

Progressive and interactive modes of image transmission: optimized wavelet-based image representation

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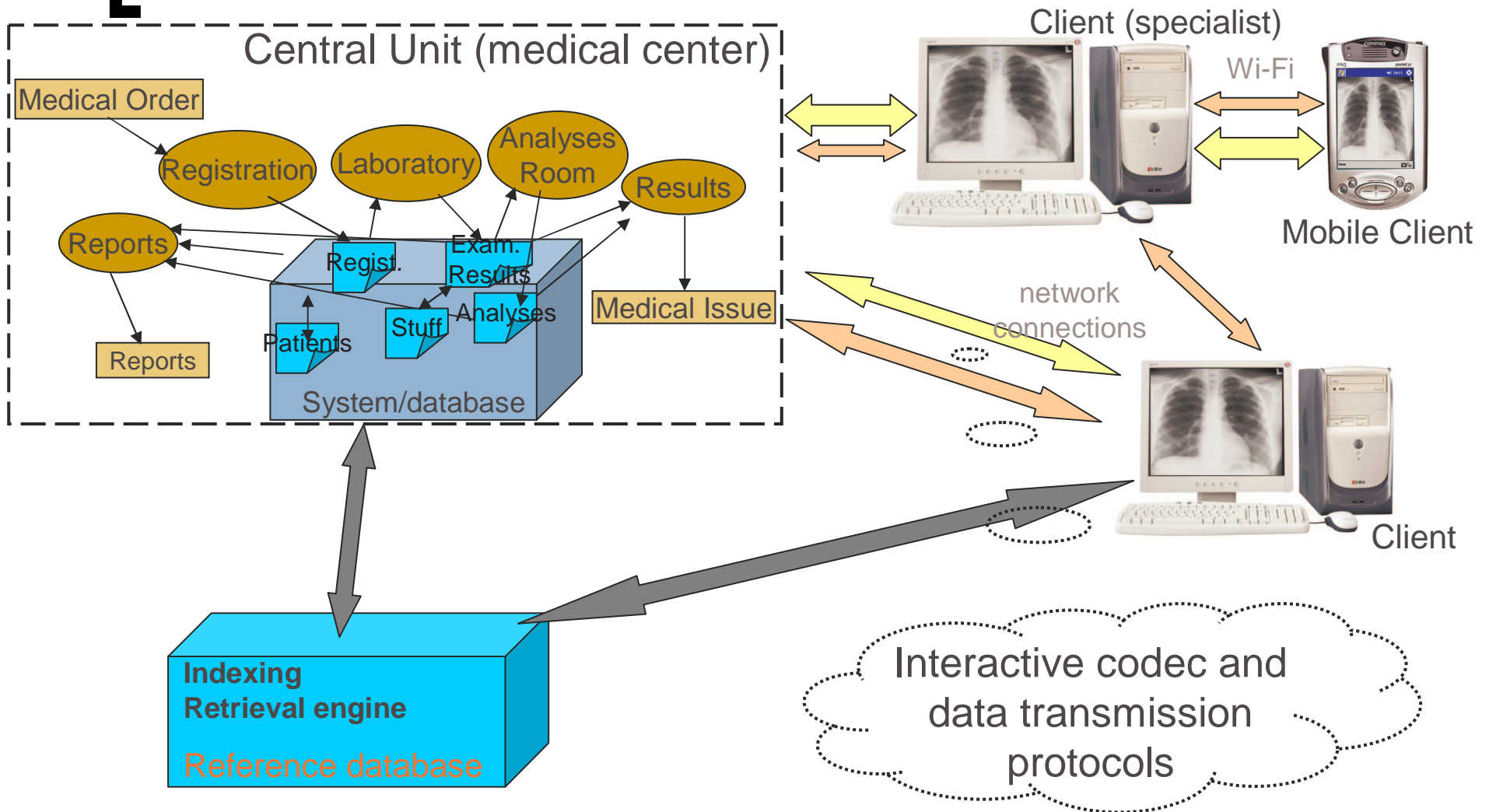
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[Outline]

- **Context:** Teleinformation medical system (PACS-RIS-telediagnosis-reference database)
- **Props1:** Interactive progression (user interface)
- **Props2:** Image indexing (reference database)
- **Props3:** JPEG2000 as medical (teleradiology) standard
- **Props4:** Faster encoder (archiving and transmission)
- **Props5:** Effective encoder (optimized)
- **Conclusions** (use it!)

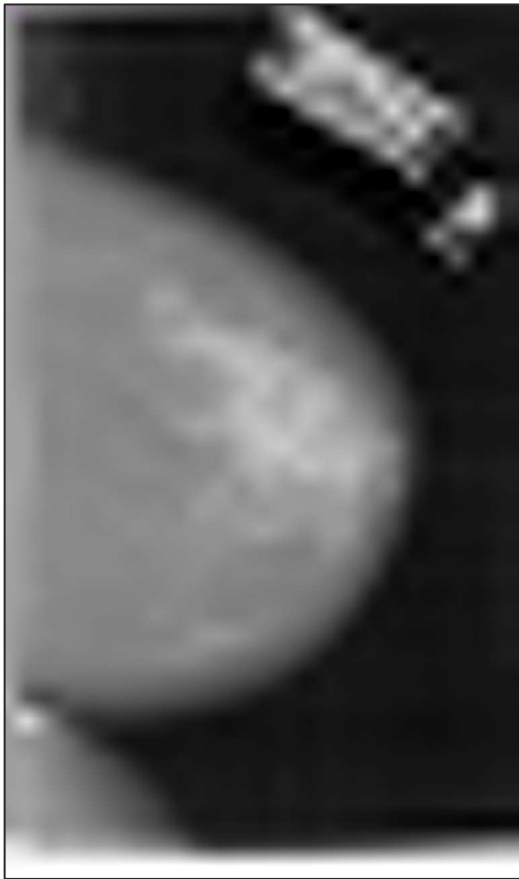
Context: Teleinformation Radiology System



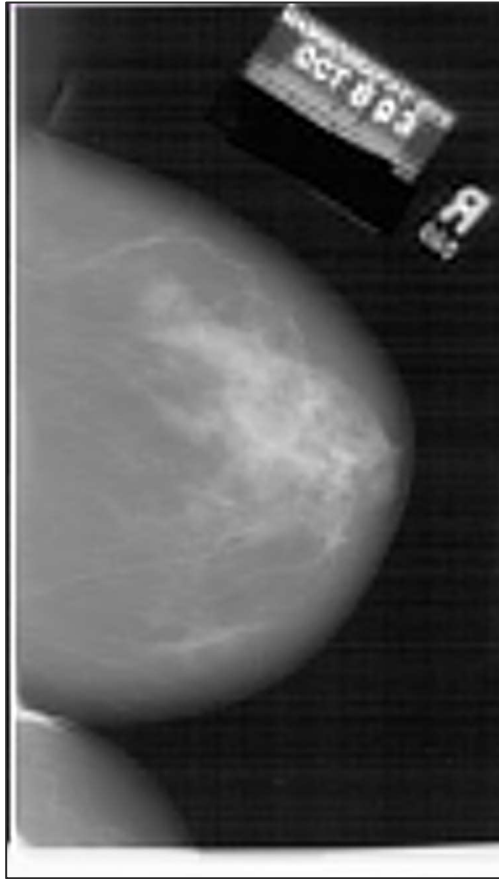
Progressive Interactive Internet Codec

- Teleconsultings and picture sharing with other system clients
- Multi-platform, system independent architecture
- Progression modes
- Region of interest (ROI) progression
- Interactive protocols
- Intelligent User Interface

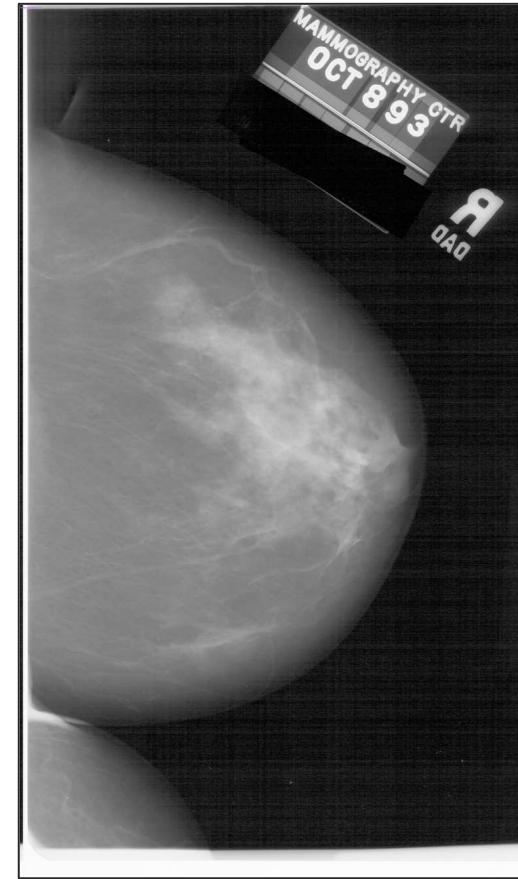
Progressive image data stream decoding



After 0.5%



After 2%



After 100%

Slajd 5

H1

Progressive image data stream decoding significantly increases effectiveness of large image transmission via low or medium-speed internet connection. It enables image character and content analyze just after few percents of downloaded data bytes. These 3 pictures contain the same image reconstructed using respectively 0.5, 2 and 100% of image data bytes. Currently I have been working at using of contourlets instead of wavelets which are expected to be more efficient

Hałasa; 2005-10-21

Interactive image exchange (JPEG2000 data stream)

The screenshot shows a web application interface for image exchange. At the top, there are navigation tabs: 'login', 'image database', 'sessions', and 'chest.jp2'. The main area displays a chest X-ray image with a selected ROI (Region of Interest) highlighted in a darker square. Below the image are several control panels:

- Image parameters:** resolution: 3301 x 5806, number of layers: 5, number of tiles: 1, tile size: 3301 x 5806, number of components: 1.
- Adjustment:** Brightness and Contrast sliders.
- Filters:** Select image filter: (...), Apply, and Import new filters.
- Transmission settings:**
 - Default packets order:**
 - Layer-Resolution-Component-Position
 - Resolution-Layer-Component-Position
 - Resolution-Position-Component-Layer
 - Position-Component-Resolution-Layer
 - Component-Position-Layer-Resolution
 - Resolution-Position-Component-Layer
 - Transform type:**
 - Wavelets
 - Contourlets

A yellow arrow points from the text **selected ROI** to the ROI in the image.

Simple image transmission protocol (SITP) = flexible XML-based control connection + high performance image stream via UDP

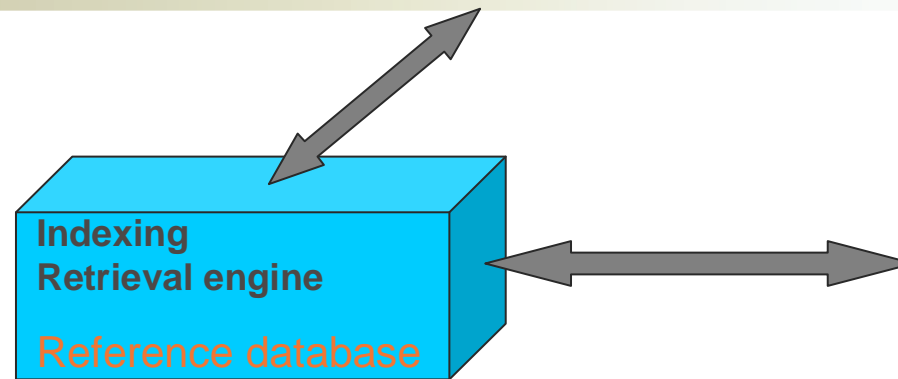
Slajd 6

H2

Progressive image data decoding may be even more efficient when used with Region of Interest selection. Selecting the ROI affects on coding blocks sequence in image stream and enables desired area to be reconstructed in the first order

Hałasa; 2005-10-21

Image database indexing and retrieval



- Reference diagnostic database
- Index in wavelet domain
- User Boxes (JPEG2000 data stream)
- Fast and precise retrieval
- Web access

Reference database

Right now, for the better conformance, new image should:

- be 256x256 at least
- have black background
- not contain any comments, markers or other non original objects

Supported input image file formats: BMP, JP2, JPC, JPCX, PGM, GIF, DCM

Enter the file name: [\(click me to show\)](#)

DICOM file (Don't have to fill the rest of form).
 Enter image source:

Enter description: (English Polish)

Select type of image:

Select patient:

Image have white background.

ZU Patient, 45 MMG Mammography

LMLO_P
 Utkanie sutków: gruczołowo - tłuszczowe
 Kwadrant: KGZ
 Wielkość (centrum / wypustki): 24 x 17
 Morfologia: zaburzenie architektury ? + gruczek ?
 Mikrozwapnienia: -
 Skóra / brodawka: +/-
 Węzły: -
 Klinicznie: T2 N1 M0
 Histopatologia: 3 x 2 x 2,5 cm prawdopodobnie nac
Carcinoma ductale invasium BII
 Węzły 12/12 sr 0,3-1,0

W bazie od: 03/31/2004 02:13:13, pochodzenie: ROIS
[Find similar in this collection...](#)

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 Węzły 12/12 sr 0,3-1,0

W bazie od: 03/31/2004 02:15:17, pochodzenie: ROIS
[Find similar in this collection...](#)

Select parameters for retrieval process.

Classifier options:

Metric: SIMILARITY = (1-distance)^{1/y} Results no.:

Euclidean Linear (g=1)
 Manhattan Increased selectivity (g=0.5)
 Correlation High selectivity (g=0.1)
 Tanimoto Paranoid selectivity (g=0.01)

Indexing parameters:

Decomposition levels (resolution):
 All
 0 (low)
 1 (worse)
 2 (medium)
 3 (better)
 4 (high)

Wavelet bands:
 All
 Approximation
 Vertical details
 Horizontal details
 Both direction details

Statistics:
 All
 MEAN
 VAR
 STDDEV
 AVGDEV
 SKEW
 KURT
 ENTR

Exclude current patient's images from retrieval

Similarity: 62.35%

PJ Patient, age: 81. MMG Mammography

Utkanie sutków: tłuszczowe
 Inne: USG
 Echogeniczność (cień / cienie boczne): niejednorodny +/-
 Wielkość (centrum / odczyn): 30 / 45
 Morfologia: lity nieregularny policykliczny
 Powieź: + +skóra
 MMG
 Kwadrant: KGZ (9 odległość od brodawki 9)
 Wielkość (centrum / wypustki) [mm]: 22 / 50
 Morfologia: spikularny
 Mikrozwapnienia: -
 Skóra / brodawka: +/-
 Węzły: -
 451 / 98 T2 N0 M0
 BAC: cell ca
 Histopatologia: ca ductale invasium B-II
 Szaro-krem, nieregularny 2.5 x 1.5 x 2
 1.5 od skóry, 1 cm od powięzi, 18 węzłów 1 do 3 cm - bz
 Klinicznie: sr 3 słabo ograniczony, ruchomy skóra bz, w pasze węzeł sr 1

W bazie od: 04/03/2004 14:33:34, pochodzenie: rois
[Find similar in Mammography collection...](#)

Similarity: 60.82%

PB Patient, age: 71. MMG Mammography

Utkanie sutków: tłuszczowe
 Inne: 2 ogniska ?
 Kwadrant: KGZ
 Wielkość (centrum / wypustki) [mm]: 7 x 9 / 15

Precision:

Images	Profiles		
	Manhattan, Var, HH, max n	Correlation, ADev, HL, max n	Tanimoto, Var, LH, max n
CT	84%		
MR		80%	
MMG			76%

JPEG2000 is medical standard? YES

DICOM:

- it allows transmission of images with improving resolution and quality, which will be **extremely useful** in teleradiology and in some PACS network environments

JPEG2000 is medical standard? NO: irreversible compression

- scientific community has not come to a consensus
- fear: valuable information might be lost through compression
- DICOM does not, and will never, “approve” compression schemes for any particular use

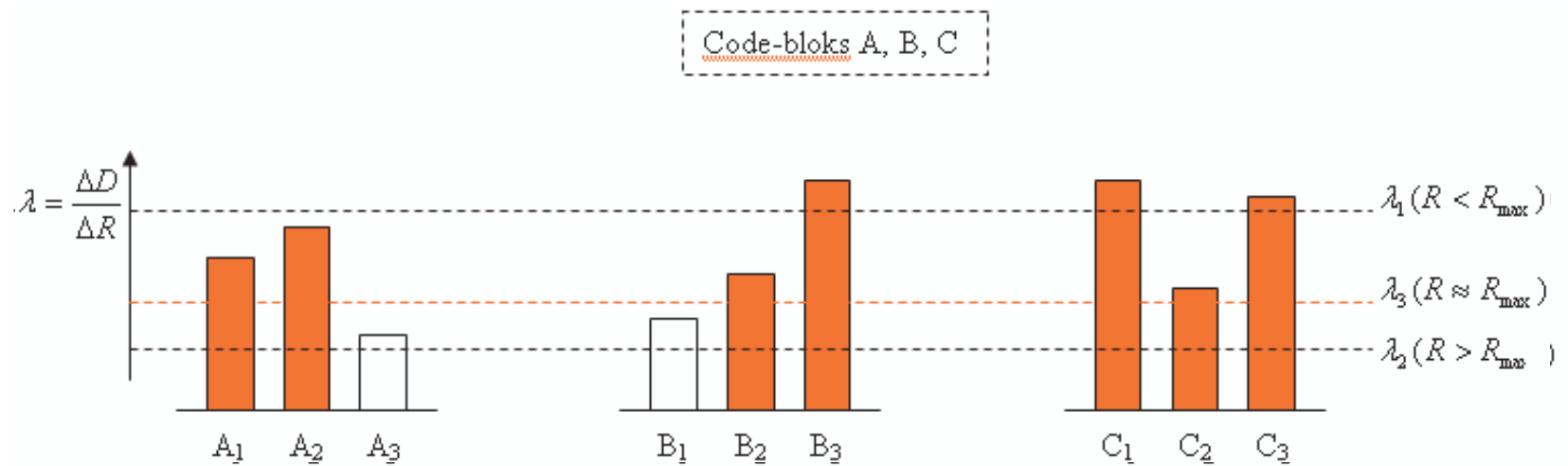
JPEG2000 is medical standard? YES

- „avoiding all risks is the risk ”
- DICOM: professionals make decision and take responsibility
- Litigation risks: regulators rely on the professions to lead the way

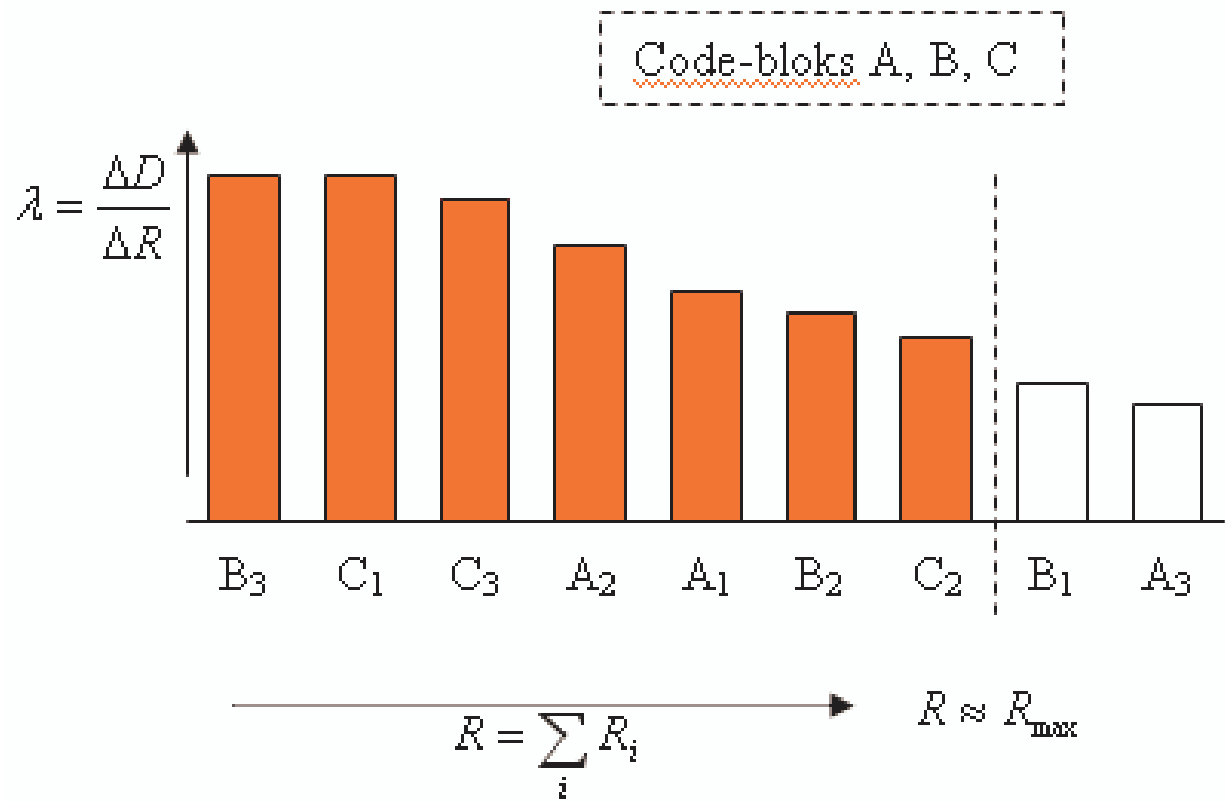
[Faster JPEG2000 encoder]

- Optimized PCRD: improvement of Jasper C implementation (JPER)
- Solution: Sorting instead of iterative bisection
- Effect: multi-layers coding without additional time costs
- Faster archiving and transmission (reduced time costs, reduced memory costs, simplicity)

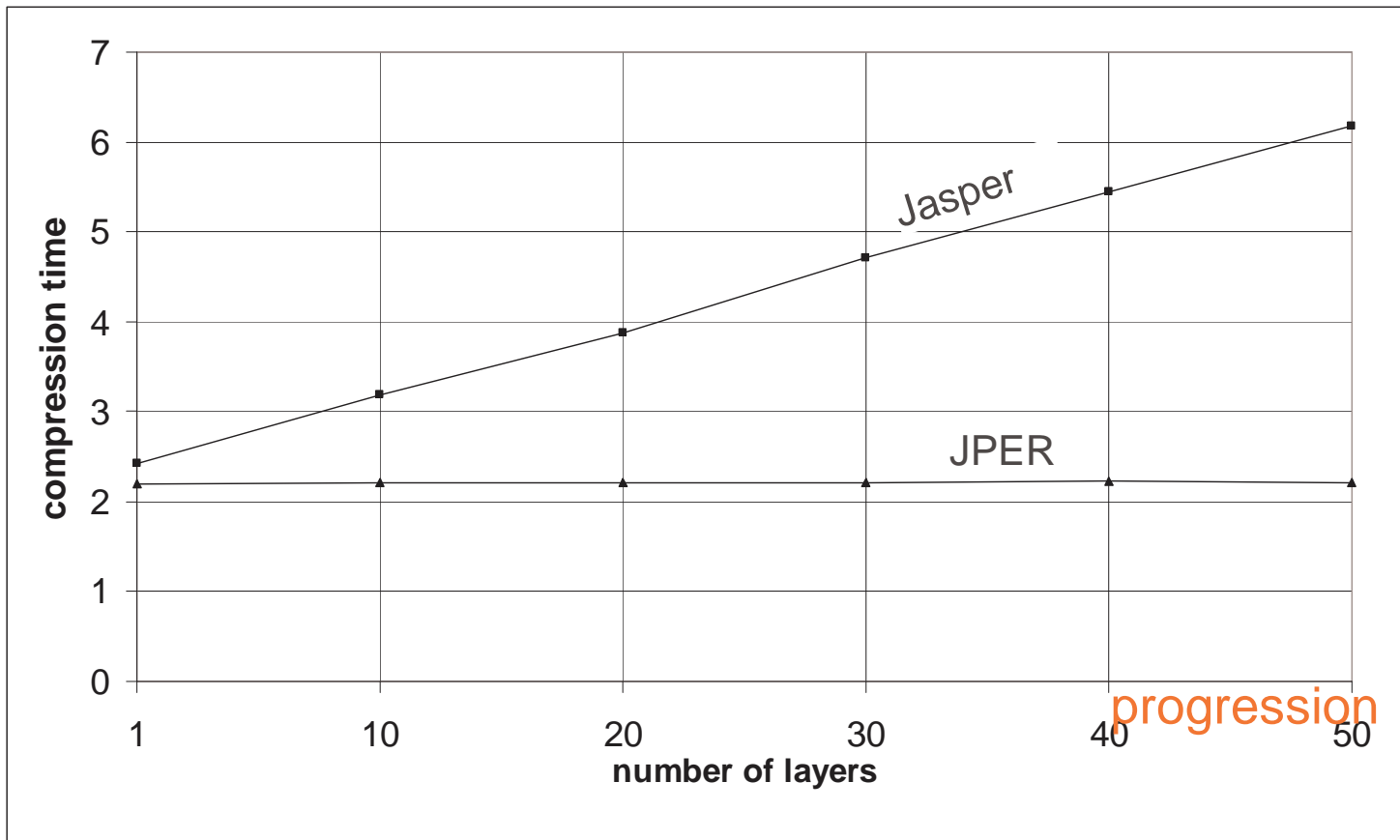
[Basic idea of PCRD in Jasper]



[Basic idea of PCRD in JPER]



[Experimental Effects]



JPER2000

The image displays several overlapping windows from the JPER 2000 software interface:

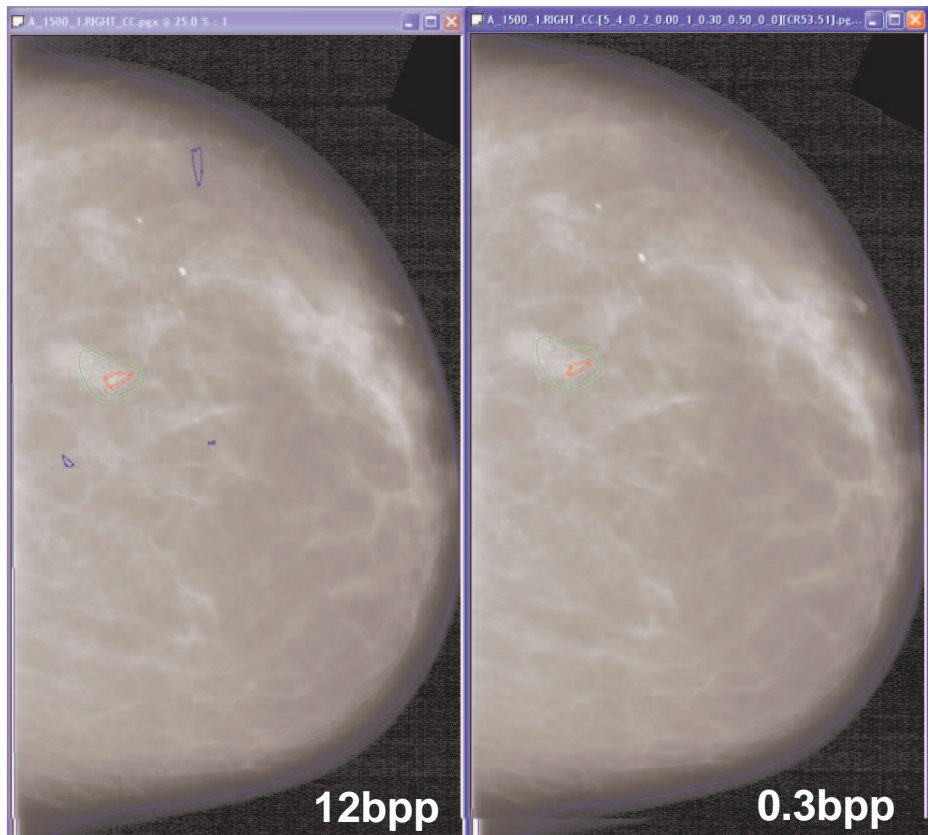
- Main Window:** Shows a medical image and a 'group of files [62@100%]' window.
- Encoder Properties (Metadata):** Includes fields for Patient ID (Jan Kowalski), Exam ID (123456), Institute ID (00001), Physician ID (ABCDEF), Doctor ID (0123456789), Subject (Tomograficzne badanie kolana), and Modality (NMR).
- Encoder Properties (Quality):** Shows 'Quality of reconstruction' options: Full quality, Quality by layers (Maximum number of layers to read: 50), and Quality by packets (Maximum number of packets to read: 2000).
- Encoder Properties (Quantization & Compression):** Shows 'Number of guard bits' (2) and 'CR (compression rate)' (0.03333).
- Encoder Properties (Extra Layers):** Shows 'Number of extra layers' (30) and 'CR of lowest layer' (300).
- Encoder Properties (Coding style & File format):** Shows options for 'Enable arithmetic coding bypass' and 'Choose JPEG 2000 file format'.
- Encoder Properties (Intercomponent transform):** Shows options for 'Use intercomponent transform' and 'Choose intermediate space' (YCC, YC, YIQ).
- Encoder Properties (Tiling):** Shows 'Image origin on reference grid' and 'Tile partitioning origin on reference grid' options.
- Encoder Properties (Timing):** Shows 'Encoding time: 9.92 sec' and 'Decoding time: 2.45 sec'.
- Encoder Properties (Reconstruction distortion):** Shows a table of metrics for 1st, 2nd, and 3rd components.

	1st component:	2nd component:	3rd component:
Boolean equality:	NO	n/a	n/a
MAE (mean absolute error):	77.8848	n/a	n/a
MSE (mean squared error):	11636.6398	n/a	n/a
RMSE (root mean squared error):	107.8733	n/a	n/a
PAE (peak absolute error):	842	n/a	n/a
PSNR (peak signal to noise ratio):	31.5868 dB	n/a dB	n/a dB

Increased compression efficiency

- Reduced bit rates
- Selective compression: diagnostic quality progression
- Profiles (e.g. for mammograms: 17/11 filter bank, 8 levels of diadic, $nz=0.6$, layer progression, code-blocks 64x64)

The results: diagnosis based on JPEG2000 compressed images

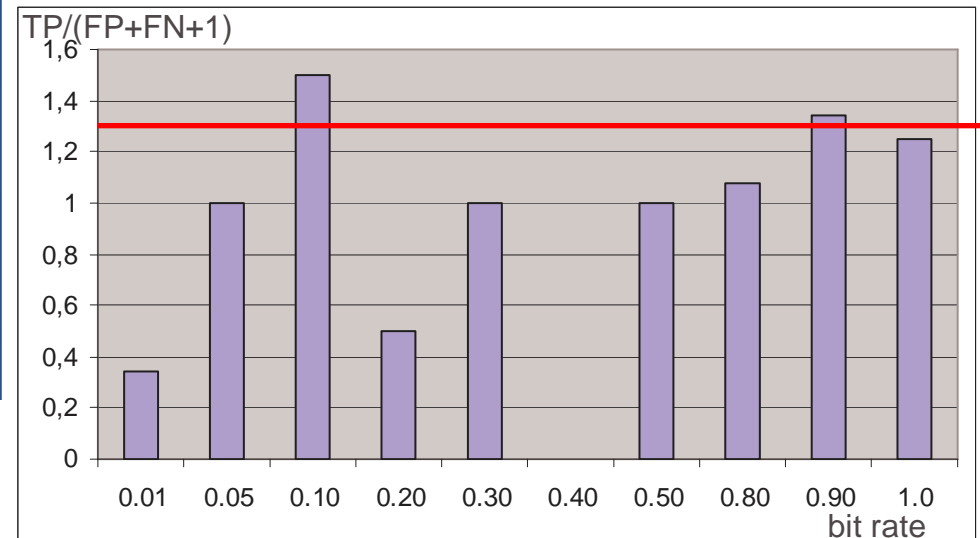


mammograms

Quality subjectively: 1bpp

ROC-based detection: 0.1bpp

CAD: 0.9bpp



[Conclusions]

- JPEG2000 is flexible enough for teleradiology
- Implemented improvements enhanced information exchange
- Clinical experiments are required to verify our complex system
- Please, use it! It works!