I-ImaS

Workpackage-3:

Update on current progress and report for deliverable D.8:
"Translating information signatures to a sequence of well-defined processing functions"

London, 12th – 13th October 2004

Harris Georgiou (WP3/CTI)

WP3 tasks:

Task 3.1: creation of an image database for medical applications

Task 3.2: Identification of important features to be measured by the image analysis

Task 3.3: Feature analysis and selection, in order to decide which features to use as feedback to the sensor system for different applications using the information from previous task

Task 3.4: Evaluation of operator response to the images created by using selected features as feedback to the sensors

WP3 deliverables:

D.7: An organized, searchable database of images from medical applications (Oct.2004)

D.8: A report on the translation of the information signatures to a sequence of well-defined processing functions (Oct.2004)

D.9: A report summarizing the results of evaluating the different approaches to providing intelligence in the sensor/imaging system (Dec.2004)

Organization of current work:

1. Compatibility of current image analysis source code with SIMD specification as proposed by SINTEF for sensor IC design.
2. Organized database of images in accordance to the RIEDS templates for image acquisition experiments (**D.7**)
3. Preliminary feature functions assessment, analysis and performance evaluation (**D.8**)
4. Discussions & Proposals on image acquisition experiments and clinical evaluation of image sets
5. Further work & Requirements

Current Progress Overview:

- **SIMD compatibility of current feature functions**
- D.7: Organized database of images (mammoDB/RIEDS)
- D.8: Preliminary feature functions evaluation
- Discussions & Proposals
- Further work & Requirements

SIMD compatibility – Overview

Requirements [18-19]:

- code should be effectively executed with multiple instances of input data (SIMD: Single-Instruction-Multiple-Data)
- process data as they arrive from line-scanning modules
- avoid branching functions (“if-then”) on data streaming
- limited access to global image statistics or measurements
- provide localized data streaming & processing

Main Advantages [18-19]:

- Data-oriented processing on relatively independent data blocks
- Similar processing executed in parallel for various local areas
- Limited data bus traffic
- Simple hardware implementation using multiple similar IC modules

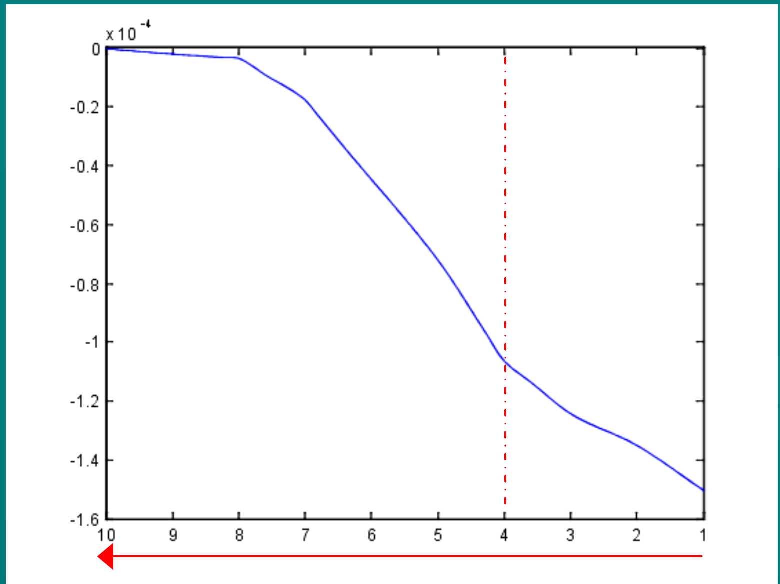
Texture Features Calculation Procedure:

1. Calculate each feature function for a fixed-sized box
2. Average feature values for current “column”
3. Store mean, stdev values and advance to the next “column”
4. Final result is a 1-D curve for each feature function

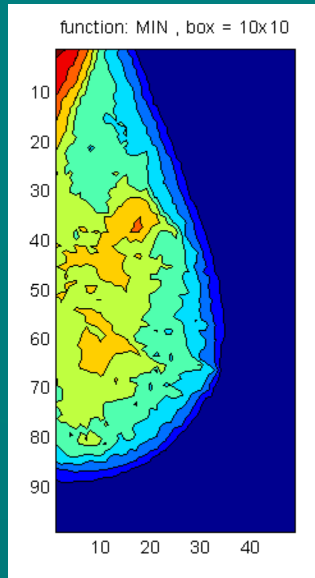
Is the above procedure SIMD-compatible?

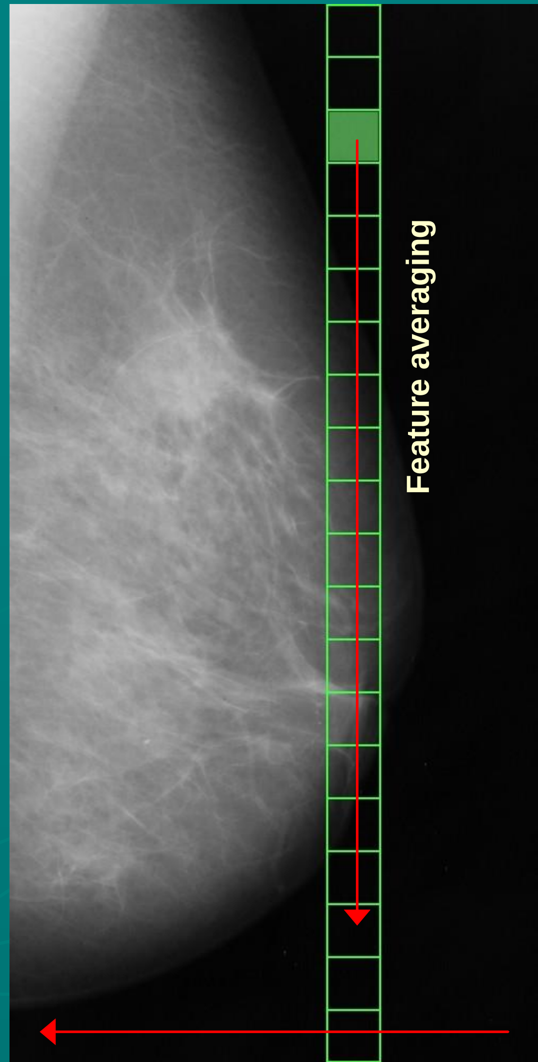
- ✓ Processing is conducted on localized instances of data
- ✓ No branching “if-then” statements
- ✓ Limited requirements for global image statistics
- ✓ Can be implemented for on-line, single-stage processing

Feature value singature (1-D)



Intermediate matrix (2-D)





X-axis scanning

- ✓ Maximum data storage requirement is one image "column"
- ✓ 2-D processing can be done in parallel by N vertically-aligned sensor IC modules
- ✓ 1-D processing is a simple mean, stdev of the N intermediate output values
- ✓ Final "signature" is one value per "column"

Current Feature Functions: Organization & Complexity

MATLAB sample:

```
function npower=func_SF19( I )
    npower = sum(sum(I.^2))/(size(I,1)*size(I,2));
```

C/C++ sample:

```
int func_SF19( unsigned char *pixel, int boxsz )
{
    int    i, j, sum=0, px, npower;

    for ( i=0; i<boxsz; i++ )
        for ( j=0; j<boxsz; j++ )
        {
            px = *(pixel+(i-1)*boxsz+j);
            sum = sum + px*px;
        }

    npower = sum / (boxsz*boxsz);
    return(npower);
}
```

Current Feature Functions: Organization & Complexity

x86 Assembly sample:

```
    ...
DSEG      SEGMENT

BOX_SZ    DW        50
ICOUNT    DW        50
JCOUNT    DW        50
SUM DW    0
NPOWER    DW        0

DSEG      ENDS
    ...

FUNC_SF19           PROC

    PUSHA

    MOV   SUM,0

L1: CMP   JCOUNT,0
    JNG   L0

L2: CMP   JCOUNT,0
    JNG   L1
    MOV   DI,JCOUNT
    MOV   BX,ICOUNT
    SUB   BX,1
    MUL   BX,BOX_SZ
    MOV   AX,PIXEL[BX][DI]
    MUL   AX,AX
    ADD   SUM,AX

    SUB   JCOUNT,1
    JMP   L2

    SUB   ICOUNT,1
    JMP   L1

L0: MOV   AX,BOX_SZ
    MUL   AX,AX
    MOV   CX,AX
    MOV   AX,SUM
    DIV   CX

    MOV   NPOWER,CX

    POPA

    RET

FUNC_SF19           ENDP
```

Current Progress Overview:

- ✓ *SIMD compatibility of current feature functions*
- ➢ **D.7: Organized database of images (mammoDB/RIEDS)**
- D.8: Preliminary feature functions evaluation
- Discussions & Proposals
- Further work & Requirements

Experiment Documentation

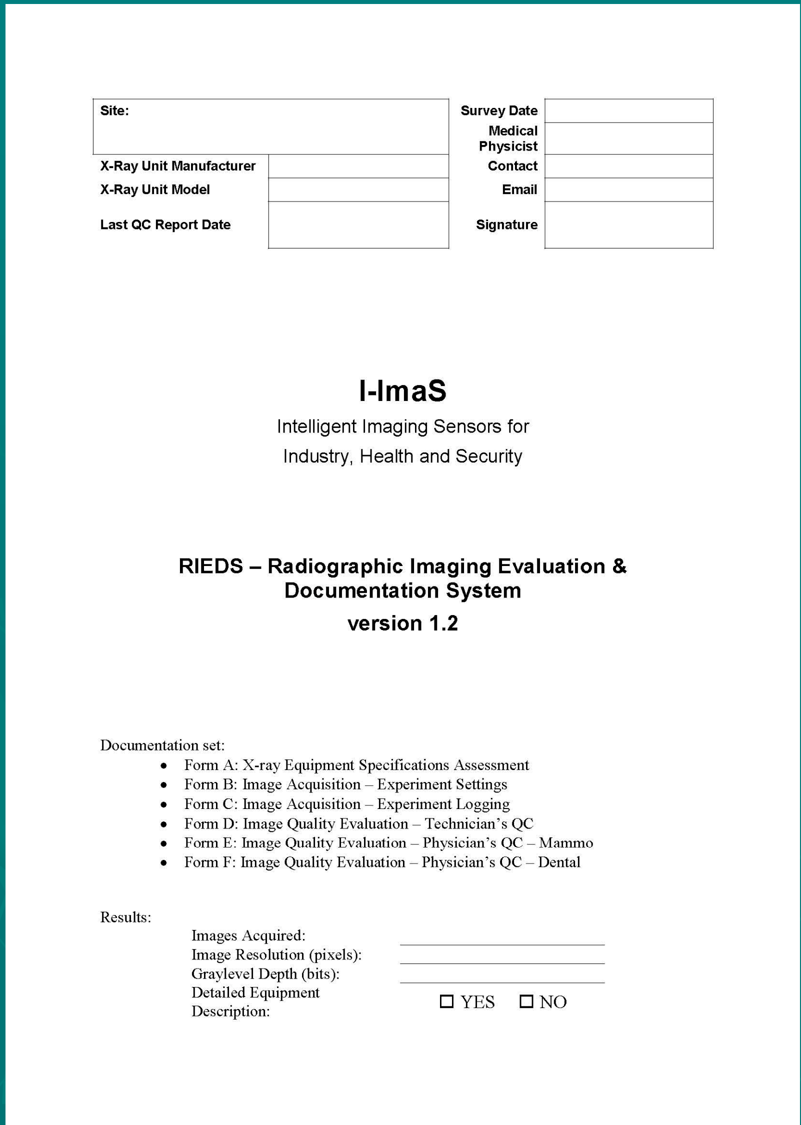
Basic Task:

- document mammographic device specifications
- document experiment settings and environment
- log experiment progress and image acquiring (samples)
- document technical aspects of image quality for each sample
- document clinical aspects of image quality for each sample

Reference Base:

- Mammographic device quality assessment reports
- List of technical aspects related to image quality (Technician's QC)
- List of clinical aspects related to image quality (Physician's QC)

RIEDS: Radiographic Imaging Evaluation & Documentation System [21,23]



Site:		Survey Date	
		Medical Physicist	
X-Ray Unit Manufacturer		Contact	
X-Ray Unit Model		Email	
Last QC Report Date		Signature	

I-ImaS

Intelligent Imaging Sensors for
Industry, Health and Security

RIEDS – Radiographic Imaging Evaluation & Documentation System

version 1.2

Documentation set:

- Form A: X-ray Equipment Specifications Assessment
- Form B: Image Acquisition – Experiment Settings
- Form C: Image Acquisition – Experiment Logging
- Form D: Image Quality Evaluation – Technician's QC
- Form E: Image Quality Evaluation – Physician's QC – Mammo
- Form F: Image Quality Evaluation – Physician's QC – Dental

Results:

Images Acquired: ____
Image Resolution (pixels): ____
Graylevel Depth (bits): ____
Detailed Equipment Description: ☐ YES ☐ NO

version 1.2:

- **Form A**: X-ray Equipment Specifications Assessment
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- **Form E**: Image Quality Evaluation – Physician's QC – Mammo
- **Form F**: Image Quality Evaluation – Physician's QC – Dental

Form F: Image Quality Evaluation – Physician's QC – Dental [23]

RIEDS /FORM F: Image Quality Evaluation – Physician's QC
Dental Template

Project ID[1]:		Target ID[3]:	
Machine ID[2]:		Experiment ID[4]:	
Site:		Survey Date	
		Medical Physicist	
Contact		Signature	
Email			

Test Set ID[5]: ______ Image ID[6]: ______

Image Quality Property	Scale										
	–5	–4	–3	–2	–1	0	+1	+2	+3	+4	+5
Typical Measurements											
Contrast Estimation											
Spatial Resolution Estimation											
Noise Estimation (%)											
Background / Tissue Discrimination											
Intraoral Elements											
Teeth Enamel and Dentine											
Caries Lesion											
Periodontal Lesions											
Periapical Lesions											
Bone											
Bone Lesions											
Soft Tissues											
Restoration Materials											
Overall Quality on Intraoral Elements											
Extraoral Elements											
Bone											
Teeth											
Soft Tissues											
Sharpness											
Slice Thickness											
Other: ______											
Overall Quality on Extraoral Elements											

Image Quality Properties (doctor's grading):

- Contrast Estimation (quality)
- Spatial Resolution Estimation (quality)
- Noise Estimation (%)
- Background / Tissue Discrimination

- Teeth Enamel and Dentine (intraoral)
- Caries Lesion (intraoral)
- Periodontal Lesions (intraoral)
- Periapical Lesions (intraoral)
- Bone (intraoral)
- Bone Lesions (intraoral)
- Soft Tissues (intraoral)
- Restoration Materials (intraoral)

- Bone (extraoral)
- Teeth (extraoral)
- Soft Tissues (extraoral)
- Sharpness (extraoral)
- Slice Thickness (extraoral)

D.7: Organized database of images (SINTEF)

- Need for electronic organization of image acquisition & evaluation
- Create a RIEDS-compatible database for image documentation
- Create electronic versions of RIEDS forms for electronic submission
- Full R-DBMS design for RIEDS data integrity & control

Proposed design:

✓ Use MS-Access, MS-Excel and Matlab as core platform
✓ Use hierarchical ID structure for unique image descriptors
✓ Use electronic version of RIEDS forms in MS-Excel format

Important Note:

- *Data are to be collected on-site using the electronic forms*
- *Filled forms are to be checked later by DB administrator for correctness & integrity before entered into the current database (2-phase "commit")*

Current Progress Overview:

- ✓ *SIMD compatibility of current feature functions*
- ✓ *D.7: Organized database of images (mammoDB/RIEDS)*
- ➢ **D.8: Preliminary feature functions evaluation**
- Discussions & Proposals
- Further work & Requirements

Preliminary Feature Functions Evaluation (D.8)

Basic Tasks [21]:

- Use simple textural feature functions to map image quality into quantitative measurements for sensor intelligence (feedback)
- Investigate the translation of the information signatures to a sequence of well-defined processing functions (Oct.2004)

D.8 report – Overview [23]:

- Web-based public mammographic image database (DB1)
- Experiment planning & documentation (RIEDS)
- Preliminary phantom image database (DB2)
- SimModel-1A: exposure simulation
- PredModel-1A: texture features extraction
- PredModel-1B: feature quality evaluation versus exposure

SimModel-1A: Exposure simulation

Basic Task:

- Formulate a realistic theoretical model for simulating manual exposure configurations using optimal exposure images.
- Apply simulation model in all (optimal) mammographic images to create simulated (sub-optimal) images (DB1).
- Validate simulation results (DB1) using real phantom images at various exposure configurations (DB2).
- use base set of **20** images, generate **21** exposure simulation for each one, calculate **20** features over **3** box sizes (10, 25, 50), calculate feature **mean** and **stdev** values.

Model Design (parameters):

- Rx : Radiation Exposure
- OD : Optical Density of X-ray projected subject
- GL : Gray Value of (digital) sensors
- GI : Greylevel of pixels in the resulting image

SimModel-1A: 4-phase model implementation

F1:
kVp: [25…29] , mAs: [50…200]
Rx : [0,0128…4,000] mGy

$$Rx: f_1(kVp, mAs) = C_{1,1} \cdot \log_{10}\{(kVp)^2 \cdot (mAs)\} + C_{1,0}$$

$$C_{1,0} = -0{,}897021103$$

$$C_{1,1} = 0{,}000029114$$

F2:
Rx : [0,0128…4,000] mGy
OD: [0,04…3,60]

$$OD : f_2(Rx) = C_{2,1} \cdot \log_{10}(Rx) + C_{2,0}$$

$$C_{2,0} = 2{,}740896827$$

$$C_{2,1} = 1{,}426939483$$

F3:
OD: [0,04 …3,60]
GL: [495 …4069]

$$GL : f_3(OD) = (OD - C_{3,0}) \cdot {}^{1}\!/_{C_{3,1}}$$

$$C_{3,0} = 4{,}093060996$$

$$C_{3,1} = -0{,}000996083$$

F4:
GL: [4095 …0]
GI: [0 …255]

$$GI : F_4(GL) = C_{4,1} \cdot (GL) + C_{4,0}$$

$$C_{4,0} = 255$$

$$C_{4,1} = -0{,}062271062$$

SimModel-1A: Processing

FULL SIMULATION PROCEDURE:

1. $Input: \{kVp(0), mAs(0)\}, \{image(0)_{x,y}\}, \{kVp(z), mAs(z)\}$

2. $$\left.\begin{array}{l}\{kVp(0), mAs(0)\} \xrightarrow{f1} [Rx(0)] \\ \{kVp(z), mAs(z)\} \xrightarrow{f1} [Rx(z)]\end{array}\right\} \Rightarrow r = \frac{Rx(z)}{Rx(0)}$$

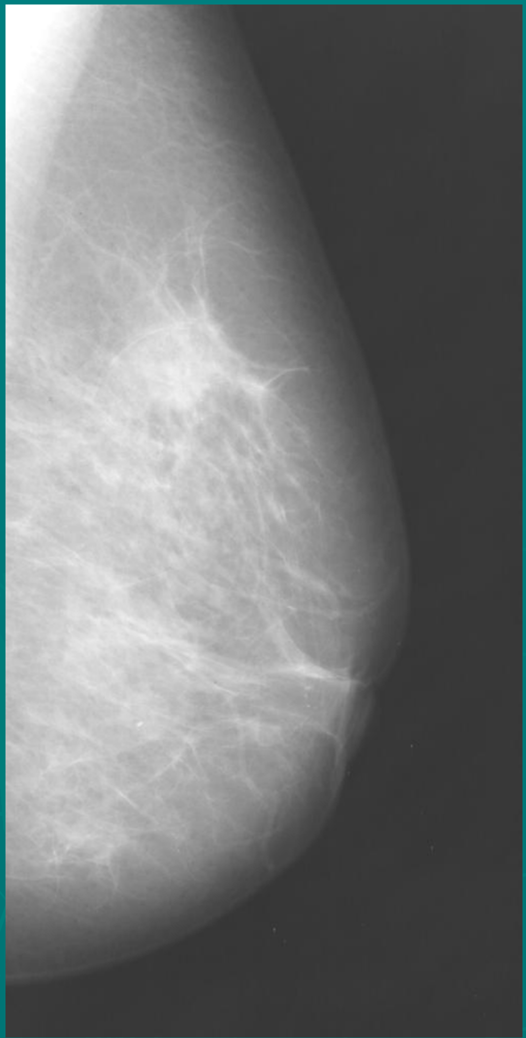
3. $\{image(0)_{x,y}\} \longrightarrow GI(0)_{x,y} \xrightarrow{f_4^{-1}} GL(0)_{x,y} \xrightarrow{f_3^{-1}} OD(0)_{x,y} \xrightarrow{f_2^{-1}} Rx(0)_{x,y}$

4. $Rx(z)_{x,y} = \frac{Rx(0)_{x,y}}{r}$

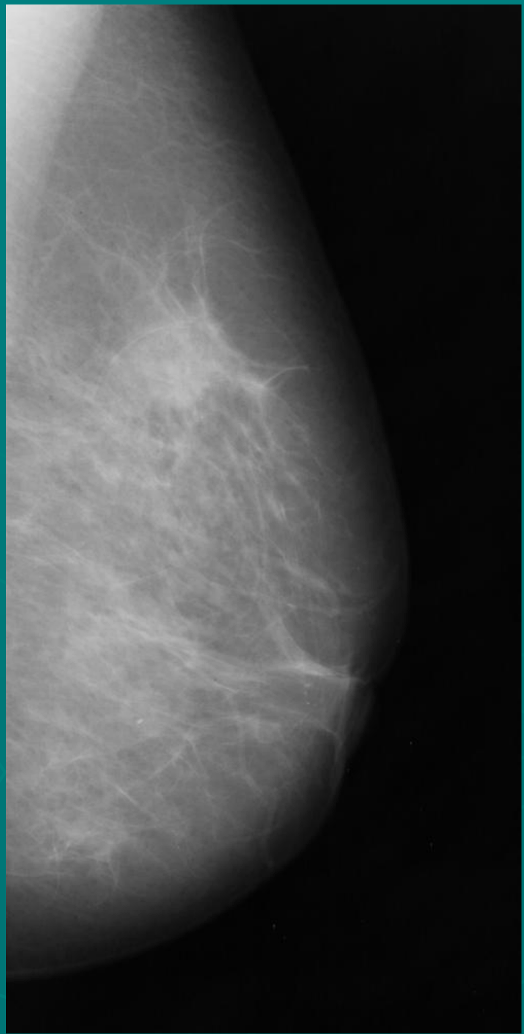
5. $Rx(z)_{x,y} \xrightarrow{f_2} GL(z)_{x,y} \xrightarrow{f_3} GI(z)_{x,y} \longrightarrow \{image(z)_{x,y}\}$

6. $Output: \{image(z)_{x,y}\}$

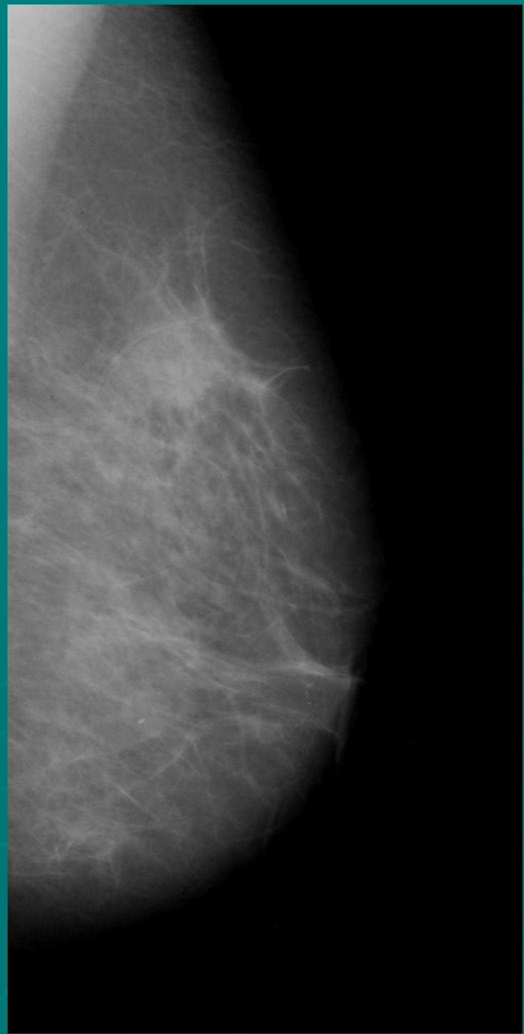
SimModel-1A: simulation example from DB1



sim.#1: 25 kVp / 75 mAs



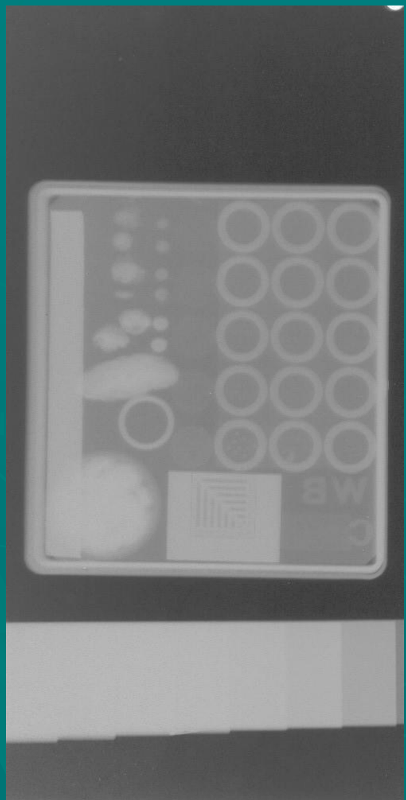
init: 27 kVp / 125 mAs



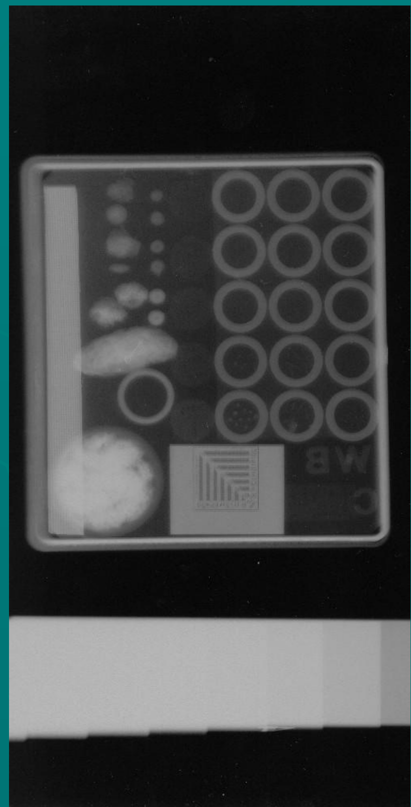
sim.#2: 29 kVp / 200 mAs

SimModel-1A: Validation & Verification example from DB2

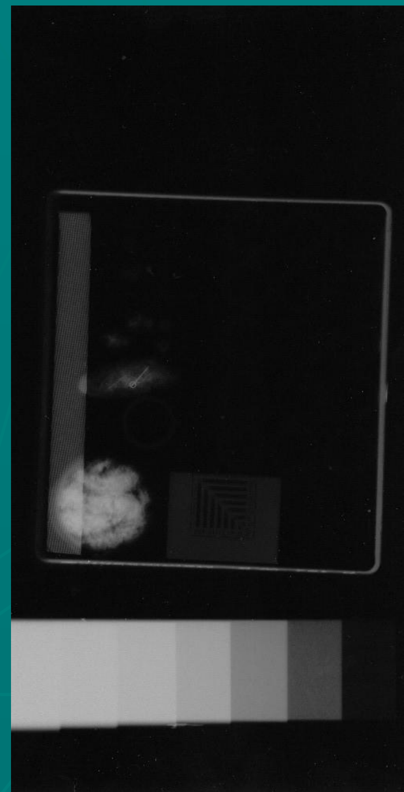
Real experimental phantom images included in DB2:



cfg.F2: 23 kVp / 4 mAs



cfg.A1: 26 kVp / 4 mAs



cfg.G2: 30 kVp / 4 mAs

PredModel-1A: Texture Features Extraction

Basic Task [20]:

- Formulate a set of content-rich textural feature function, well-suited for mammographic image analysis.
- Use only first-order statistics or functions of low computational complexity
- Apply complete set of feature functions over all the available images (real + simulated) and construct analytical profiles.

Model Design (specifications):

- Apply progressive image scanning on x-axis
- Average calculated feature values per scanning “column”
- Produce simple 1-D transition curves for each feature function

Min value:

$$I_{\min} = \min_{XY}\{I(x,y)\}$$

Max value:

$$I_{\max} = \max_{XY}\{I(x,y)\}$$

Mean value:

$$\mu = \frac{1}{XY}\sum_{i=1}^{X}\sum_{j=1}^{Y} I(x,y)$$

Standard Deviation:

$$\sigma = \sqrt{\frac{1}{(XY-1)}\sum_{i=1}^{X}\sum_{j=1}^{Y}\left(I(x,y)-\mu\right)^2}$$

Skewness:

$$sk = \frac{1}{XY}\sum_{i=1}^{X}\sum_{j=1}^{Y}\left(\frac{I(x,y)-\mu}{\sigma}\right)^3$$

Kurtosis:

$$kr = \left(\frac{1}{XY}\sum_{i=1}^{X}\sum_{j=1}^{Y}\left(\frac{I(x,y)-\mu}{\sigma}\right)^4\right) - 3$$

Signal Power:

$$P_{XY} = \sum_{i=1}^{X}\sum_{j=1}^{Y}\left\|I(x,y)\right\|^2$$

Entropy:

$$E = \sum_{k=1}^{100} P_{Ghist(k)} \cdot \log(P_{Ghist(k)})$$

Zero-Crossings count:

$$ZC = \sum\{k : (I_k(x,y)-\mu)\cdot(I_{k+1}(x,y)-\mu) \leq 0\}$$

Surface:

$$S_{XY} = \sum_{i=1}^{X-1}\sum_{j=1}^{Y-1}\left(I(x,y)+1+\left\|I(x+1,y)-I(x,y)\right\|+\left\|I(x,y+1)-I(x,y)\right\|\right)$$

Volume:

$$V_{XY} = \sum_{i=1}^{X} \sum_{j=1}^{Y} I(x, y)$$

Synth.Feature-12:

$$SF_{12} = \frac{(I_{\max} - I_{\min})^2}{\mu}$$

Synth.Feature-13:

$$SF_{13} = \frac{\mu - I_{\min}}{I_{\max} - I_{\min}}$$

Synth.Feature-14:

$$SF_{14} = \frac{\mu}{\sigma}$$

Synth.Feature-15:

$$SF_{15} = \frac{P_{XY}}{\mu^2}$$

Synth.Feature-16:

$$SF_{16} = \frac{\sqrt{S_{XY}}}{\sqrt[3]{V_{XY}}}$$

Synth.Feature-17:

$$SF_{17} = \frac{S_{XY}}{\mathrm{XY}}$$

Synth.Feature-18:

$$SF_{18} = \frac{ZC}{XY}$$

Synth.Feature-19:

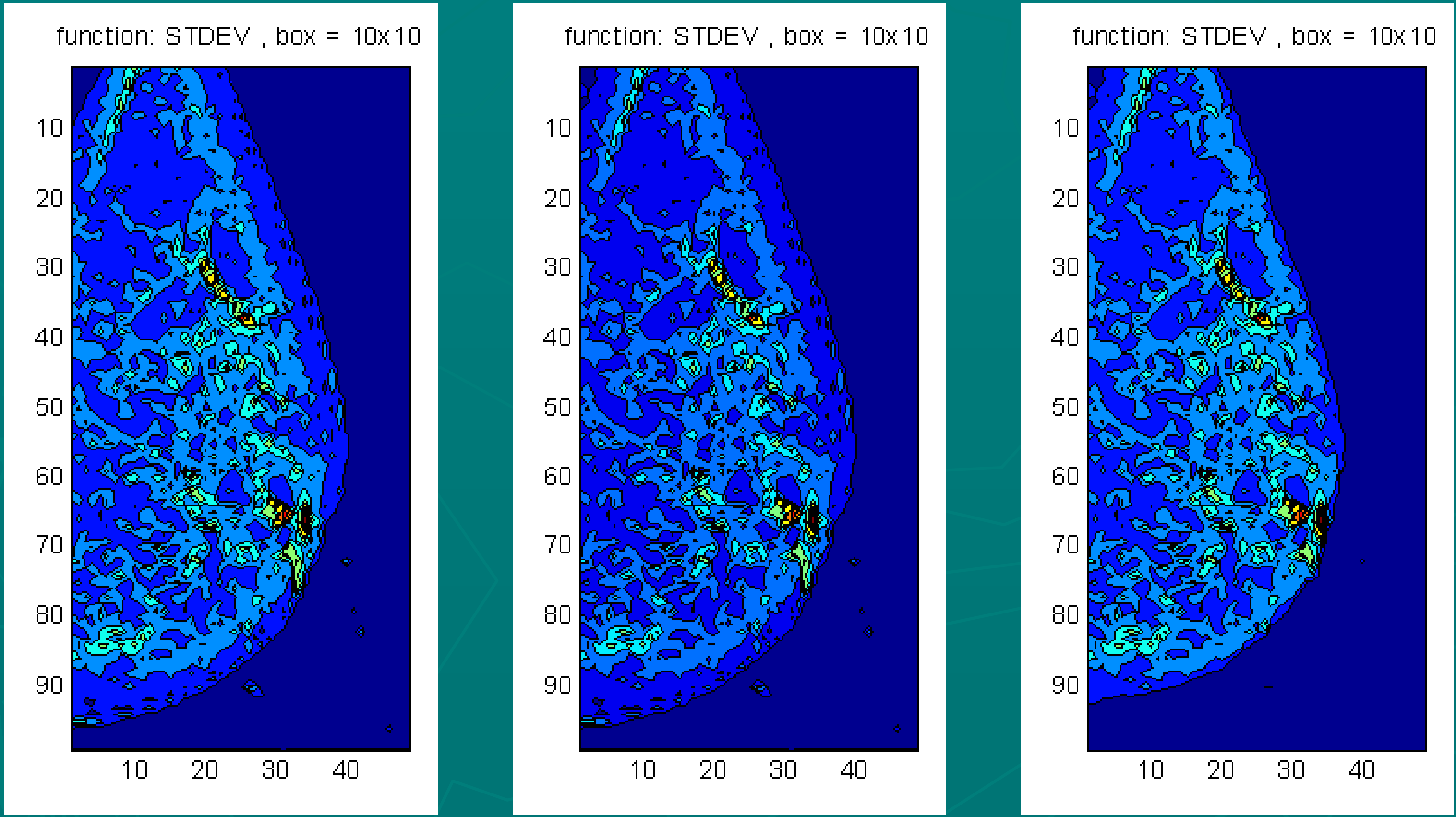
$$SF_{19} = \frac{P_{XY}}{XY}$$

Synth.Feature-20:

$$SF_{20} = \log\left(1 - \frac{SF_{19}}{255^2}\right)$$

PredModel-1A: Intermediate 2-D results (example)

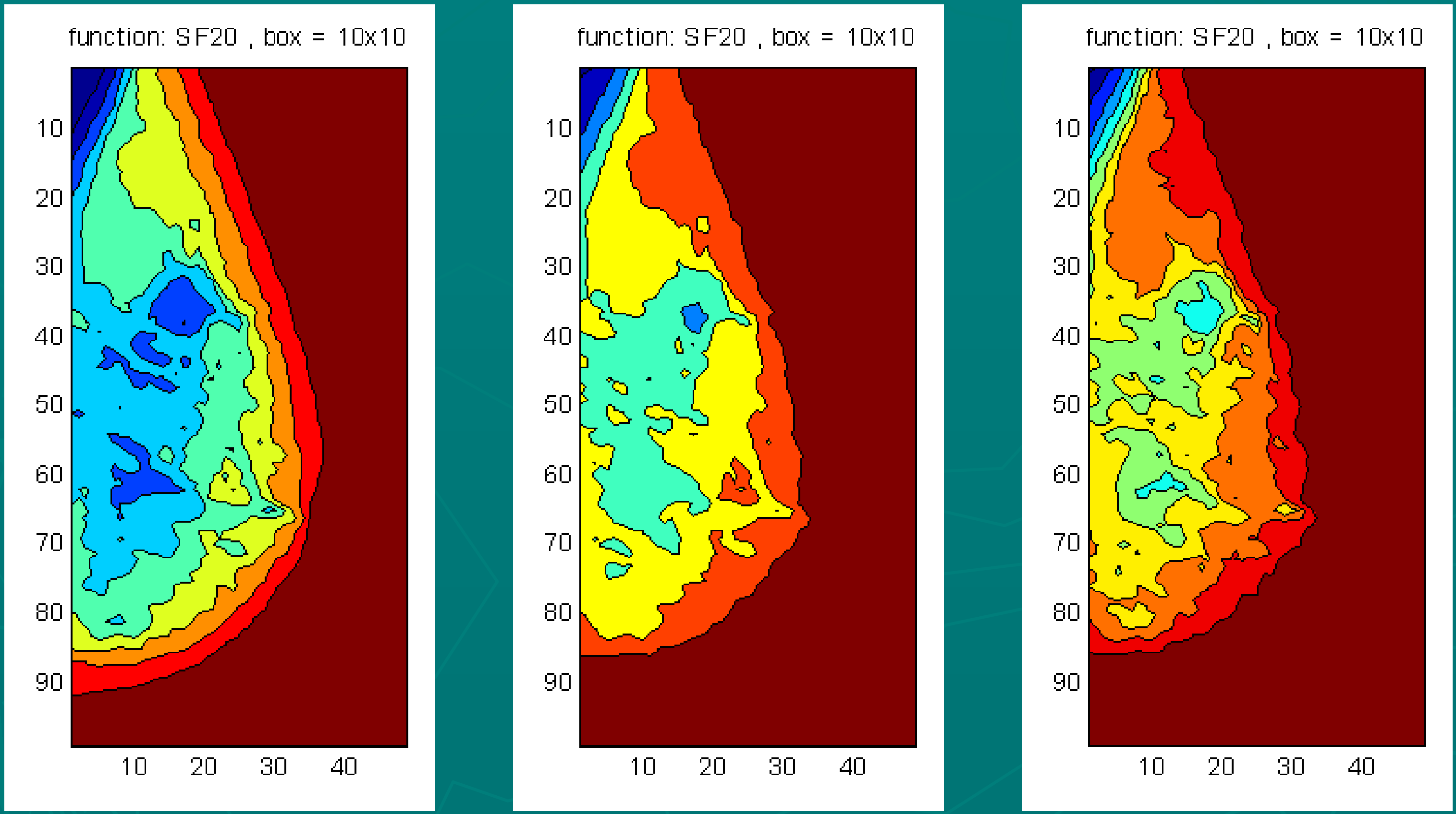
Function: F04 (STDEV) / boxsize: 10



sim.#1: 25 kVp / 75 mAs **init:** 27 kVp / 125 mAs **cfg.2:** 29 kVp / 200 mAs

PredModel-1A: Intermediate 2-D results (example)

Function: SF20 (Synthetic) / boxsize: 10



sim.#1: 25 kVp / 75 mAs | **init:** 27 kVp / 125 mAs | **cfg.2:** 29 kVp / 200 mAs

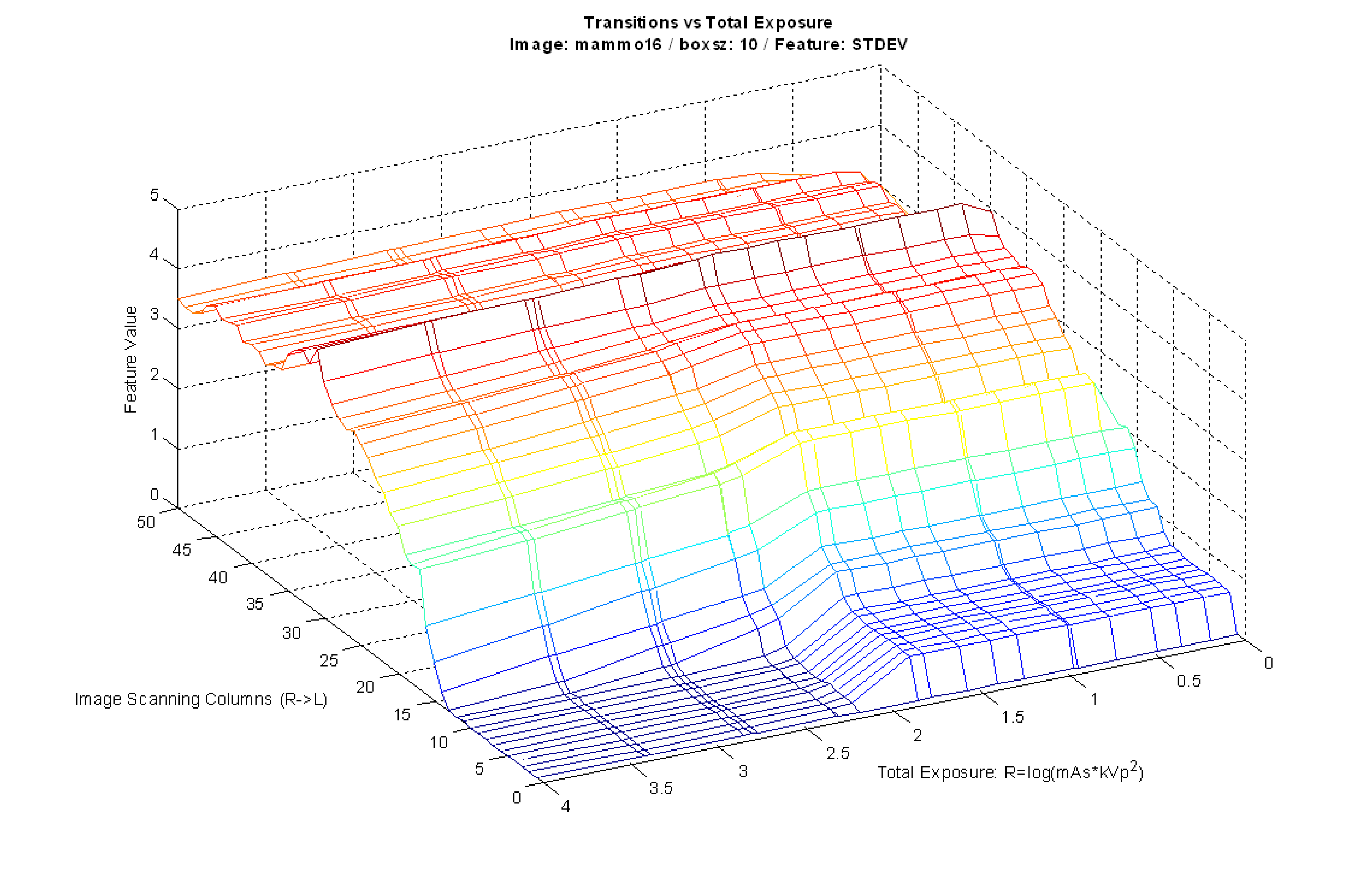
PredModel-1B: Texture Features Evaluation

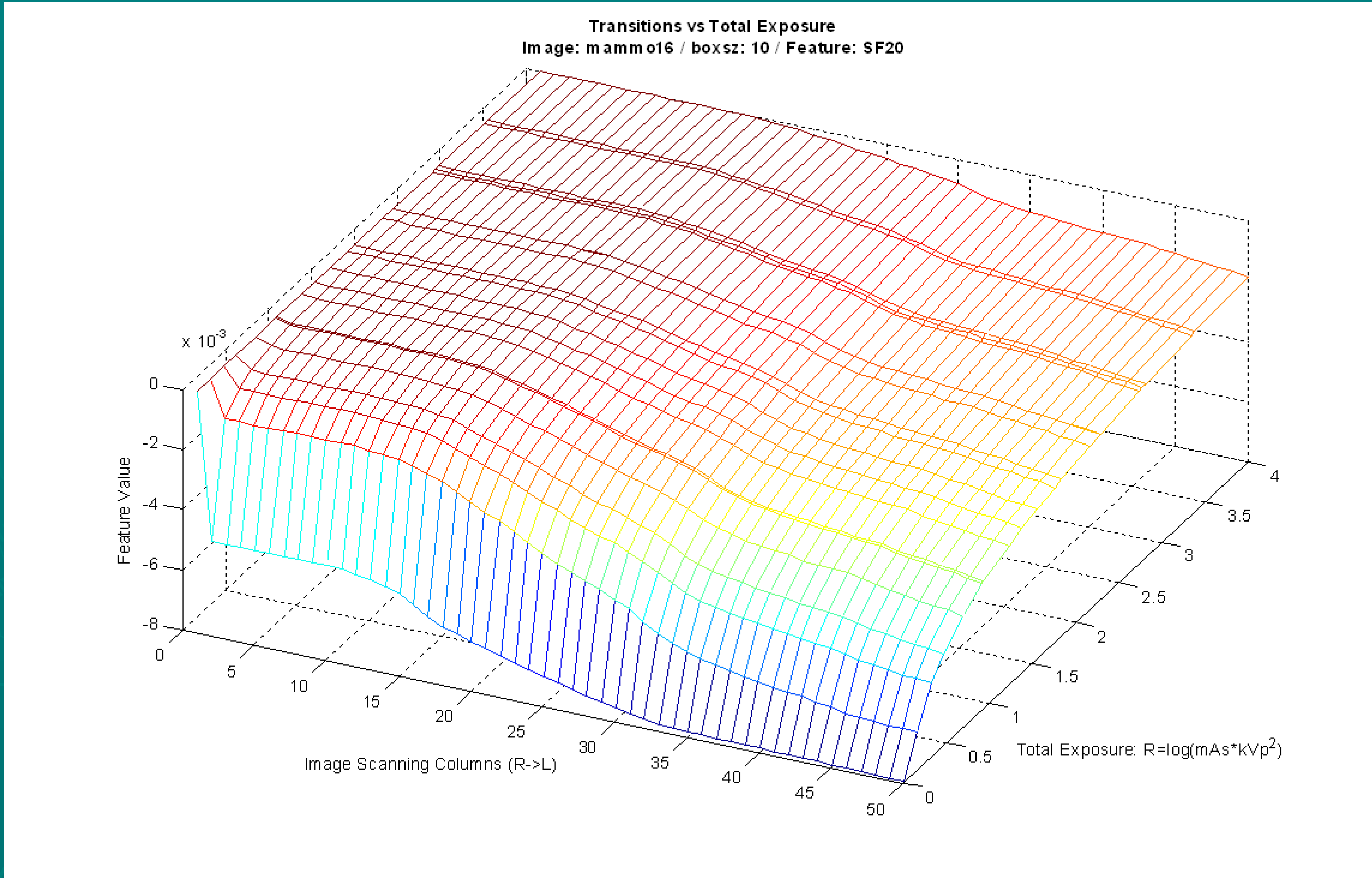
Basic Task:

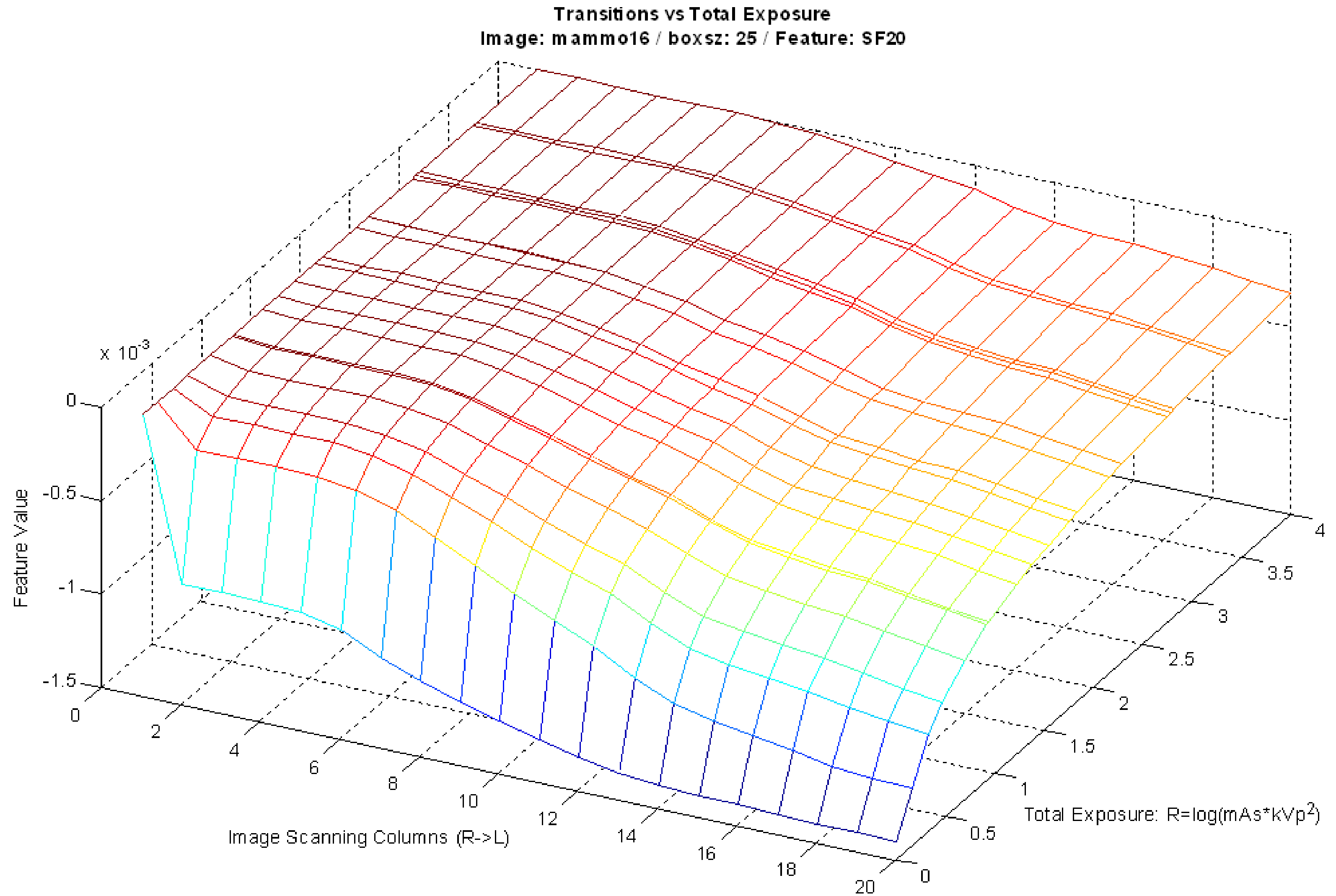
- Investigate feature results from PredModel-1A.
- Identify features with smooth & consistent behavior over the entire mammographic image set.
- Identify features with smooth & consistent behavior over the entire range of exposure settings.

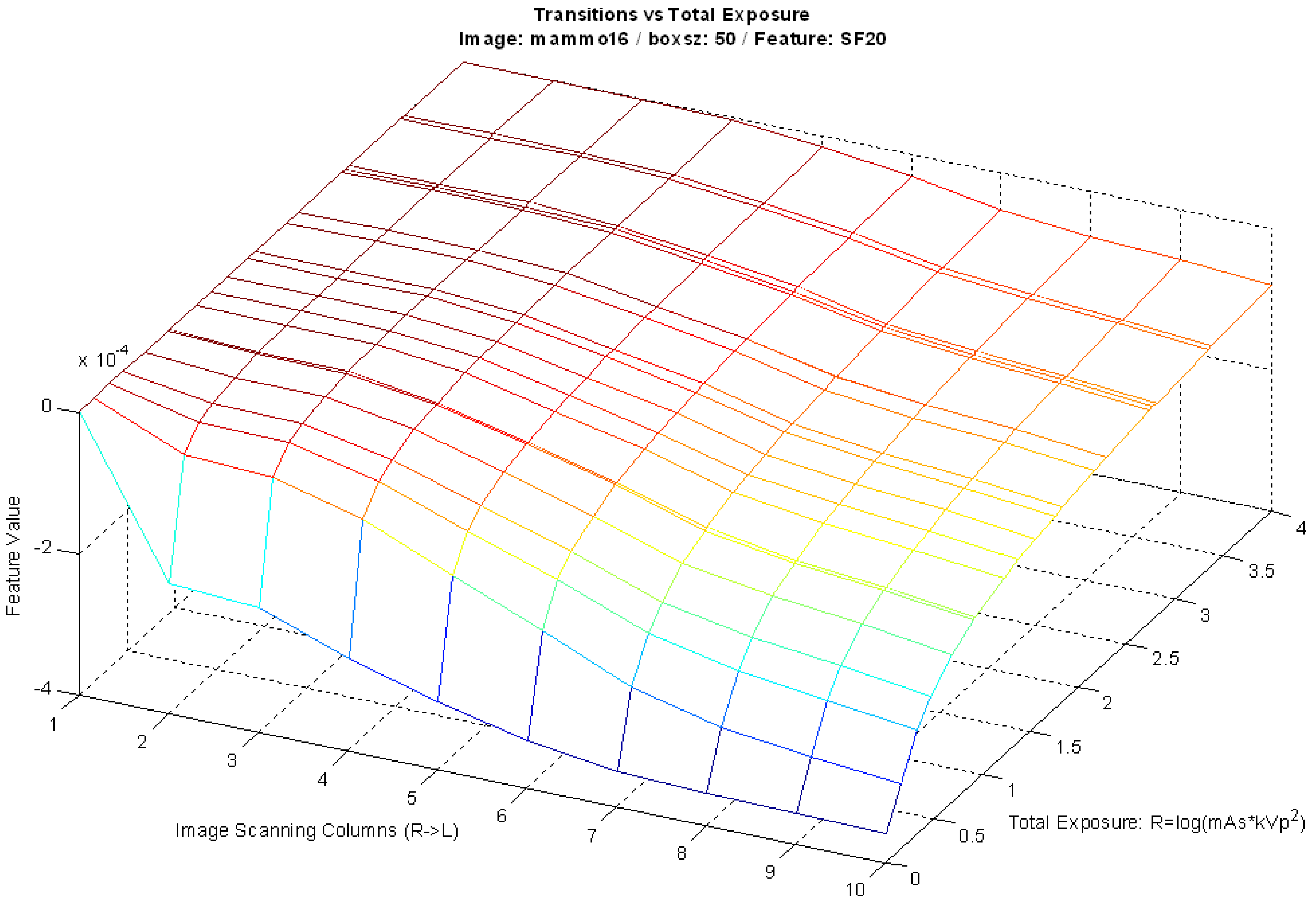
Model Design (specifications):

- Analyze feature functions behavior versus exposure.
- Conduct visual evaluation for preliminary selection.
- Investigate both exposure effects and breast tissue detection.


Transitions vs Total Exposure
Image: mammo16 / boxsz: 10 / Feature: STDEV
Feature Value
5
4
3
2
1
0
Image Scanning Columns (R->L)
50
45
40
35
30
25
20
15
10
5
0
Total Exposure: R=log(mAs*kVp2)
4
3.5
3
2.5
2
1.5
1
0.5
0


Transitions vs Total Exposure
Image: mammo16 / boxsz: 10 / Feature: SF20
x 10^-3
0
-2
-4
-6
-8
Feature Value
0
5
10
15
20
25
30
35
40
45
50
Image Scanning Columns (R->L)
0
0.5
1
1.5
2
2.5
3
3.5
4
Total Exposure: R=log(mAs*kVp^2)


Transitions vs Total Exposure
Image: mammo16 / boxsz: 25 / Feature: SF20
x 10-3
Feature Value
0
-0.5
-1
-1.5
0
2
4
6
8
10
12
14
16
18
20
Image Scanning Columns (R->L)
0
0.5
1
1.5
2
2.5
3
3.5
4
Total Exposure: R=log(mAs*kVp2)


Transitions vs Total Exposure
Image: mammo16 / boxsz: 50 / Feature: SF20
x 10^-4
0
-2
-4
Feature Value
1
2
3
4
5
6
7
8
9
10
Image Scanning Columns (R->L)
0
0.5
1
1.5
2
2.5
3
3.5
4
Total Exposure: R=log(mAs*kVp^2)

PredModel-1B: Feature evaluation for boxsize=10

BOX=10	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	SF12	SF13	SF14	SF15	SF16	SF17	SF18	SF19	SF20	Sum
Mammo_01																					0
Mammo_02																					0
Mammo_03		√																			1
Mammo_04										√							√				2
Mammo_05	√																			√	2
Mammo_06	√	√	√								√								√	√	6
Mammo_07	√	√	√				√				√								√	√	7
Mammo_08	√	√	√				√				√		√						√		7
Mammo_09	√	√	√							√	√						√		√		7
Mammo_10	√	√	√				√				√		√						√	√	8
Mammo_11	√	√	√				√				√						√		√	√	8
Mammo_12	√																√				2
Mammo_13	√	√	√				√				√		√						√	√	8
Mammo_14										√							√				2
Mammo_15	√	√	√				√				√		√						√		7
Mammo_16	√	√	√				√				√								√	√	7
Mammo_17		√	√				√				√						√		√		6
Mammo_18	√						√				√								√	√	5
Mammo_19	√																			√	2
Mammo_20	√	√	√				√				√								√	√	7
Sum	14	12	11	0	0	0	10	0	0	3	12	0	4	0	0	0	6	0	12	10	

PredModel-1B: Feature evaluation for boxsize=25

BOX=25	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	SF12	SF13	SF14	SF15	SF16	SF17	SF18	SF19	SF20	Sum
Mammo_01																					0
Mammo_02																					0
Mammo_03																				√	1
Mammo_04										√							√				2
Mammo_05	√		√				√				√								√	√	6
Mammo_06	√	√	√				√				√								√	√	7
Mammo_07	√	√	√				√				√								√	√	7
Mammo_08	√	√	√				√				√								√		6
Mammo_09	√	√	√				√			√	√						√		√		8
Mammo_10	√	√	√				√				√								√	√	7
Mammo_11	√	√	√				√			√	√		√						√	√	9
Mammo_12																				√	1
Mammo_13	√	√	√				√				√								√	√	7
Mammo_14										√							√				2
Mammo_15	√	√	√				√			√	√		√						√		8
Mammo_16	√	√	√				√			√	√						√		√	√	9
Mammo_17	√	√	√				√				√								√		6
Mammo_18	√	√	√				√				√								√	√	7
Mammo_19											√									√	2
Mammo_20	√	√	√				√				√								√	√	7
Sum	13	12	11	0	0	0	13	0	0	6	14	0	2	0	0	0	4	0	13	12	

PredModel-1B: Feature evaluation for boxsize=50

BOX=50	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	SF12	SF13	SF14	SF15	SF16	SF17	SF18	SF19	SF20	Sum
Mammo_01	√		√				√												√		4
Mammo_02																					0
Mammo_03	√	√																	√	√	3
Mammo_04										√	√						√			√	4
Mammo_05	√	√	√				√				√								√	√	7
Mammo_06	√	√	√				√				√								√	√	7
Mammo_07	√	√	√				√				√								√	√	7
Mammo_08	√	√	√				√				√								√	√	7
Mammo_09	√	√	√				√			√	√						√		√	√	9
Mammo_10	√	√	√				√				√								√	√	7
Mammo_11	√	√	√				√				√								√	√	7
Mammo_12	√										√									√	3
Mammo_13	√	√	√				√				√								√	√	7
Mammo_14											√										1
Mammo_15	√	√	√				√			√	√						√		√	√	9
Mammo_16	√	√	√				√			√	√								√	√	8
Mammo_17	√	√	√				√				√								√		6
Mammo_18	√	√	√				√				√								√	√	7
Mammo_19	√	√	√				√				√								√	√	7
Mammo_20	√	√	√				√				√								√	√	7
Sum	17	14	15	0	0	0	15	0	0	4	17	0	0	0	0	0	3	0	16	10	

PredModel-1B: Preliminary Assessment

Best feature functions:

- F01: “MIN”
- F02: “MAX”
- F03: “MEAN”
- F07: “POWER”
- F11: “VOLUME”
- SF19: (normalized power)
- SF20: (normalized exposure)

Local features combination:

- Averaging over the “column”
- Unbiased over partial results

SIMD compatibility:

- Segment “columns” into data blocks
- Almost entirely localized calculations

Basic Conclusions:

- Averaging partial feature values over “columns” produce unbiased results.
- Most feature functions can be calculated directly over the entire “column”.
- Best features relate to sums over pixel values or squared pixel values.
- Larger box sizes produce more consistent results.
- Processing complexity grows proportionally with <u>number of pixels in the box</u>.
- First order statistics can also be used successfully for breast tissue detection.

Current Progress Overview:

- ✓ *SIMD compatibility of current feature functions*
- ✓ *D.7: Organized database of images (mammoDB/RIEDS)*
- ✓ *D.8: Preliminary feature functions evaluation*
- ➢ **Discussions & Proposals**
- Further work & Requirements

Discussions & Proposals (WP3):

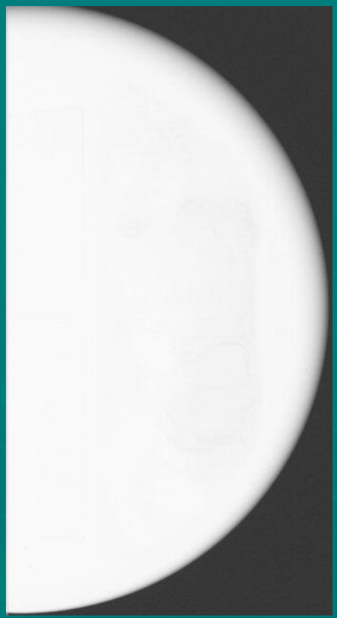
On test phantom images from Siemens Mammomat B system (**UCL**):

- 127 μm resolution
- 4,5cm standard UK compressed breast phantom
- acquired 42 images at [28...40] kVp and [5...100] mAs
- resulting images of (cropped) size 770x1440x16bit ".raw" format

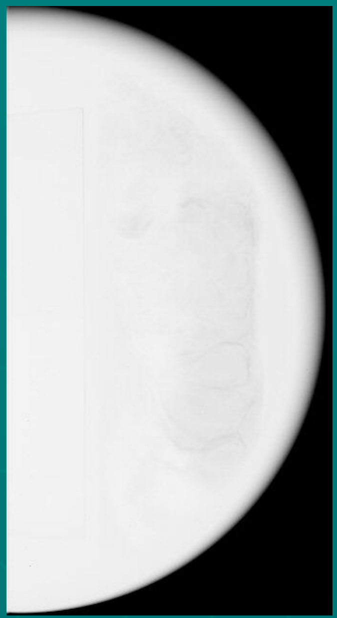
Overall quality assessment of B-phantom image sets:

- Tissue areas are underexposed, even at very high kVp/mAs settings
- kVp settings over 30 are unrealistic for mammographic purposes
- Phantom may be too "thick" or source-detector distance too large
- Phantom should be adjusted for ranges around: [26...28] kVp , [46...168] mAs
- final images must be converted to 8-bit for display purposes (evaluation)

B-phantom test images – Overview



cfg.1: 28 kVp / 16 mAs

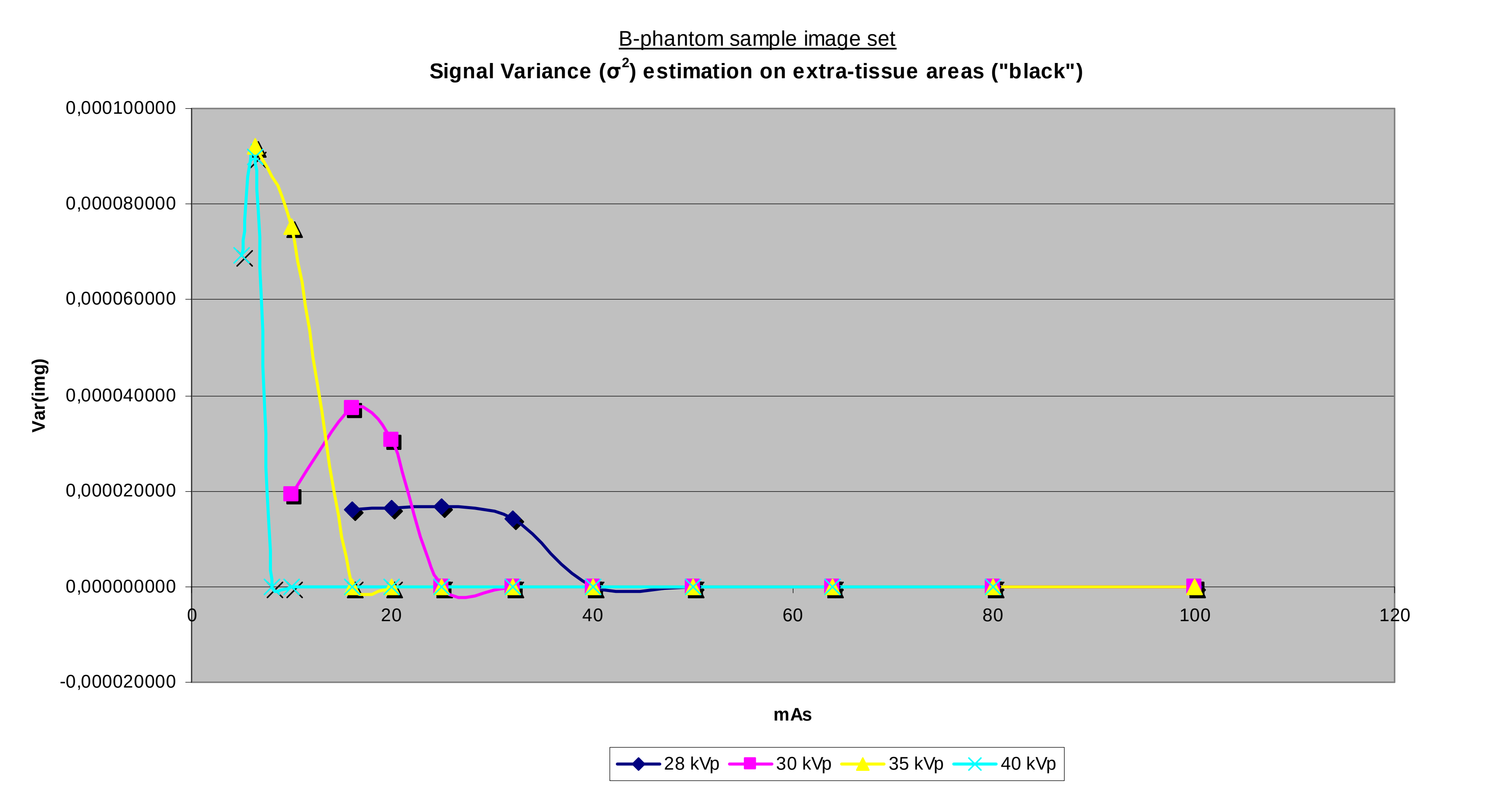


cfg.2: 30 kVp / 40 mAs

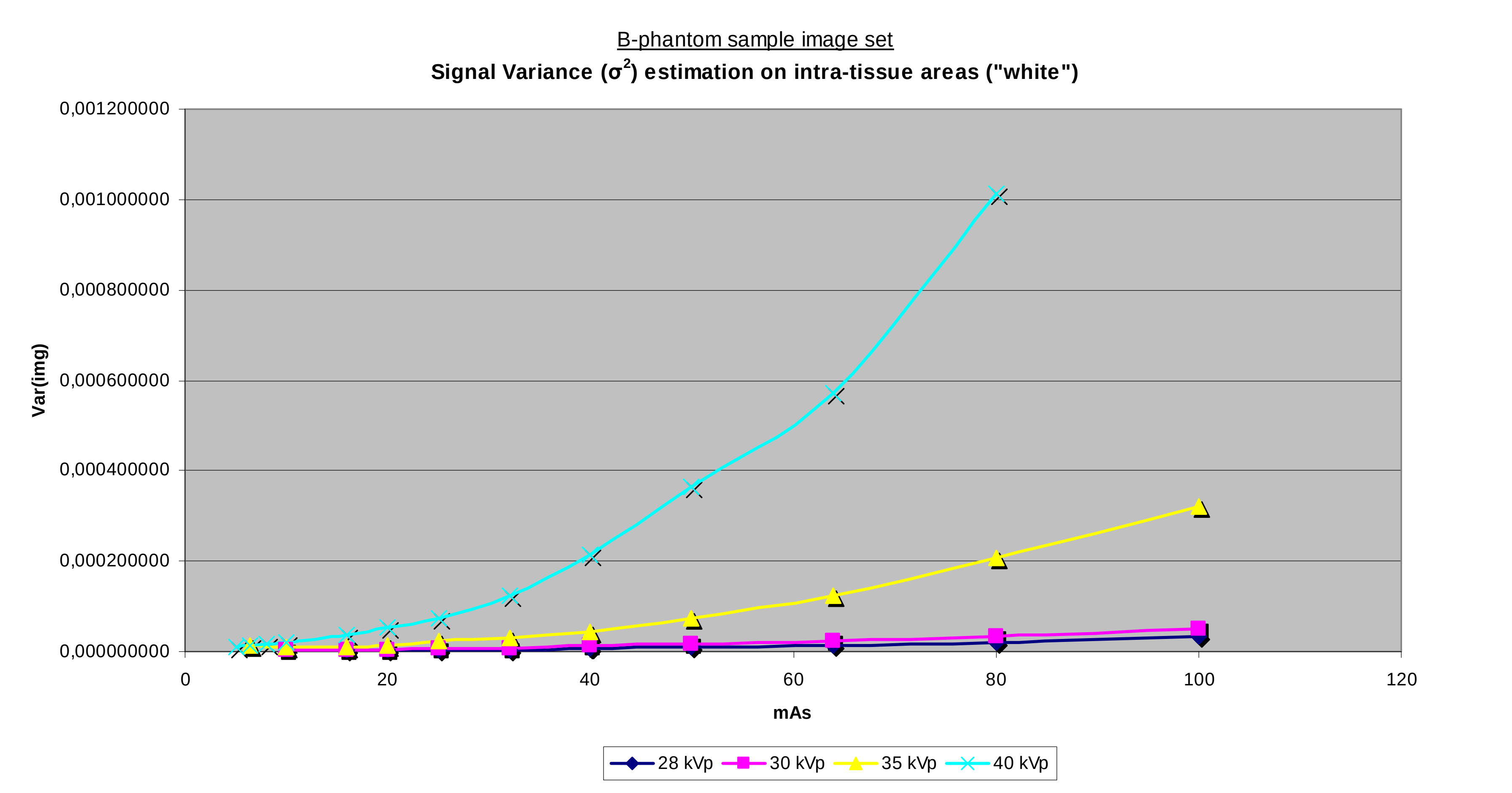
cfg.3: 35 kVp / 64 mAs

cfg.4: 40 kVp / 80 mAs

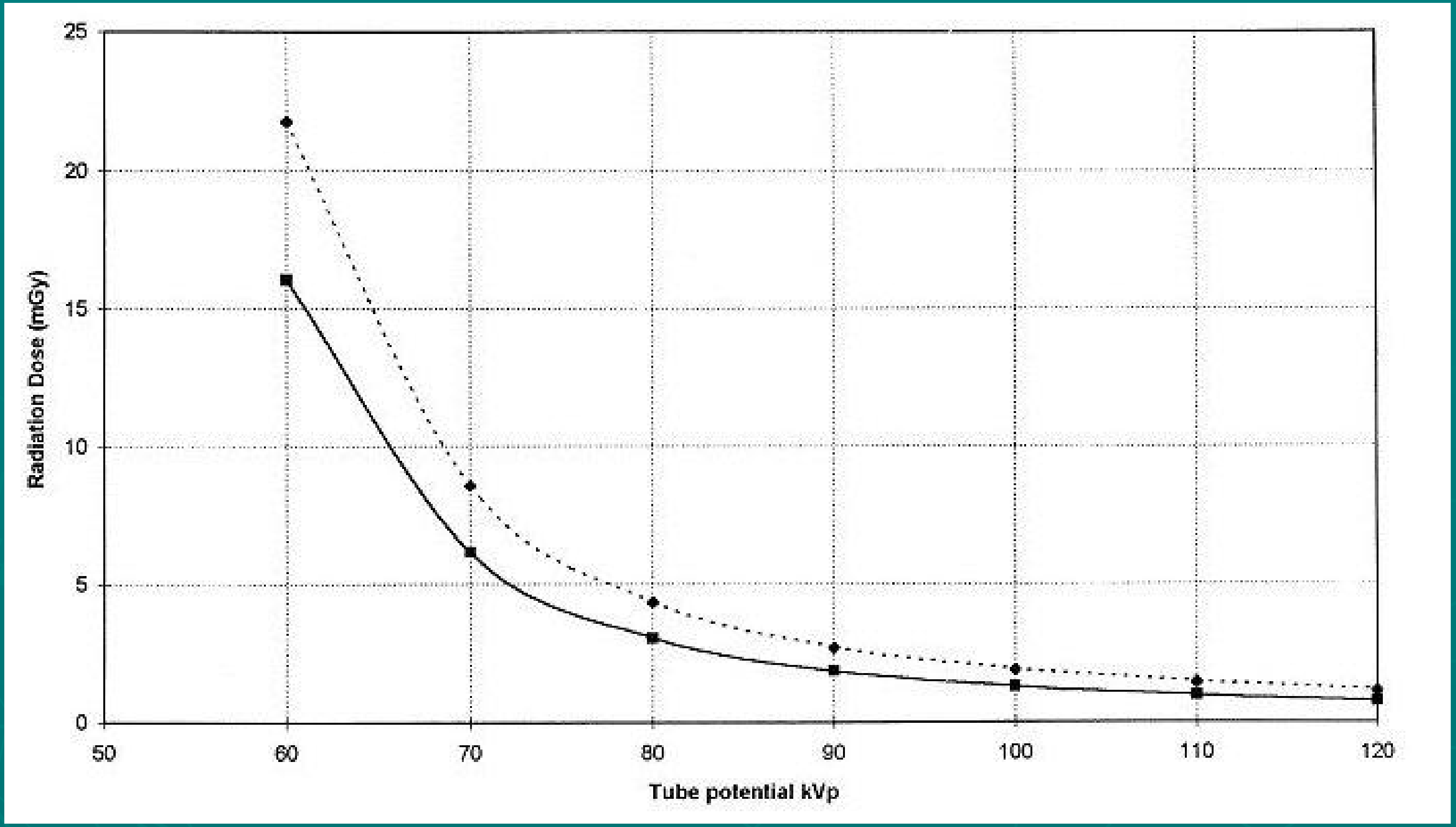
B-phantom test images – Signal variance outside phantom



B-phantom test images – Signal variance inside phantom

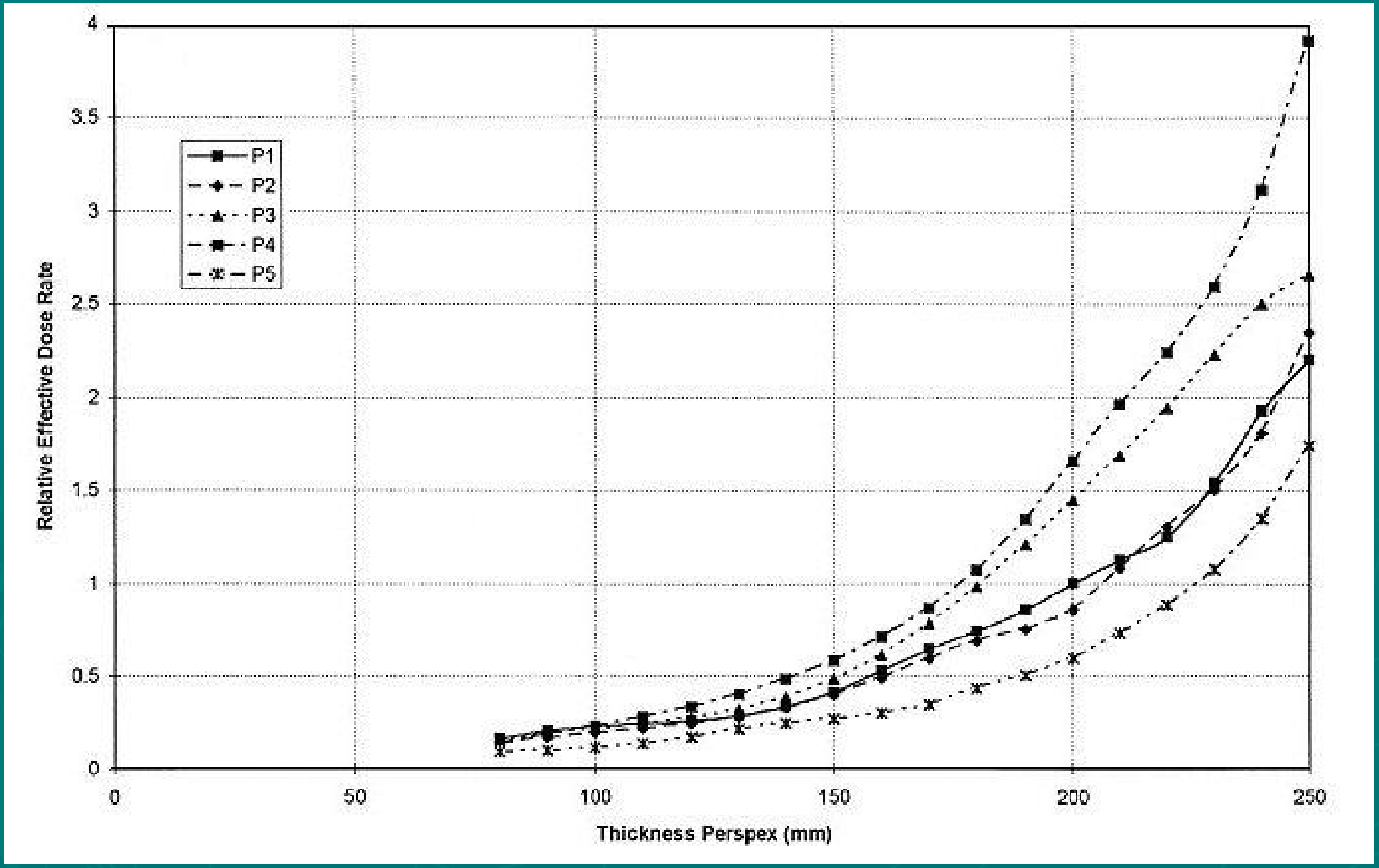


Exposure profiles: Patient dose vs kVp (abdomen)



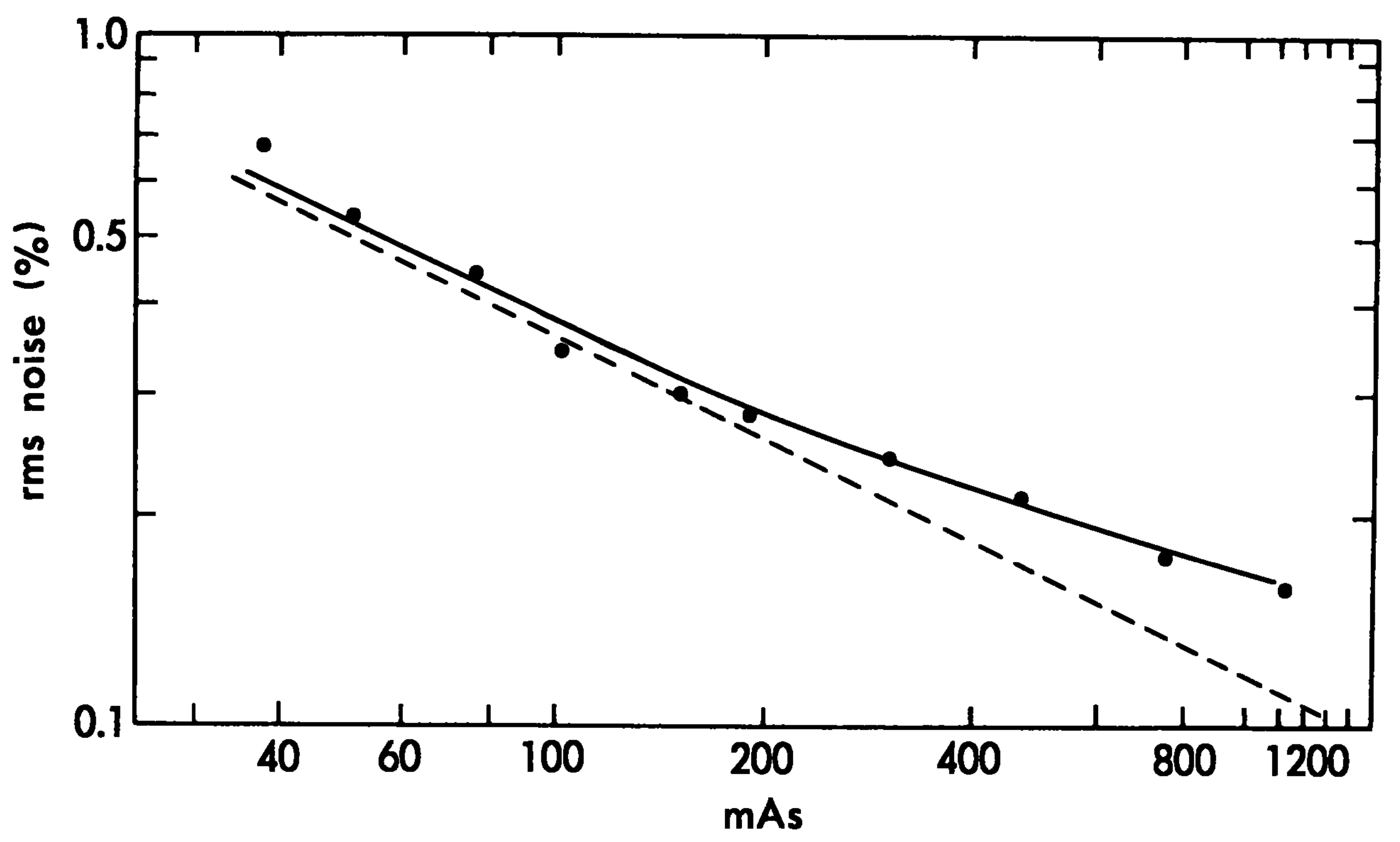
Incident air kerma (solid) and entrance surface dose (dashed) for an abdomen AP radiograph on a conventional X-ray machine [11].

Exposure profiles: Patient dose vs thickness (stomach)



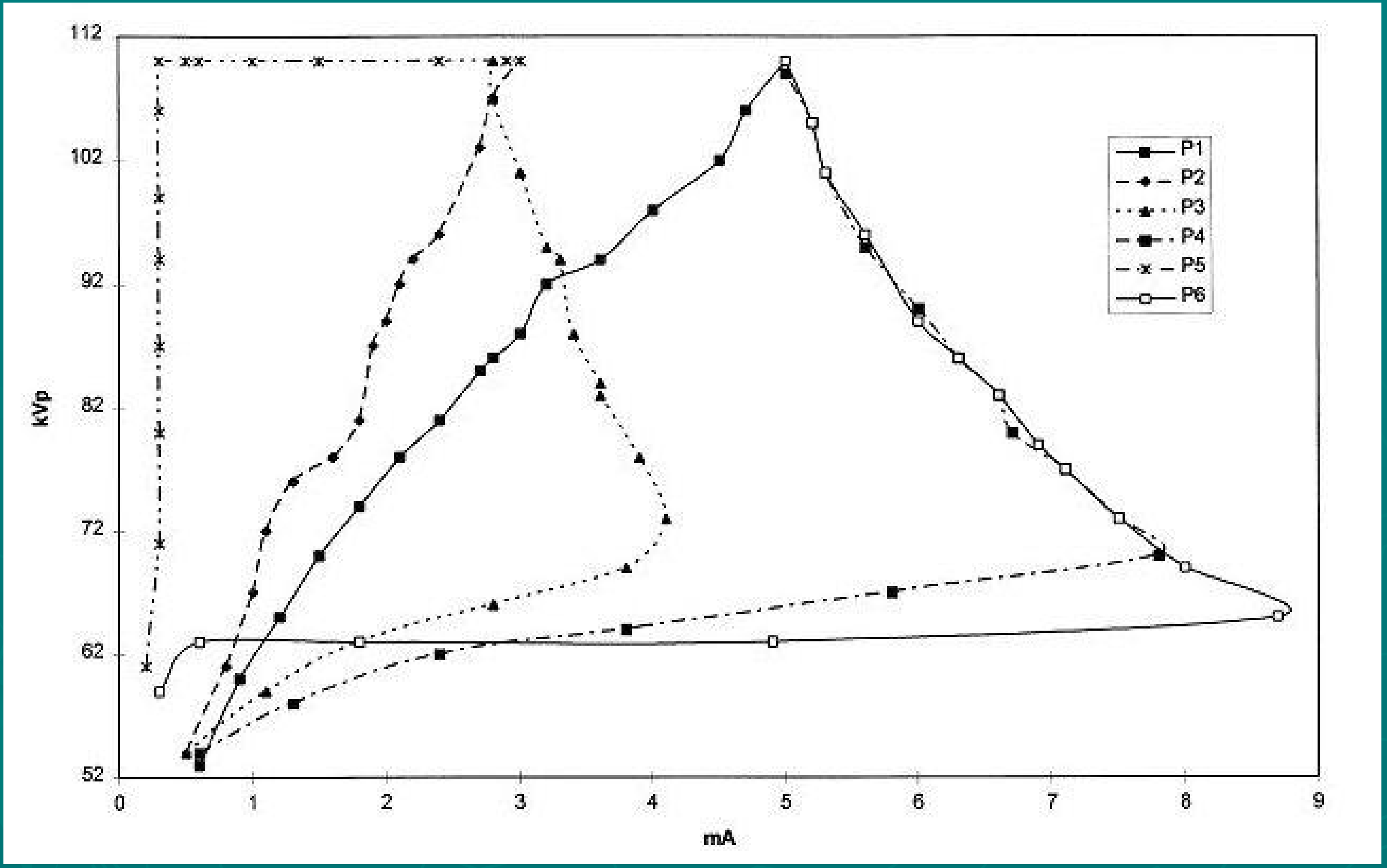
Relative patient effective dose for a stomach examination at various standard exposure profiles on a conventional X-ray machine [11].

Exposure profiles: rms noise vs mAs (CT)



The statistically expected (dashed) and true measured rms(%) noise dependence on exposure, for the GE CT/T 8800 scanner [22].

Exposure profiles: Standard AERC curves (fluoroscopic)



Standard kVp/mAs exposure profiles (AERC) for a modern fluoroscopic unit **[11]**.
P1: std 5 mA, P2: std 3 mA, P3: 4 mA high contrast, P4: 8 mA high contrast, P5: “paediatric”, P6: “iodine”

Discussions & Proposals (WP3):

On image evaluation procedure for available radiologists (**SINTEF**):

- *"Can we use dual image acquisition, one with Mammomat (UCL) for image processing tasks and one with some standard digital mammographic system for clinical evaluation tasks?"*
- *"Can optimal exposure parameters be locally defined (by the radiologist) at various areas of the same image?"*

Preliminary assessment:

- Using dual image acquisition for different tasks is risky in terms of statistical integrity, especially when display parameters vary between the two images
- Optimal exposure evaluation in terms of clinical findings depends on combining features from the complete image. Thus, the radiologist has to evaluate the same, complete image as the textural feature functions do, using the same information content and resolution.

Discussions & Proposals (WP3):

On using synchrotron images within the current design (**UoT**):

- *"Can we use synchrotron images as basis for the current work on image processing for sensor intelligence?"*
- *"If the model is adjusted so that keV is used instead of kVp and mGy instead of mAs, does the design changes radically?"*

Preliminary assessment:

- Having data from multiple sources of statistically significant differences does not permit robust and sound textural analysis.
- Due to the intrinsic value of synchrotron images and the compatibility of the proposed model, further research on this area is very promising.

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- ✓ *Discussions & Proposals*
- ➢ **Further work & Requirements**

Further Progress Requirements (WP3):

1. Finalize choices on mammographic/dental equipment and subjects (phantoms and tissue samples), designating **optimal conditions and settings** for image acquisition experiments that closely match the performance of the final system.

2. Calibrate **target properties and absorption settings**, in order to provide a test subject that produces realistic imaging results for operational ranges that are typically used in clinical practice, as well as a preconfigured embedded test pattern, in order to measure global signal attributes (noise%, SR, etc).

3. Perform all the necessary image acquisition experiments in order to create a new, thoroughly documented, **mammographic & dental image database** that will be used as a solid base for further analysis (**DB3**).

4. Perform extensive **image quality assessment** surveys for all the mammographic & dental images in the created image database (DB3), using existing RIEDS documentation templates for adding annotative clinical evaluations for all the available cases.

5. Investigate **alternative approaches and levels of providing intelligence** in the sensor/imaging system through the application of sophisticated image processing.

Current Progress Overview:

- ✓ *SIMD compatibility of current feature functions*
- ✓ *D.7: Organized database of images (mammoDB/RIEDS)*
- ✓ *D.8: Preliminary feature functions evaluation*
- ✓ *Discussions & Proposals*
- ✓ *Further work & Requirements*

For further details on description of work and current status, see: **[21]** and **[23]** ➔

Suggestive References:

[11] *C.J.Martin, D.G.Sutton, P.F.Sharp*, "Balancing patient dose and image quality", *Applied Radiation and Isotopes*, 50 (1999) pp.1-19.

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[20] *S.Theodoridis, D.Cavouras, H.Georgiou,* "I-ImaS: Preliminary Analysis Report and Proposed Design", *Dept. of Informatics & Telecomm., Univ. of Athens, Greece,* Mar.2004.

[21] *I-ImaS, Workpackage 3*, "Update on current progress and preliminary results for the on-chip processing", *presentation for 2nd I-ImaS meeting, Amsterdam, 26-27 May*, 2004.

[22] *G.Cohen, F.DiBianca,* Figure on rms noise dependence on exposure for the GE CT/T 8800 scanner, *J. Comput. Assist. Tomogr.*, 3:189-195, 1979.

[23] *I-ImaS, Workpackage 3 – Deliverable D.8*, "Translating information signatures to a sequence of well-defined processing functions", Oct.2004.