOM archive (PACS).
  - It has a single link to a higher magnification image (down the pyramid). The link might be null, if the image is of the lowest level of the pyramid, or there is no real object in particular image area.



Thank you for your attention!

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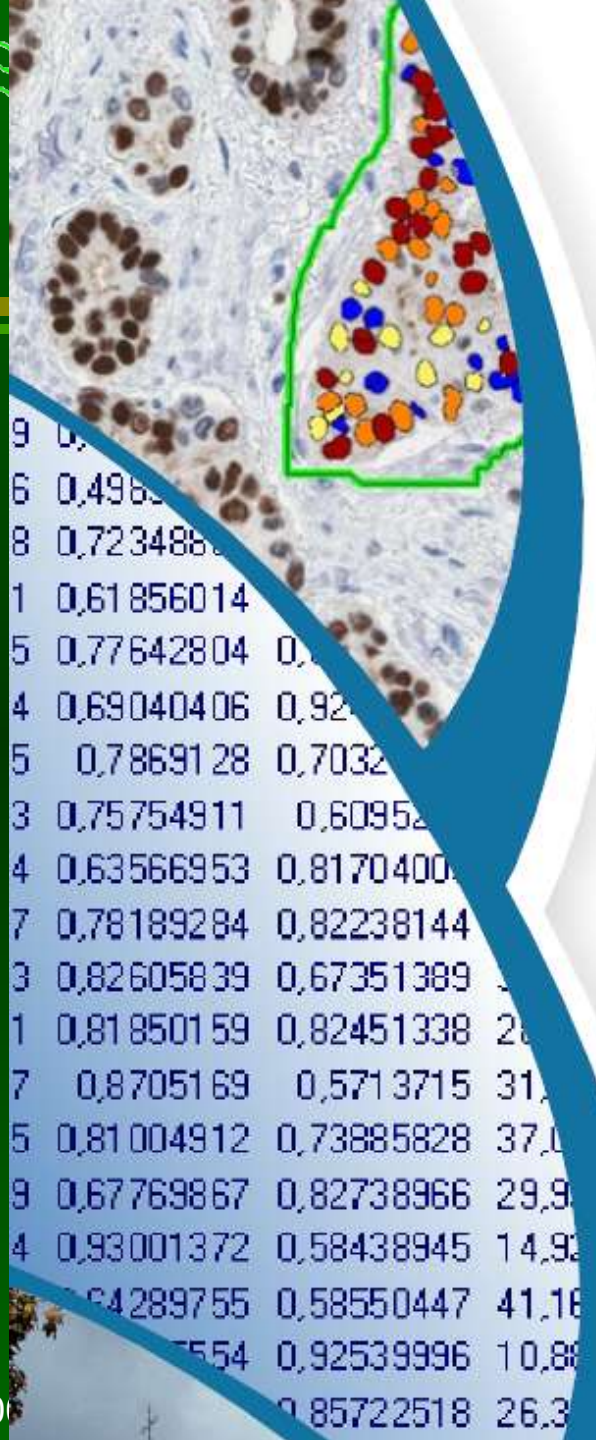

10th european congress on telepathology

4th international congress on virtual microscopy

10th European Congress on Telepathology and 4rd International Congress on Virtual Microscopy

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