

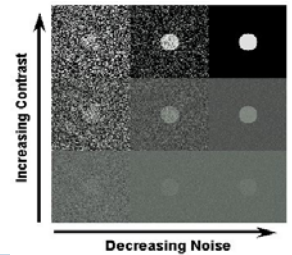
Sentinel teaching course on digital mammography

Optimisation of exposure settings in digital mammography

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Things affecting visibility of objects

- Size
- Contrast
- Noise (from different sources)



Optimisation



- Image quality should be good enough.
- How to evaluate it?
 - physical measurement
 - clinical measurement
- What is good enough?
- Risk to the patient should be as low as reasonably achievable.
- How to evaluate it?
- In mammography the mean glandular dose (MGD) is a proper parameter.

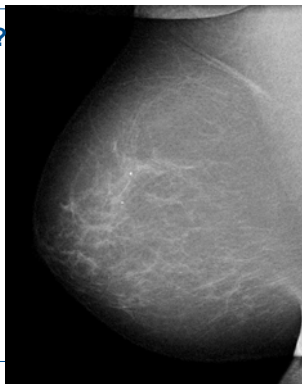
Exposure parameters

- Anode (Mo, Rh, W...)
- Filter (Mo, Rh, Al...)
- Tube voltage (kV)
- Dose or tube loading (mAs)

What do we want to see?

Lesions in mammography:

- Masses
- Calcifications
 - (macro calcifications)
 - micro calcifications
- Status is evaluated based on shape and size of the lesions.



Exposure parameters

- Anode (Mo, Rh, W...) => contrast, (resolution)
- Filter (Mo, Rh, Al...) => contrast
- Tube voltage (kV) => contrast
- Dose or tube loading (mAs) => noise
- The intrinsic spatial resolution cannot be improved by optimal selection of these parameters. So we can only adjust contrast and noise.

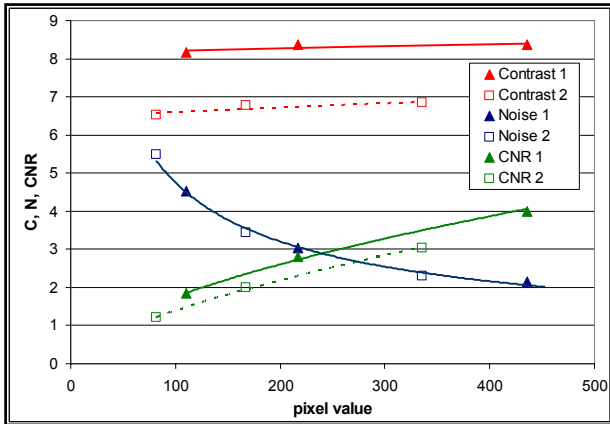
CNR, contrast to noise ratio

- In digital image contrast can be adjusted but then also noise is changing so better parameter is CNR.
- Tells how good the contrast is compared to the noise.

$$CNR = \frac{Mean(B) - Mean(S)}{\sqrt{\frac{SD(B)^2 + SD(S)^2}{2}}}$$

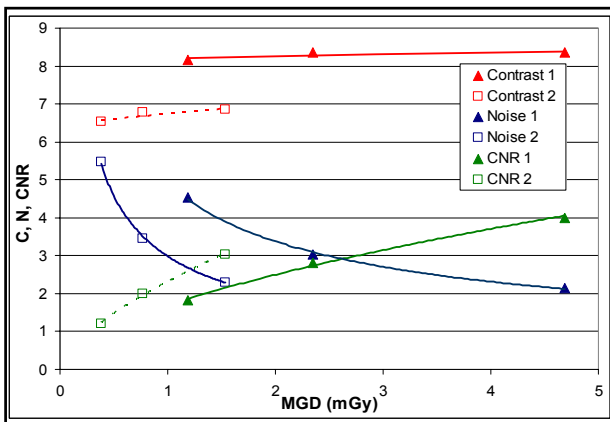
S= signal
B= background

How to do the measurements?



Images without post processing

- Optimise the effective use of radiation.
- Image quality => information from the patient
- Post processing (PP) can't increase information from the patient but it can be loosed or changed.
- Exposure parameters should be optimised without PP to avoid problems.
- PP should be adjusted separately (without adjusting exposure parameters simultaneously).

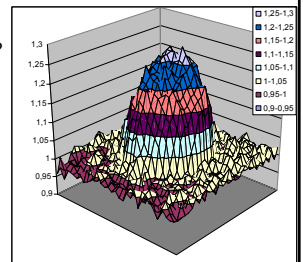


Optimisation using clinical image

Many questions:

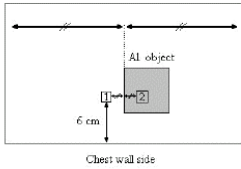
- One target, different exposures?
- Different target:
 - Different background
 - Different size of the target
- How and what to measure?

$$CNR = \frac{Mean(B) - Mean(S)}{\sqrt{\frac{SD(B)^2 + SD(S)^2}{2}}}$$



Optimisation using a phantom

- PMMA simulating breast?
- Aluminium simulating calcification?
- Optimisation for calcifications => optimisation for masses?



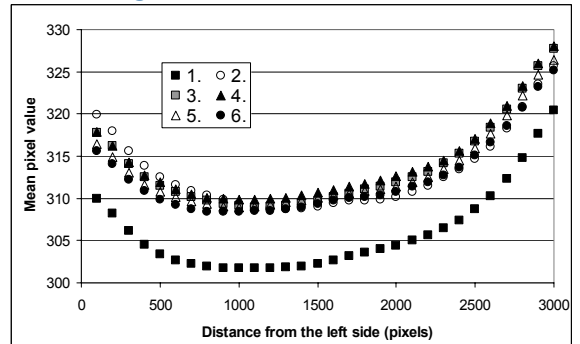
$$CNR = \frac{Mean(B) - Mean(AI)}{\sqrt{\frac{SD(B)^2 + SD(AI)^2}{2}}}$$

AI= aluminium, signal
B= background

Fig. 2.1 Position of the aluminium filter for the CNR measurement

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Background measurements



PMMA simulating breast

- Different thicknesses to cover the whole range of breast thicknesses should be used.
- Simulating only glandularity of 50 %.
- No anatomical noise included.

Background measurements

- The inhomogeneity:
 - stronger in the vertical than in the horizontal line
 - different for different thickness and for different radiation quality.
- The changes between separate exposures (3 %) are larger than the variations (1 %) within the central part (6 cm of horizontal line) of an image.
- Background should be measured from the same image and near to the place where signal is measured.

Background measurements

- In theory, the background should be taken "under" the aluminium sheet from the same place as the signal is measured.
- In practice there is two possibilities for background measurements:
 - from the same place as the signal is measured but from different images.
 - from same image but from different place.
- Even if flat field correction is done by the system, the response is not totally flat.

Aluminium sheets

- Thickness
 - not so important.
 - 0,1 - 0,2 mm Al gives attenuation near to value from micro calcifications.
 - With 0,2 mm a better contrast is achieved (recommended also in Euref protocol).
- Size
 - large or small sheet?
- Placement
 - In the middle (6 cm from the chest wall)



Exposure parameters for testing

- Selected radiation qualities (anode, filter and tube voltage) wanted to be tested.
- At least 3 different dose or tube loading (mAs) for same radiation quality should be used.

Study of Pöyry, Zanca, Bosmans et.al 2006

Table 1. PMMA thickness (cm) used for different radiation qualities

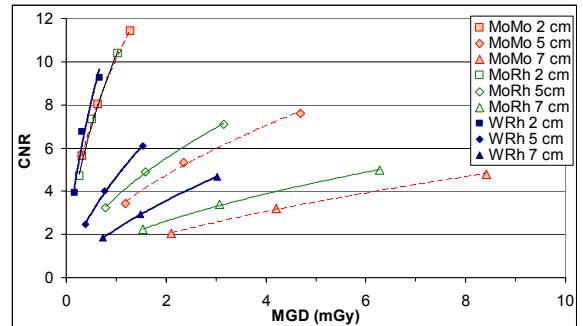
Tube Voltage (kV)	Anode-filter		
	Mo-Mo	Mo-Rh	W-Rh
23	2-4	2-4	2-4
24	2	2	2-4
25	2-4	2-4	2-4
26	2-4-5	2-4-5	2-4-5-6-7
27	2-4-5-6-7	2-4-5-6-7	2-4-5-6-7
28	2-4-5-6-7	4-5-6-7	2-4-5-6-7
29	5-6-7	4-5-6-7	2-4-5-6-7
30	2-4-5-6-7	2-5	2-4-5-6-7
31			4-5-6-7
32	4-5-6-7	4-5-6-7	4-5-6-7
33			4-5-6-7
34			4-5-6-7
35		4-5-6-7	4-5-6-7

Study of Young et.al

pers. communication. Subm. To BJR 2006

- 2 systems: Fuji Profect and GE Senographe 2000D.
- 4 different radiation qualities: 25 kV Mo/Mo, 28 kV Mo/Mo, 30 kV Mo/Rh and 34 kV Rh/Rh.
- PMMA blocks with a total thickness: 20 - 70 mm.
- An aluminium square (10 mm x 10 mm) with a 0.2 mm thickness was placed on top of the 20 mm thick block, with one edge on the midline and 6 cm from the chest wall edge.

Optimisation measurements for Siemens Novation, Leuven 2005 - 2006



Study of Young et.al

Pers. communication. Subm. to BJR (2006)

- The optimal beam quality selection was similar for the two systems.
- For breasts with a thickness of 21 or 32 mm either a tube voltage of 25kV or 28 kV and a Mo/Mo target/filter combination was optimal.
- For breast thicknesses of 45 mm and greater, the kV/target/filter combination that had the highest x-ray energy (34 kV Rh/Rh) was optimal.

What image quality (CNR) is enough?

- Comparison to the CDMAM measurements.
- Comparison of clinical and physical study.
 - CNR measurements from clinical images and comparison with the visibility study.
 - CNR measurements from AI measurements and comparison with the visibility study from clinical images.
- Effect of post processing in clinical images?
- CNR values from different systems are not comparable.

Thank you !

Kiitos!