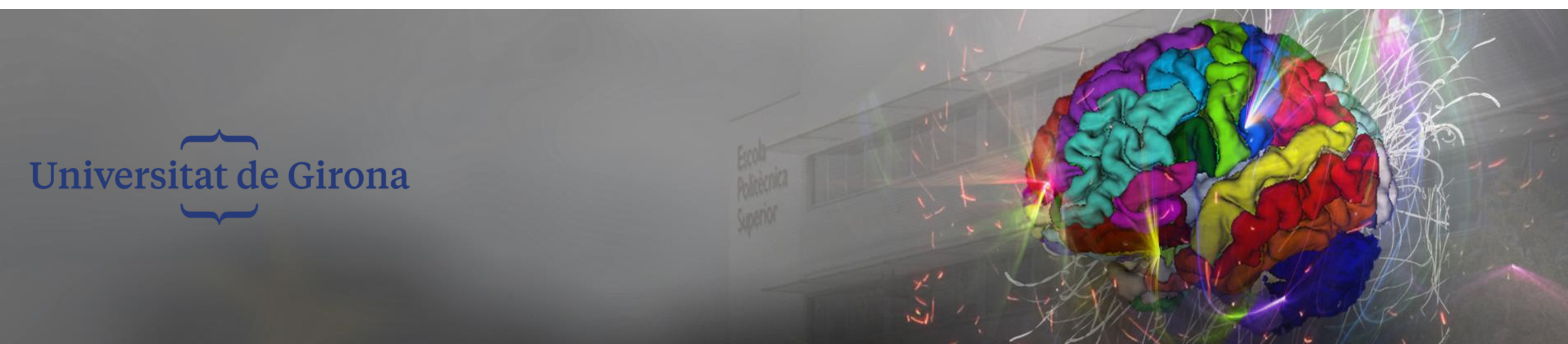
MAIA

E-Health Visualization

Robert Martí

robert.marti@udg.edu

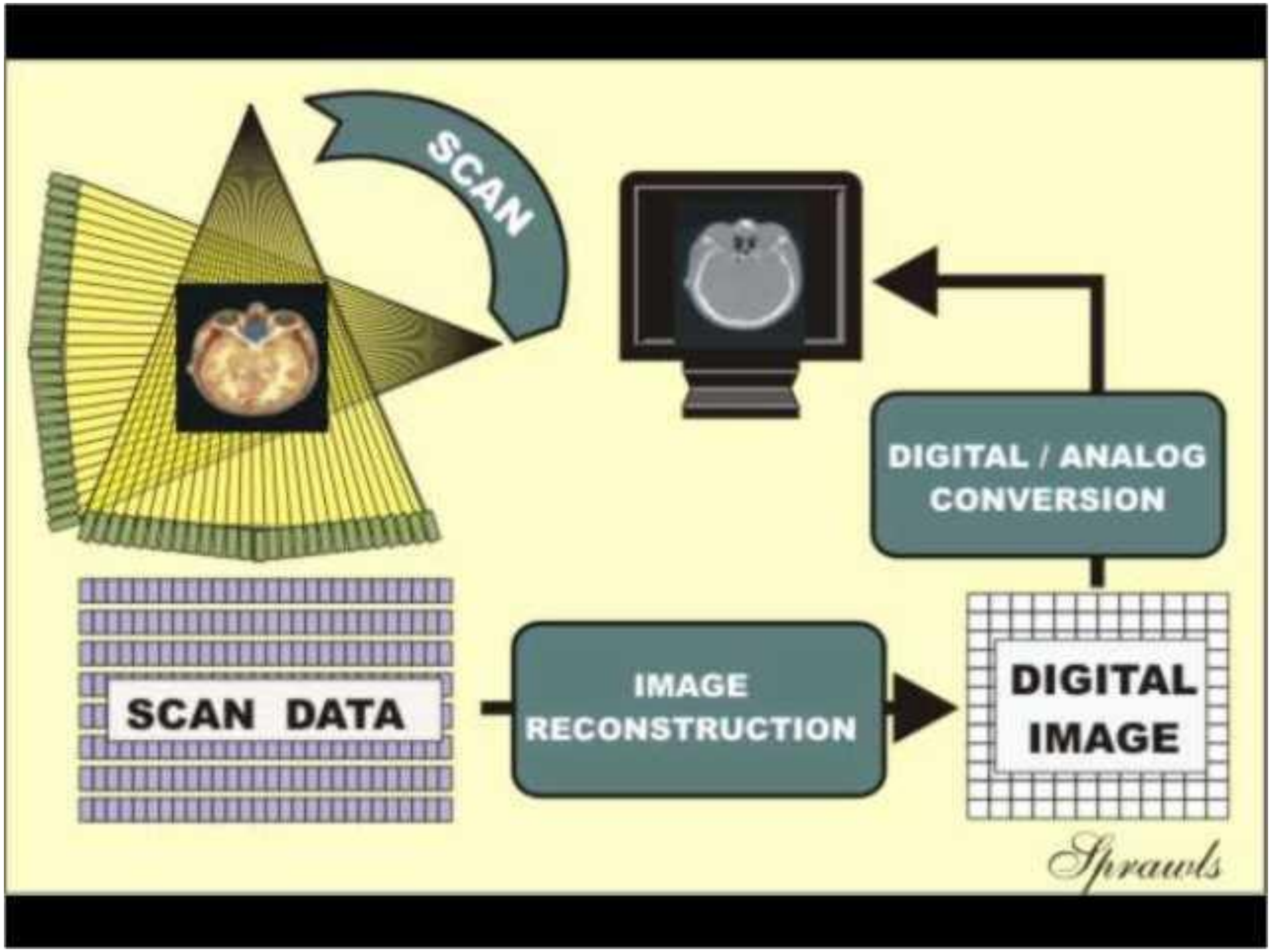


Displaying information

- Resolution
- Bit depth (aka. Bits per pixel): from 8 to 16 bits (integer).
- How can we display a given intensity range?
- Have the same tissues the same intensities in different patients? In MRI? In CT? In US?
- Best way to display information: 2D, 3D, rendering, cine-view.

CT

CT image formation



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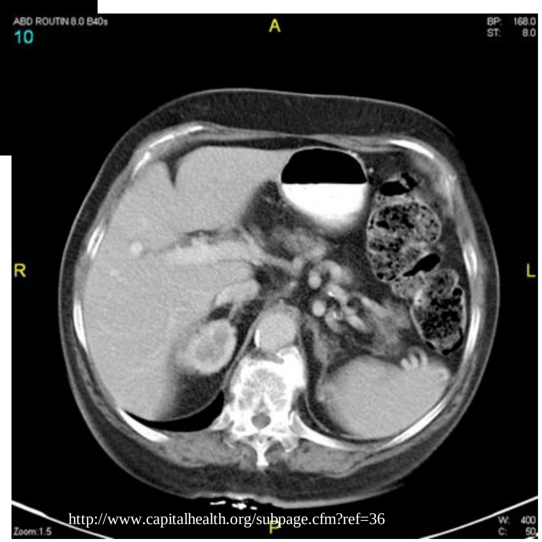
CT information

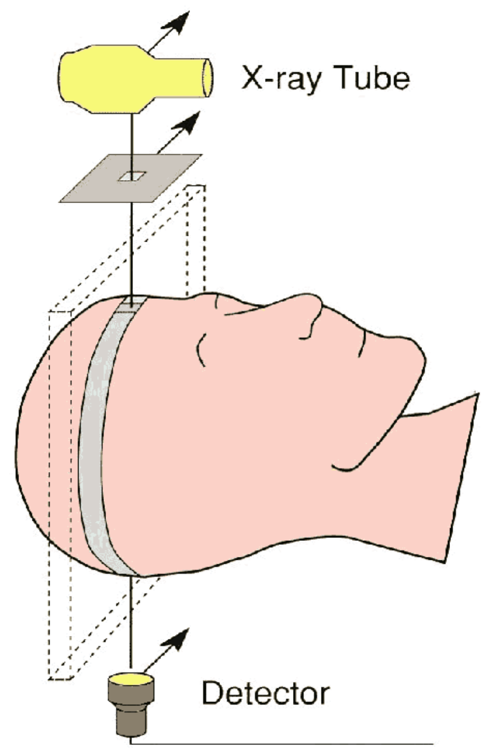
- CT acquisition.

http://upload.wikimedia.org/wikipedia/commons/archive/d/da/20060904231838!Head_CT_scan.jpg



http://www.capitalhealth.org/subpage.cfm?ref=36

http://www.stabroeknews.com/images/2009/08/20090830ctscan.jpg



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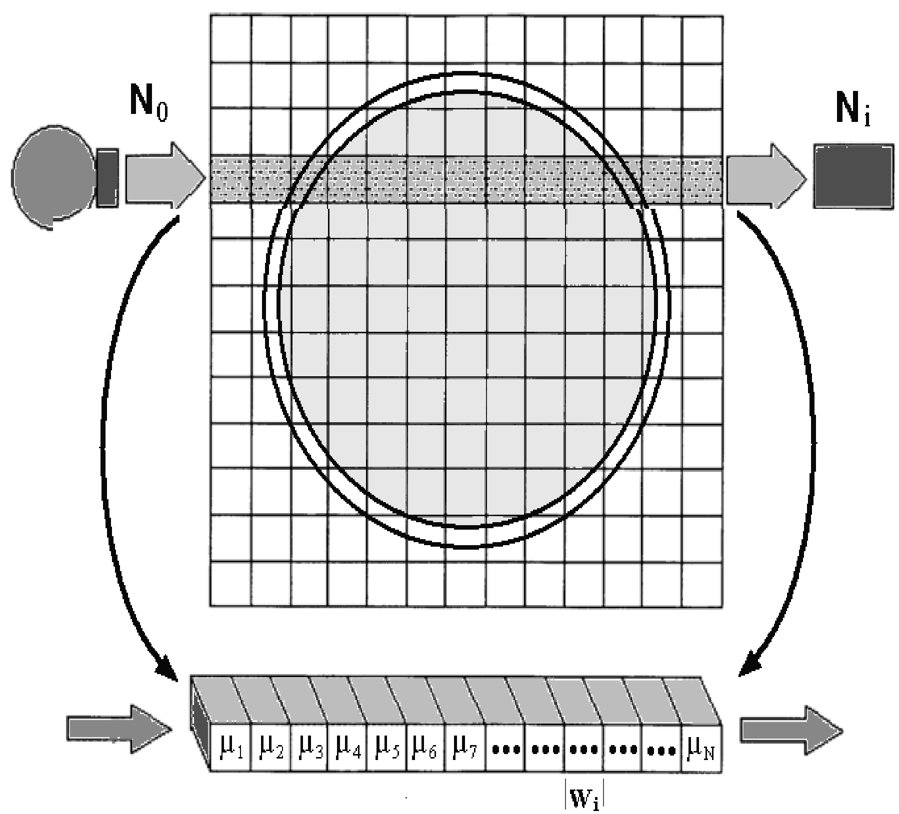
Houndsfield Units

- Also known as CT units.
- Final intensity Ni: weighted sum of tissue attenuation



$$Xi = \mathrm{Ln}\,(N_0/Ni) = \mu_1 w_1 + \mu_2 w_2 + \mu_3 w_3 + \mu_4 w_4 + \cdots + \mu_N w_N$$

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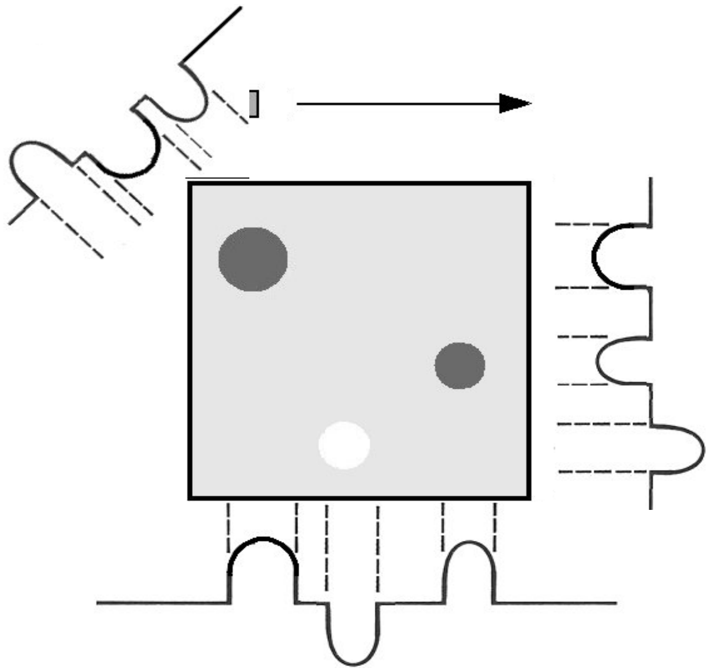
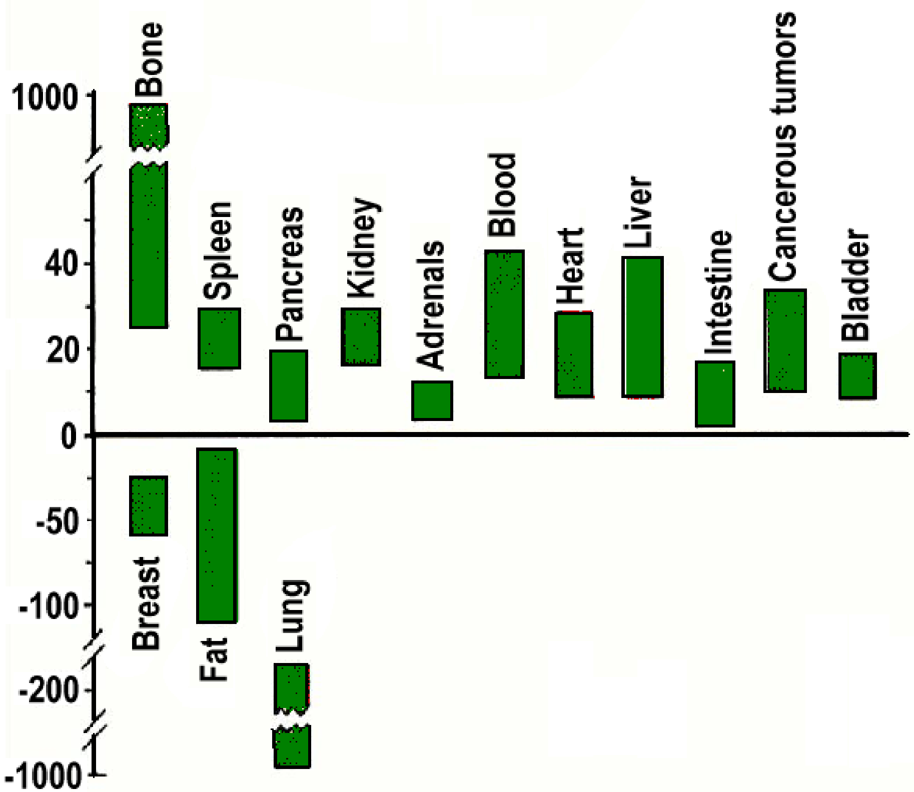
Houndsfield Units

- Reconstruction of the 3D volume: backprojection



Houndsfield Units

- CT Units or Houndsfield units
- % of the difference with the attenuation of the voxel and the attenuation of water x 1000.



$$CT\# = \left(\frac{\mu_{tissue} - \mu_{water}}{\mu_{water}} \right) \times 1000$$

Windowing

- Windowing: Window **width** and window **level** to optimize the contrast of the viewer.
- Level: the midpoint of the window range (Low level: contrast in the lungs or high levels in the bones).
- Width: intensity range

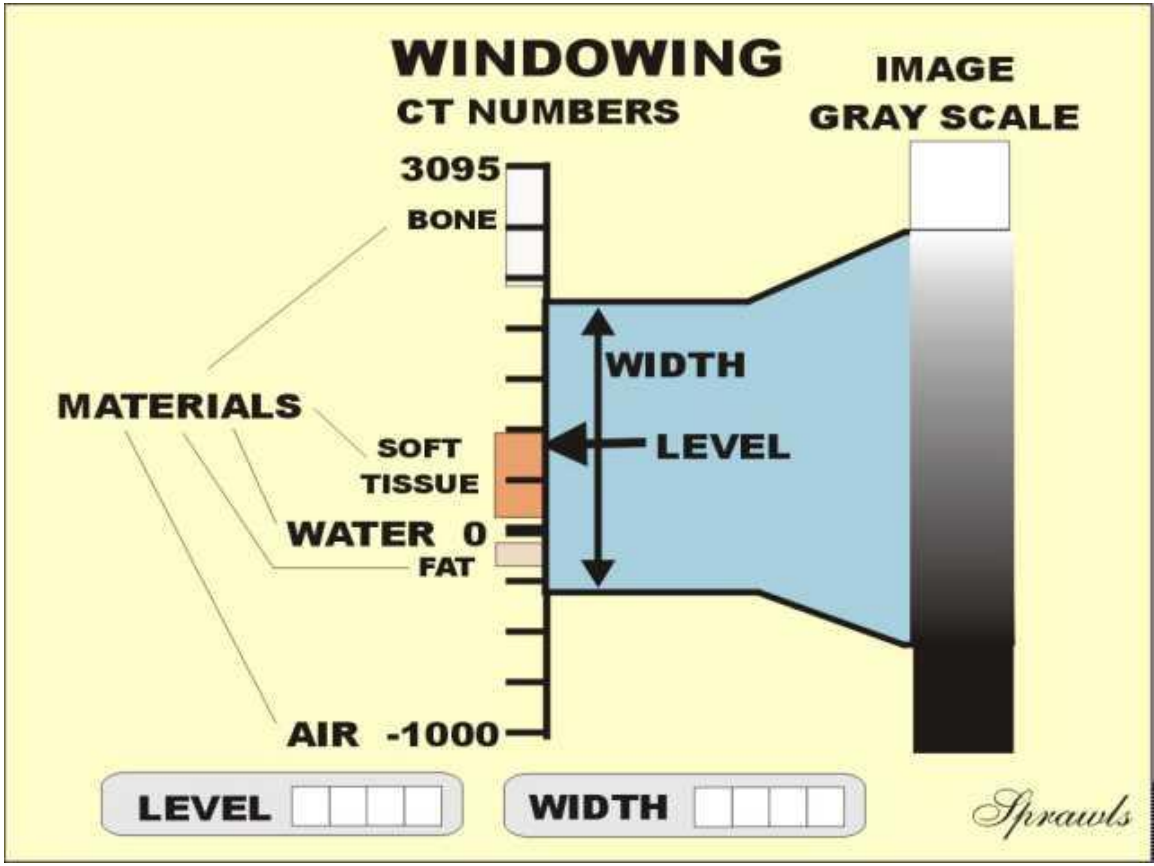


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Image quality

- Contrast resolution. Ability to differentiate between different tissue densities.
- High contrast. Ability to see small objects and details with high density compared with the background.
  - Lung nodules/lesions
- Low contrast. Ability to visualise objects with little difference in density.
  - Example: differentiating white matter and grey matterd in CT.

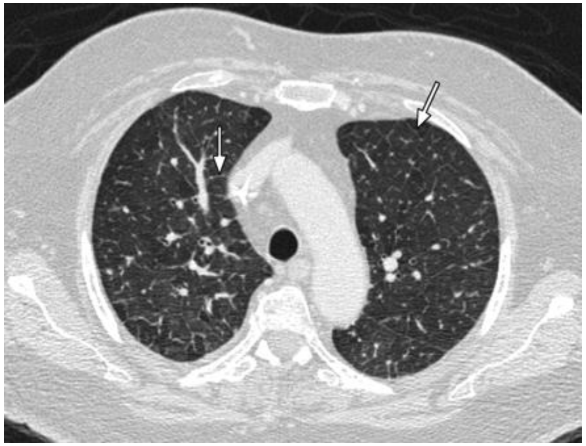
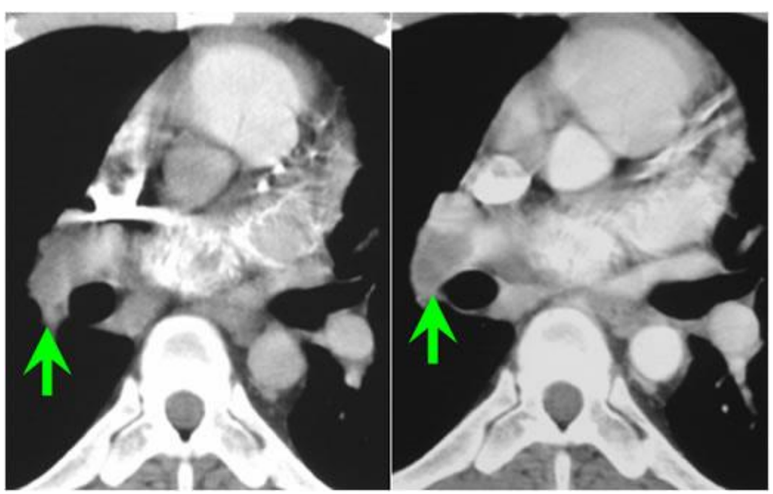


Image quality

- Artifacts: degrade image quality and perception of details.
- Streaks: patient motion or metal and noise
- Rings: problems with the detector
- Shading: problems with the reconstruction (not enough views).



Streaks

Rings and bands

Shading

Mammography

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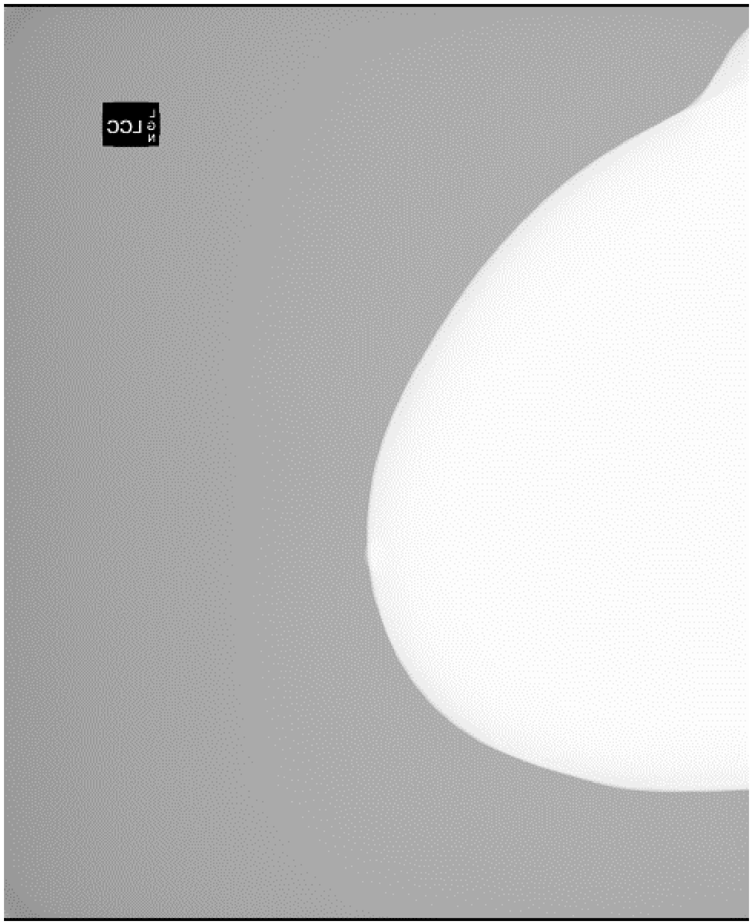
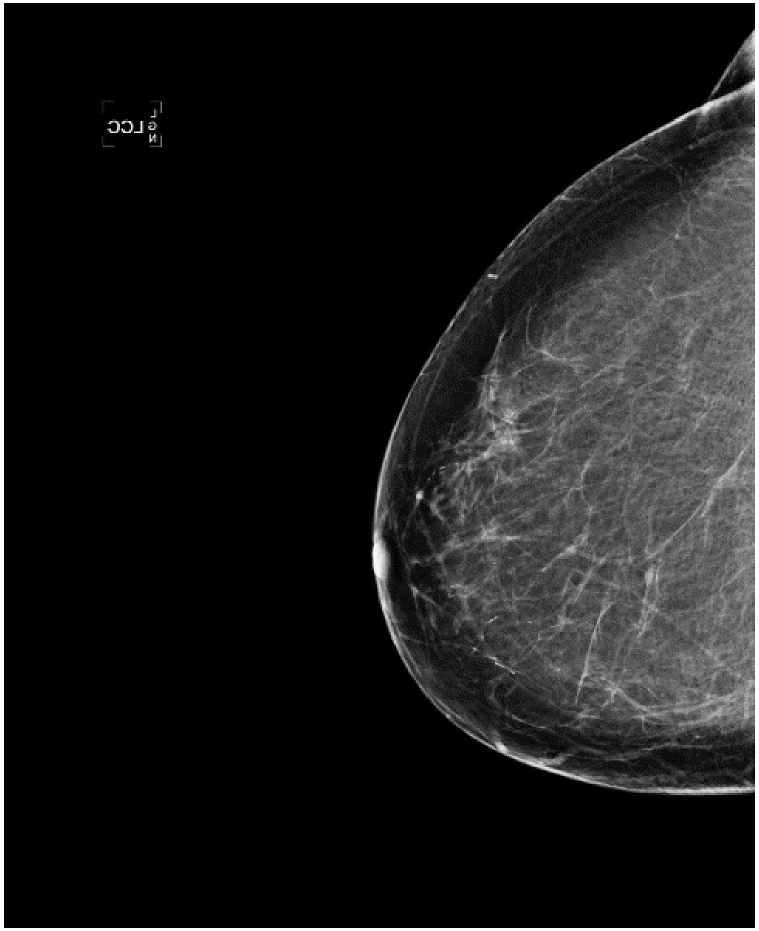
Mammography

- “RAW” to “For Presentation”





Grayscale Transforms

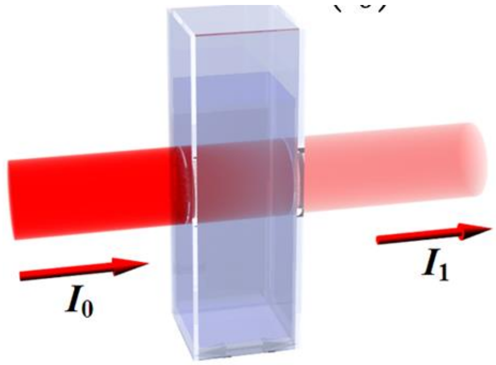
- Aplication of lookup tables (LUT) to change grayscale.
- Highest diagnostic information content should be displayed with optimal contrast
- DICOM standard of displays
  - Medical displays should be perceptually linear.
  - DICOM Grayscale Standard Display Function
- If properly calibrated, similar differences in pixel values should be perceived as similar differences in luminance, regardless of the luminance level.

Films and digital displays

- Film screen response to a x-ray exposure E is determined by its **characteristic curve**: the relation between the log of the exposure and optical density.
- Exposure (E): concentration of radiation (ionization in a given volume of air) (Roetgens).
- Optical density (D or OD): is a measure of the degree of film darkening (measure of light transmitted through the film-It- with respect to the incident I0)

$$D = \log \frac{I_0}{I_t}$$

Transmittance (I_t/I_0)	Percent Transmittance	Inverse of Transmittance (I_0/I_t)	Film Density (Log(I_0/I_t))
1.0	100%	1	0
0.1	10%	10	1
0.01	1%	100	2
0.001	0.1%	1000	3
0.0001	0.01%	10000	4
0.00001	0.001%	100000	5
0.000001	0.0001%	1000000	6
0.0000001	0.00001%	10000000	7



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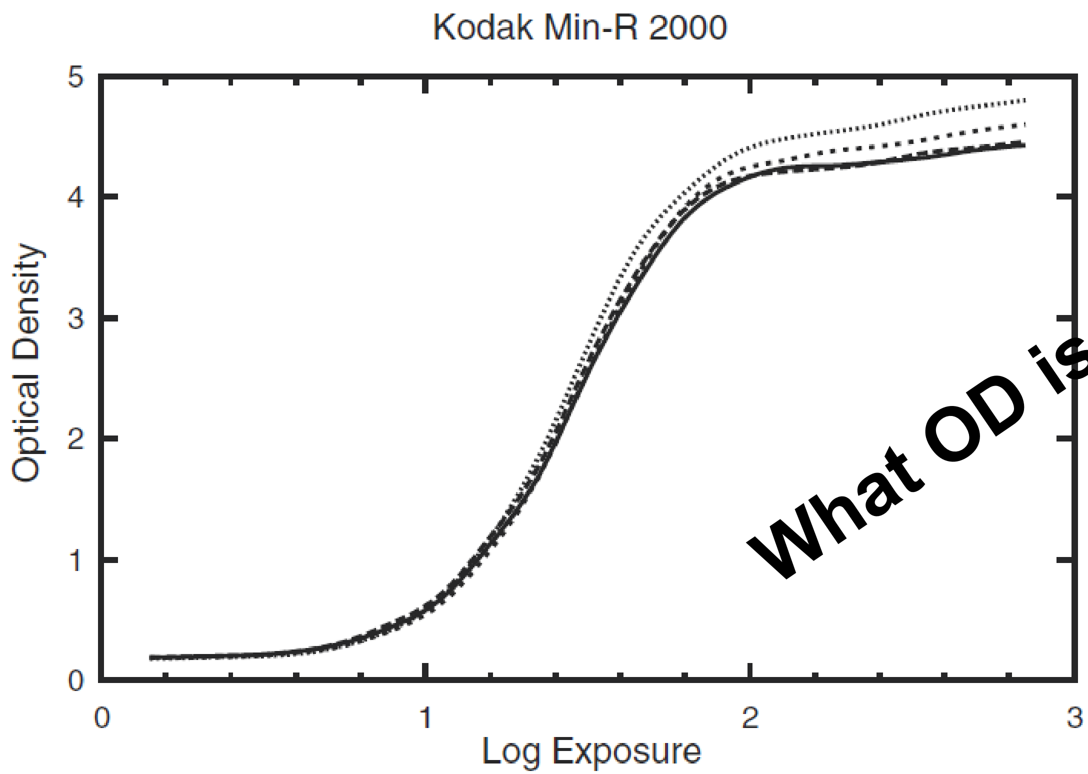
Films and digital displays

- Film screen response to a x-ray exposure E is determined by its **characteristic curve**: the relation between the log of the exposure and optical density.

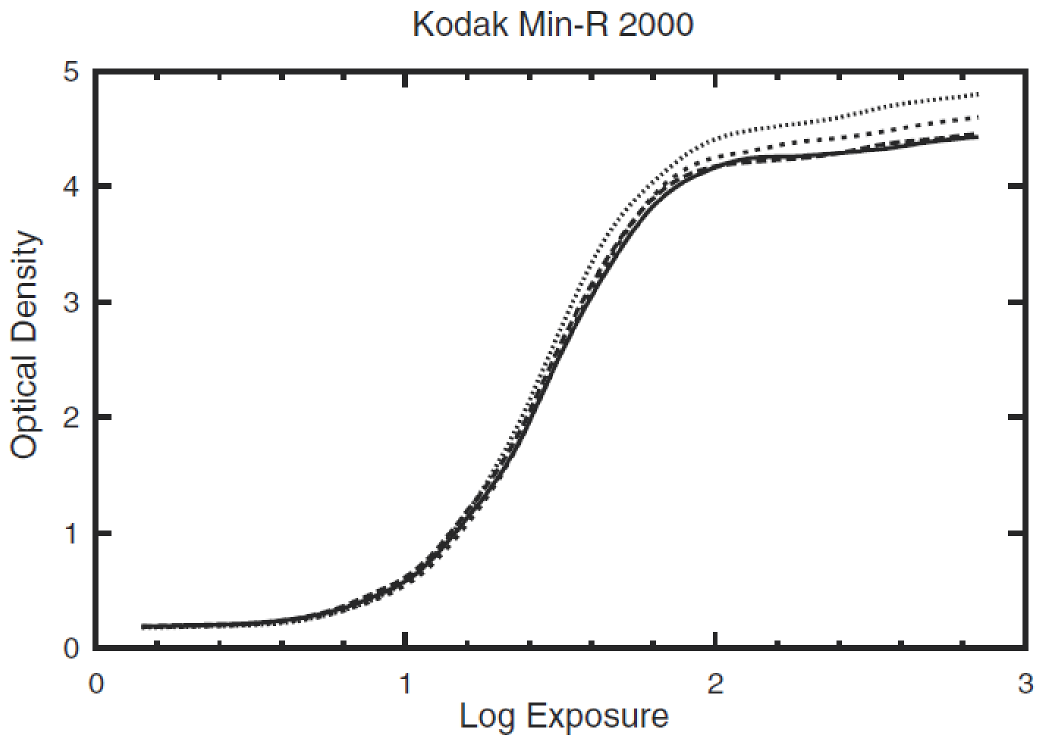


What OD is low intensity?

Films and digital displays

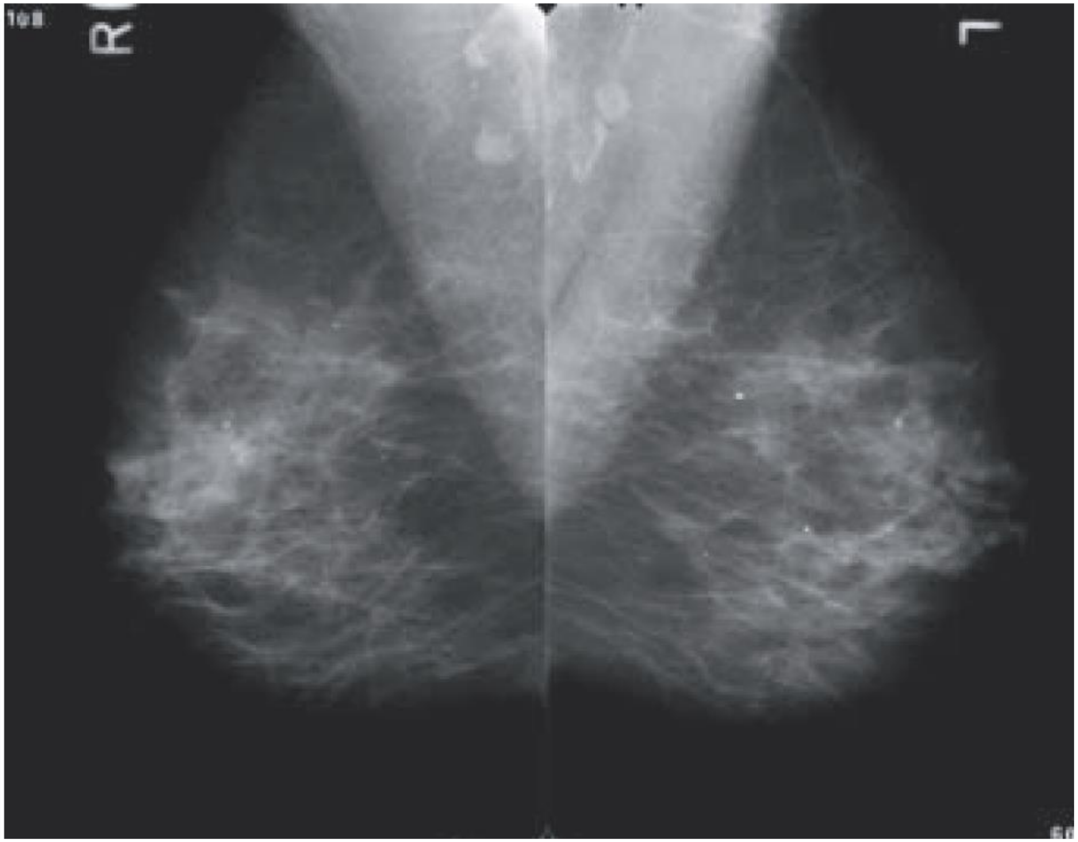
- When viewed in a light box (with luminance I0), the transmitted light is $$I = I_0 \log_{10}(-D)$$

- Hence applying a similar function to the exposure of FFDM we can estimate the intensity of the image.



Films and digital displays

- FFDM images to give them a film like appearance
- With the characteristic curve we can obtain the LUT
- Other LUTs can be applied (linear, non-linear, sigmoid).



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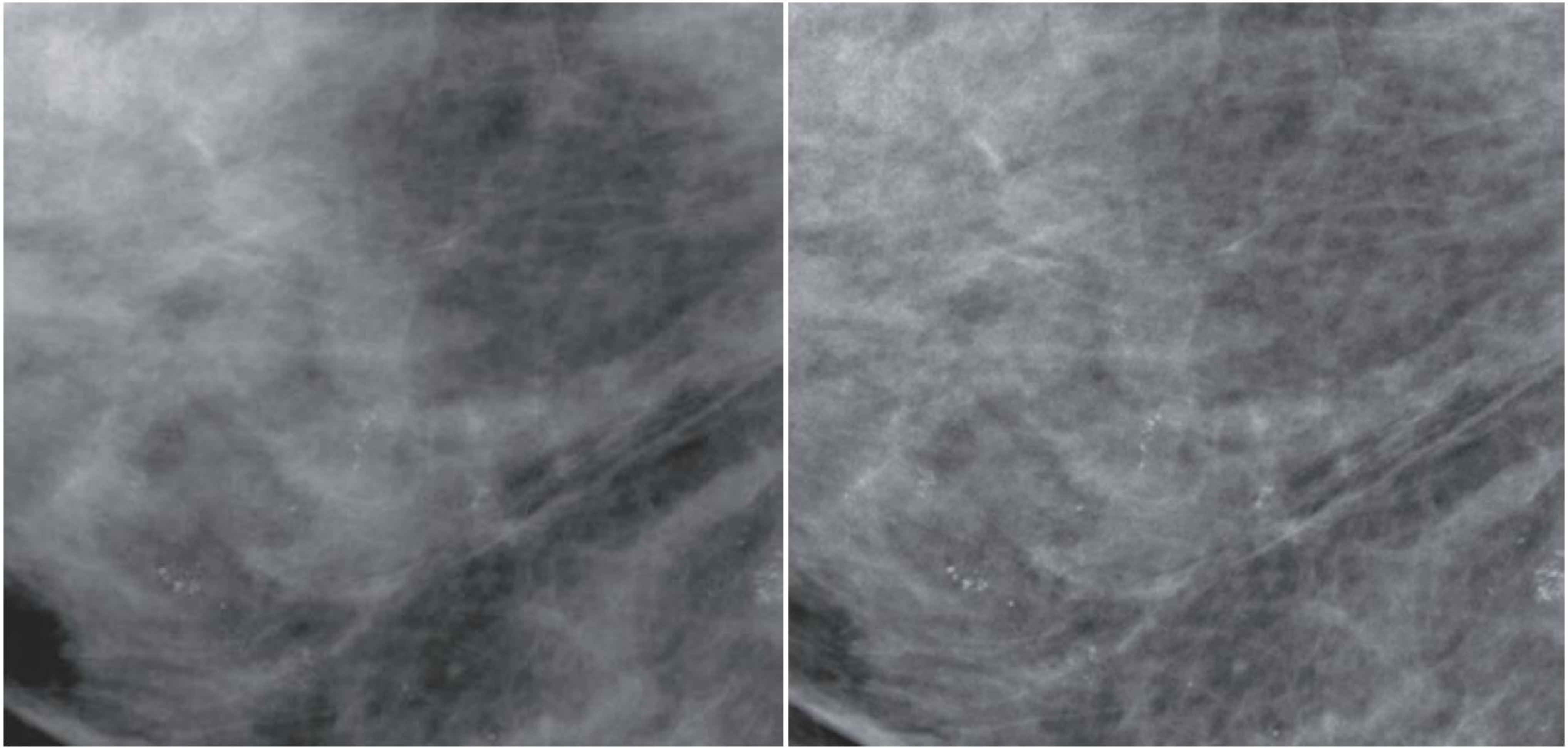
Films and digital displays

- Is that enough? Spatial enhancement.

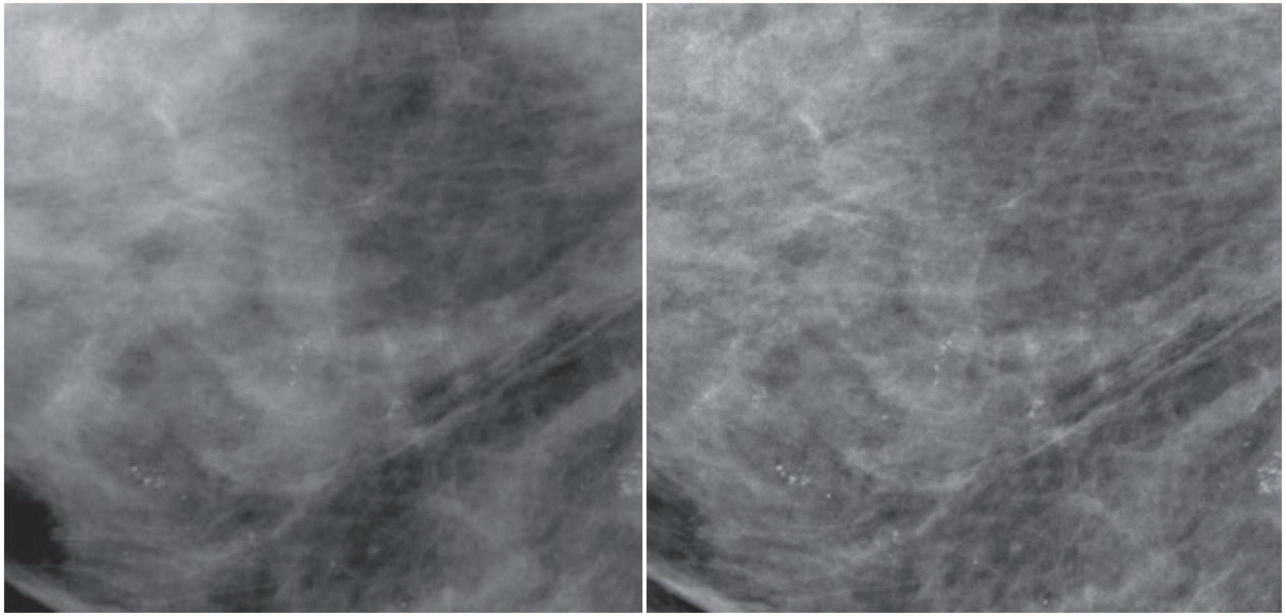


Films and digital displays

- Unsharp masking

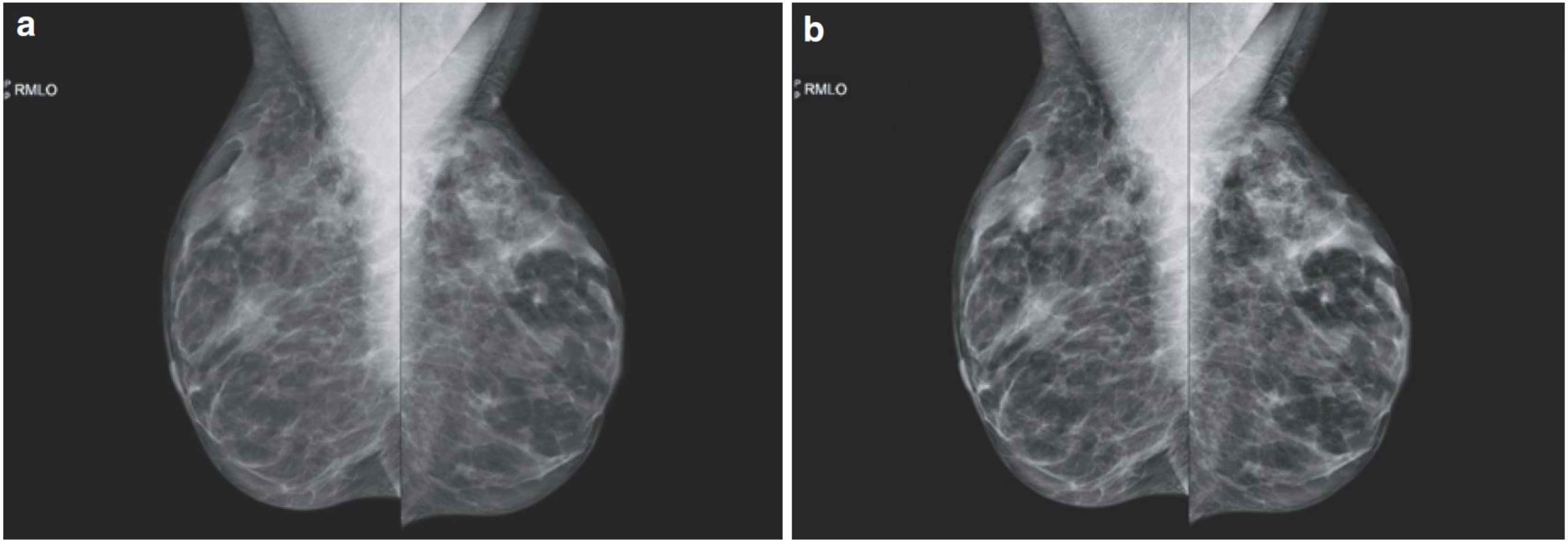
$$y_i' = y_i + f\,(y_i - s_i\,(\sigma))$$

New image yi’ (si, smoothing, f amount of enhancement)
  - Basically, subtracting a smoothed version of the image.
  - Matlab: B = imsharpen(A)
  - Enhances high frequency: edges (and noise!).



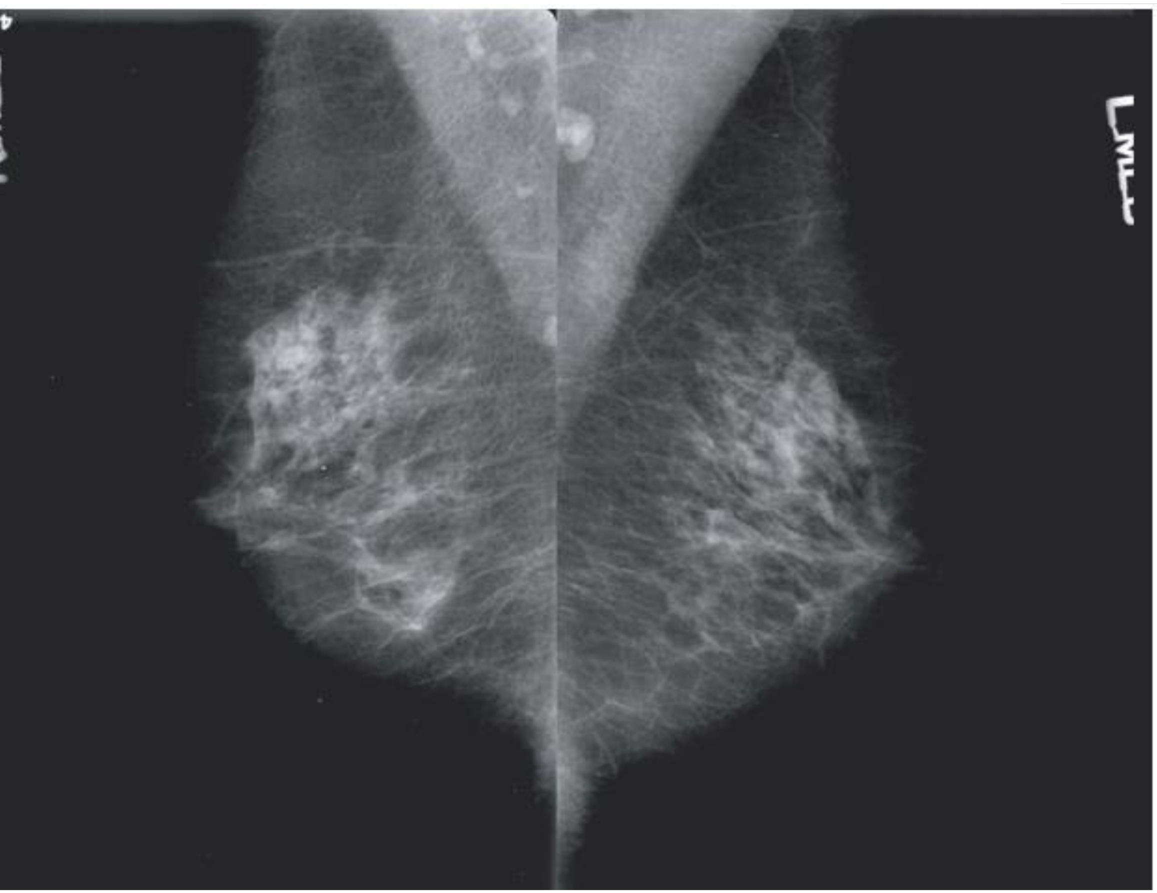
Films and digital displays

- Adaptative Histogram Equalization (CLAHE)
  - Locally (patches) equalise the histogram to a given statistical distribution (parameter).
  - Matlab: J = adapthisteq(I)



Films and digital displays

- Other (vendor specific) post-processing approaches.
- Application specific: Breast Peripherial Enhancement.



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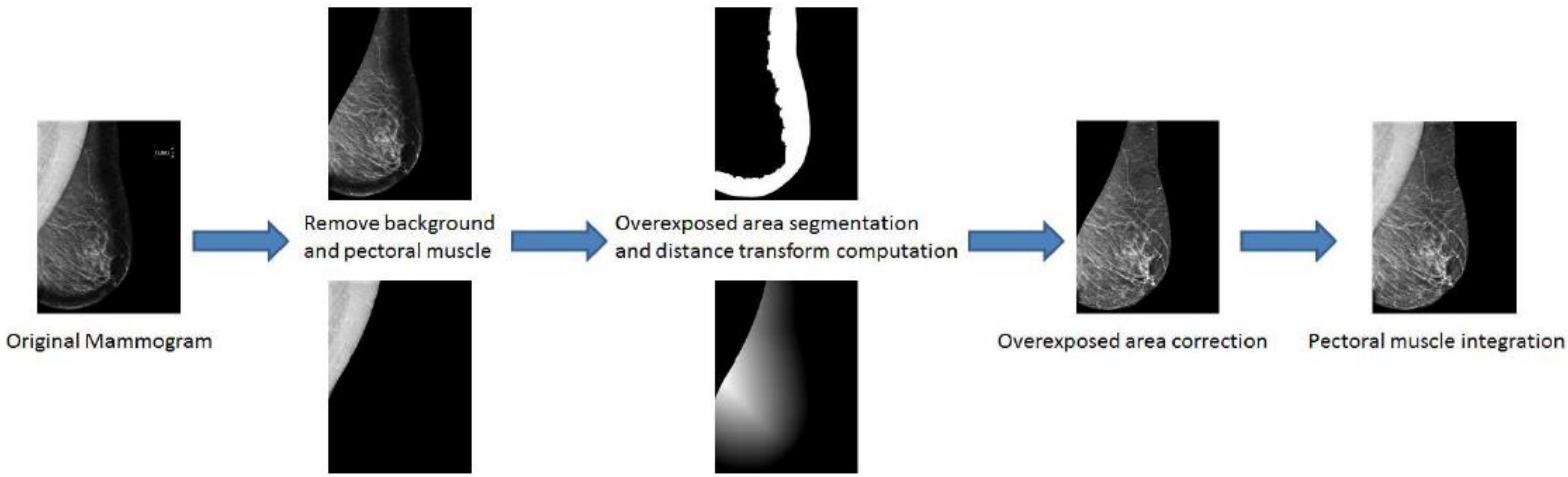
Films and digital displays

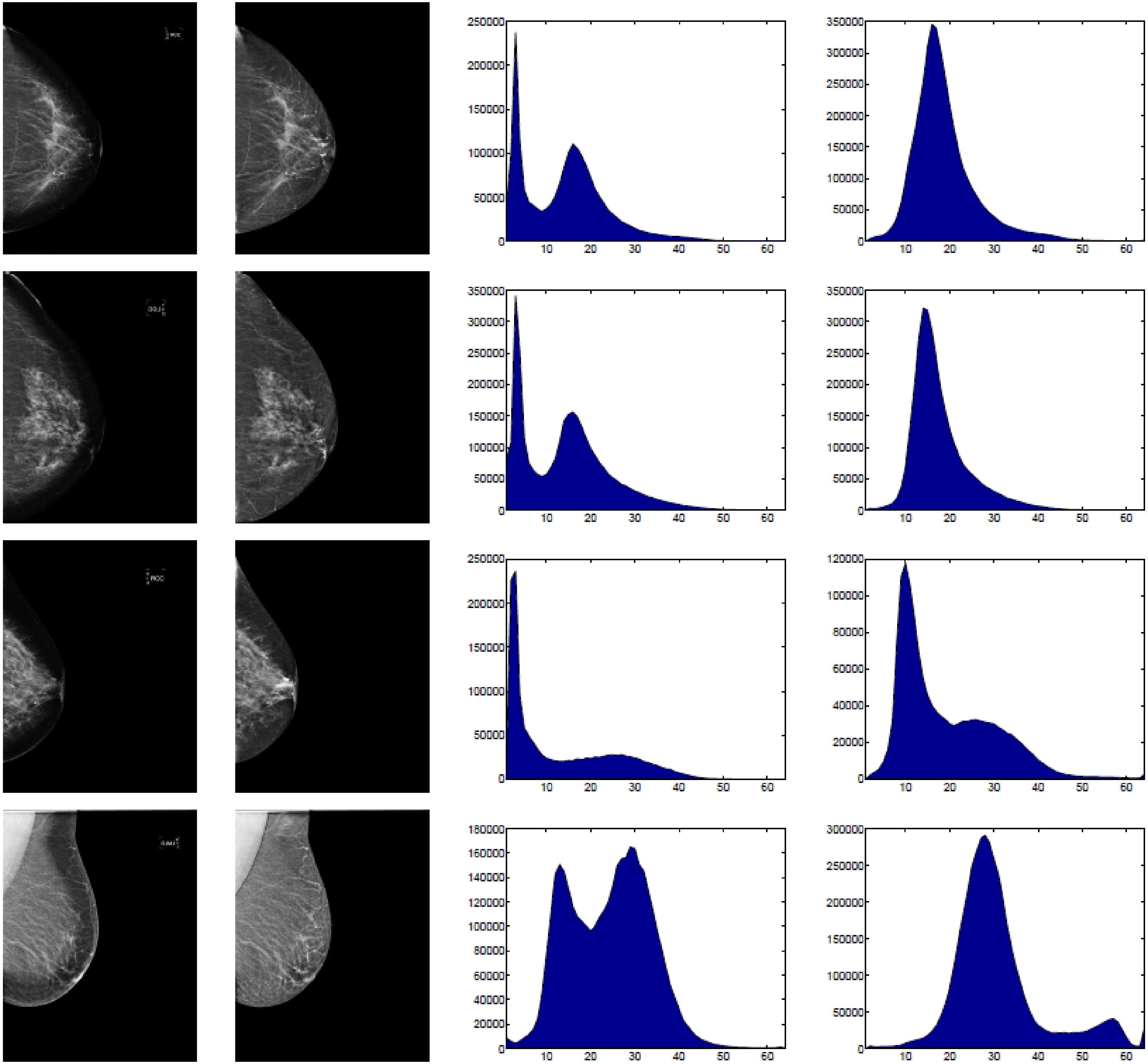
- Breast Peripherial Enhancement.

Films and digital displays

- Breast Peripherial Enhancement.



$$I'(x) = I(x)\frac{\overline{I}_{N_{in}(x)}}{\overline{I}_{N(x)}}$$



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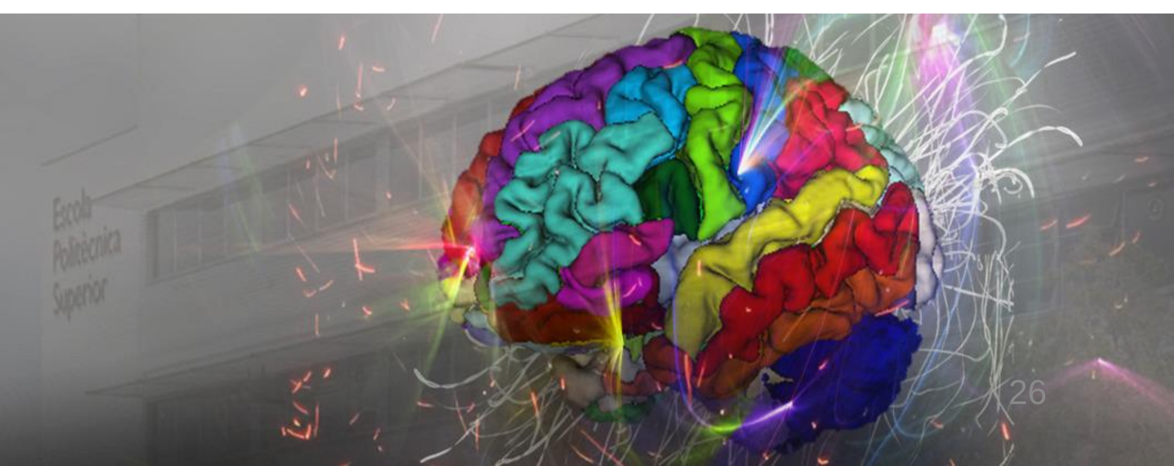
Medical Displays & Calibration



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Medical Displays

- Several Manufacturers (Eizo, Totoku, Barco, …)

RX850	RX560
Delete	Move Delete
	
8MP(Color Monitors) Dimension Drawing	5MP(Color Monitors) Dimension Drawing

Brightness (typical)	850 cd/m^2	1100 cd/m^2
Recommended Brightness for Calibration	500 cd/m^2	500 cd/m^2
Contrast Ratio (typical)	1450:1	1500:1
Response Time (typical)	20 ms (on / off)	12 ms (on / off)
Type	Color (IPS)	Color (IPS)
Backlight	LED	LED
Size	79 cm / 31.1"	54.1 cm / 21.3"
Native Resolution	4096 x 2160 (17:9 aspect ratio)	2048 x 2560 (4:5 aspect ratio)
Viewable Image Size (H x V)	697.9 x 368.0 mm	337.9 x 422.4 mm
Pixel Pitch	0.1704 x 0.1704 mm	0.165 x 0.165 mm
Display Colors	10-bit colors (DisplayPort) : 1.07 billion (maximum) colors 8-bit colors: 16.77 million from a palette of 68 billion colors	10-bit colors (DisplayPort) : 1.07 billion (maximum) colors 8-bit colors: 16.77 million from a palette of 68 billion colors

http://www.eizoglobal.com/products/radiforce/rx850/index.html

Medical Displays

Momentum QHD LCD display with

M Line, 32 (31.5" / 80 cm diag.), Quad HD (2560 x 14

similar products ›

...ers (Eizo, Totoku, Barco, …)

Overview | Specifications

Backlight type	W-LED system
Panel Size	31.5 inch / 80 cm
Color gamut (typical)	NTSC 108%*, sRGB126%*
Effective viewing area	698.11 (H) x 392.69 (V)
Aspect ratio	16:9
Optimum resolution	2560 x 1440 @ 60 Hz
Pixel Density	93 PPI
Response time (typical)	5 ms (Gray to Gray)*
Brightness	250 cd/m²
Contrast ratio (typical)	1200:1
SmartContrast	50,000,000:1
Pixel pitch	0.273 x 0.273 mm
Viewing angle	• 178º (H) / 178º (V) • @ C/R > 10
Flicker-free	Yes
Picture enhancement	SmartImage
Display colors	1.07G (8bits + FRC)
Scanning Frequency	30 - 83 kHz (H) / 48 - 76 Hz (V)
sRGB	Yes

Brightness (typical)	850 cd/m^2	1100 cd/m^2
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http://www.eizoglobal.com/products/radiforce/rx850/index.html

Medical Displays

- See
  http://www.eizoglobal.com/products/radiforce/rx850/index.html

Study on the Efficiency of
RadiForce RX850 in Mammography

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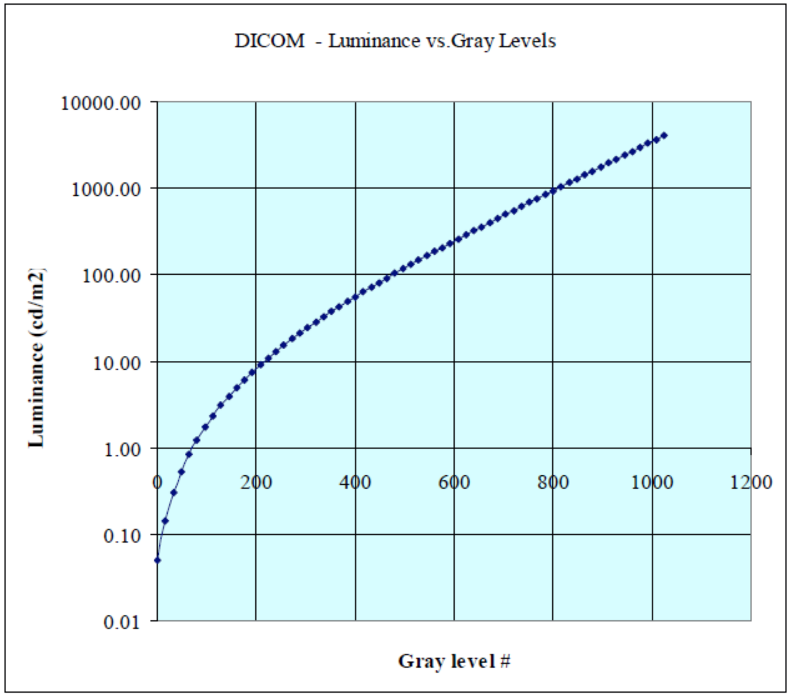
http://www.eizoglobal.com/products/radiforce/rx850/index.html

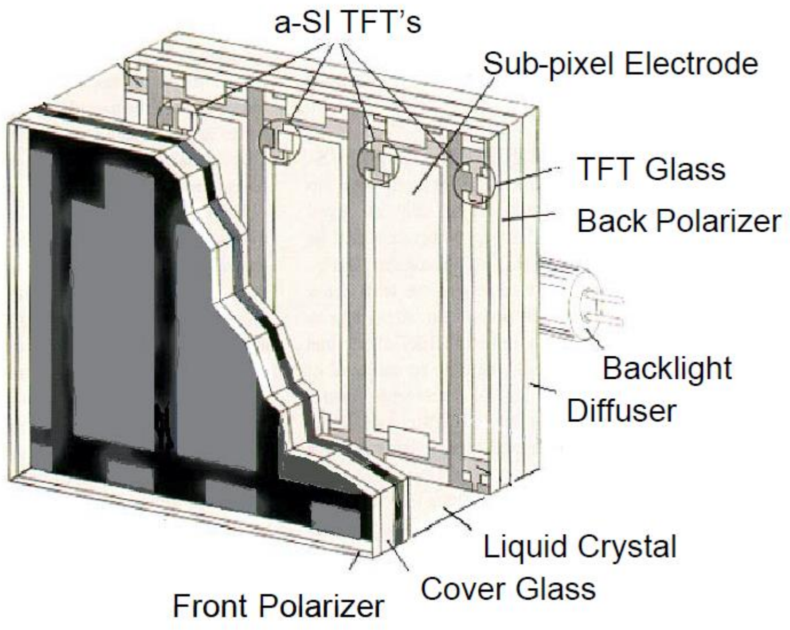
Calibration and QC

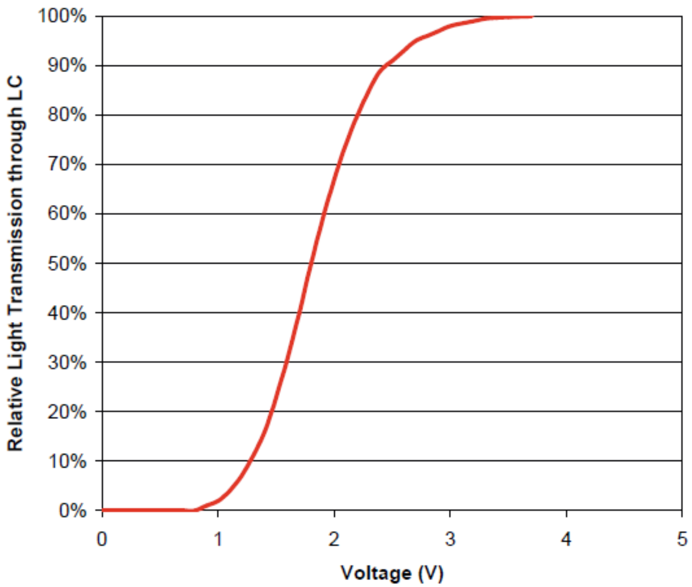
- DICOM standard part 14. Grayscale Standard Display Function (GSDF).
- http://dicom.nema.org/dicom/2004/04_14pu.pdf
- The way human eye responds to contrast in light levels is not linear. At higher luminance, the change needs to be much greater before we perceive the difference from one level to the next.



Calibration and QC

- Need to calibrate medical displays.
- The amount of light to control pixels is also non linear





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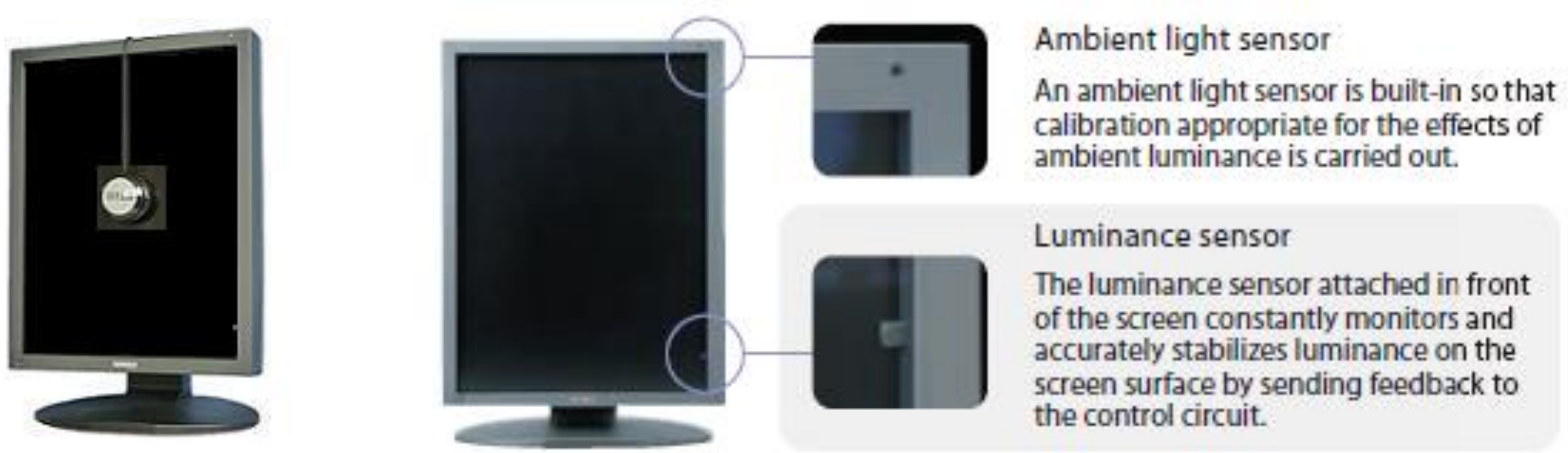
Calibration and QC

- Two variables involved
  - Peak luminance. Maintain a constant maximum luminance (declines with time) of the backlight.
  - Gray level separation. Provide the accurate voltage to obtain the accurate level of light to achieve the DICOM standard.



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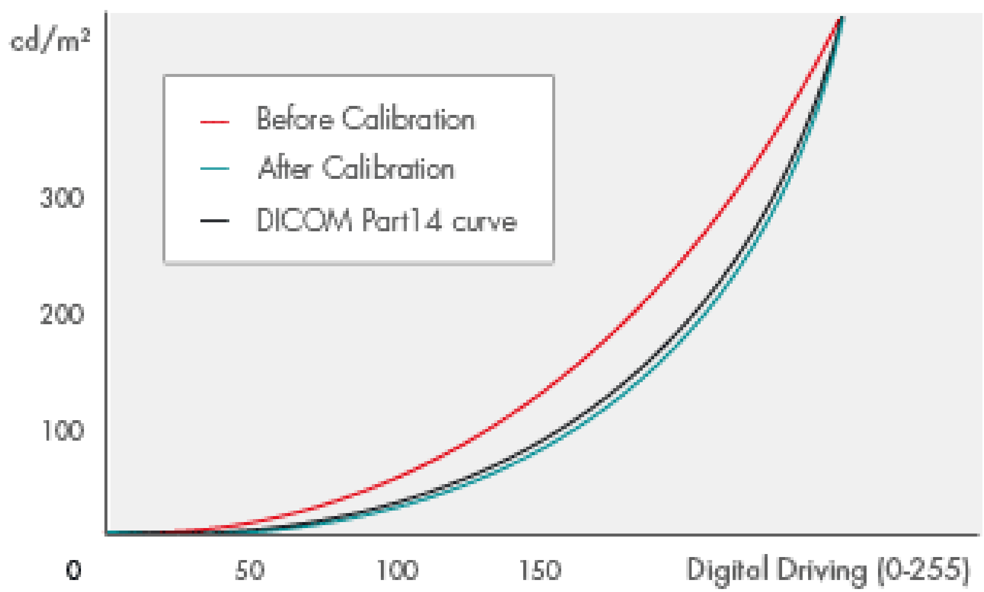
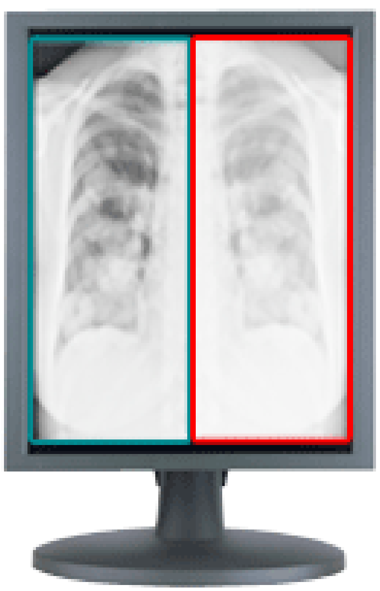




Calibration and QC

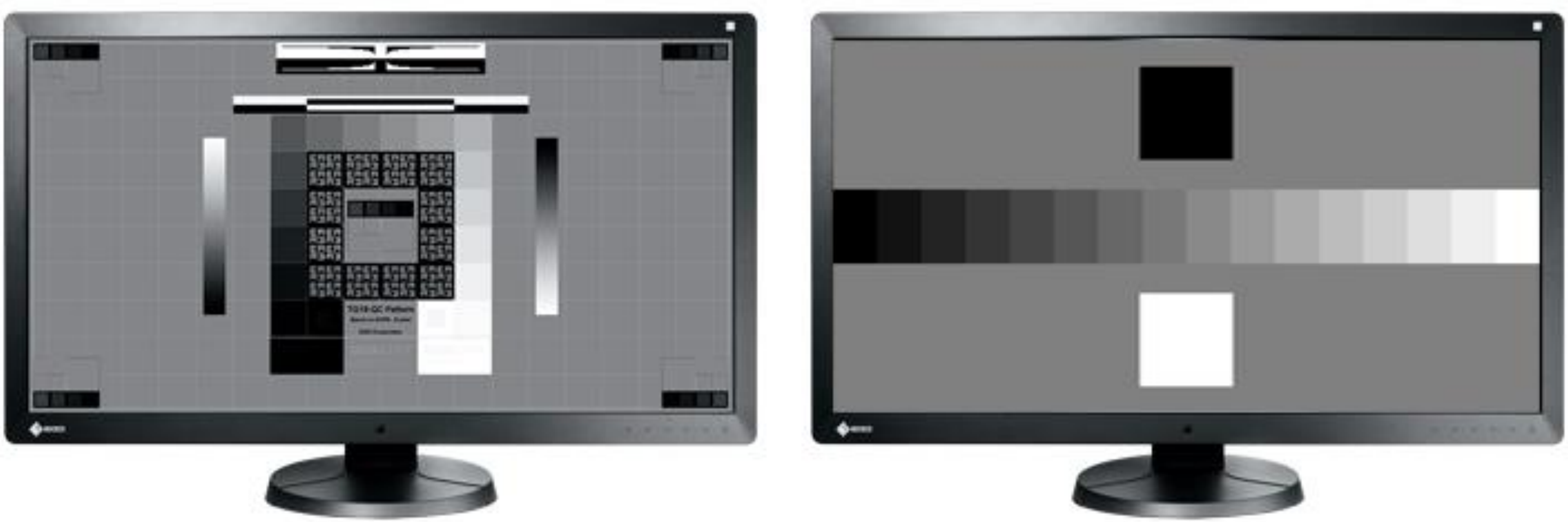
Home > Products > RadiForce > RadiCS UX2

RadiCS® UX2

Quality Control Software & Calibration Sensor

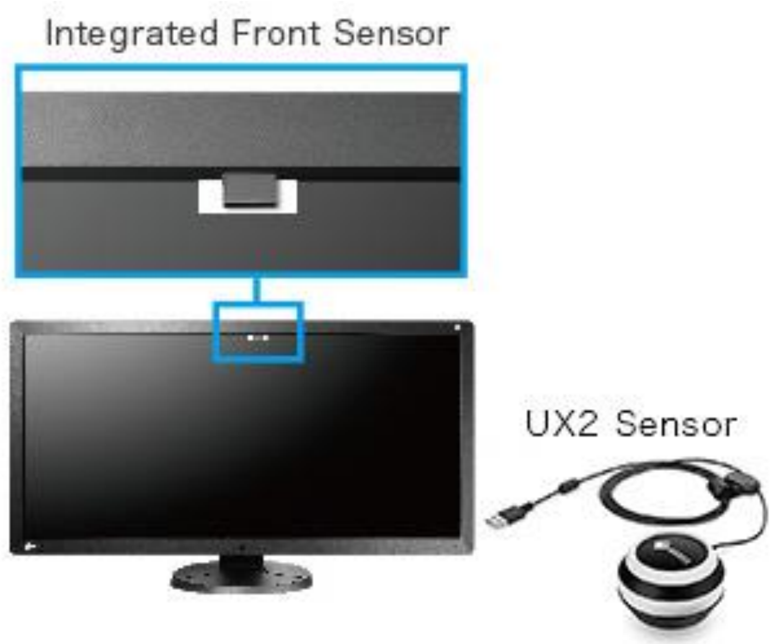
RadiCS provides total support for the quality maintenance and control of client monitors, covering everything from calibration to acceptance and constancy tests, calibration asset, and historical management. Complying with AAPM, DIN, IEC and other standards, RadiCS enables precise QC with easy-to-follow procedures.

Contact EIZO



Calibration and QC

- Support for different display functions: DICOM Part 14 GSDF, CIE, Exponential (gamma value), Log Linear, Linear, User definition.



Calibration and QC

- QC standards

AAPM On-Line Report No.03

"Assessment of Display Performance for Medical Imaging Systems" formulated by Task Group (TG) 18 of American Association of Physicists in Medicine.

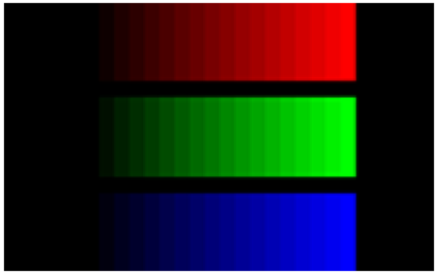
ACR-AAPM-SIIM "Practice Guideline for Determinants of Image Quality in Digital Mammography"

This guideline was formulated collaboratively by specialists in mammography and medical physics who represent the American College of Radiology (ACR), the American Association of Physicists in Medicine (AAPM), and the Society for Imaging Informatics in Medicine (SIIM).

New York State Department of Health Bureau of Environmental Radiation Protection Guide for Radiation Safety / Quality Assurance Program Primary Diagnostic Monitors NEW

The guidelines describe the types and extension of information and criteria used by the New York State Department of Health Bureau of nvironmental Radiation Protection to evaluate Primary Diagnostic Monitor (PDM) in facilities as a part of the radiation safety and quality assurance program.

NYC Quality Assurance Guidelines for Primary Diagnostic Monitors NEW



Refers to the "Guidance related to quality assurance for Primary Diagnostic Monitor (PDM)" based on the health regulations of New York city provided by the New York City Health Department's Office of Radiological Health.

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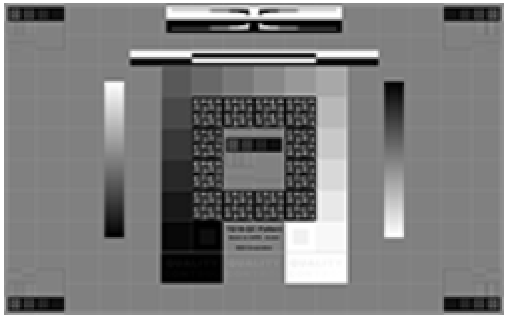
Calibration and QC

- QC standards

EUREF "European Guidelines for Quality Assurance in Breast Cancer Screening and Diagnosis Fourth Edition"

This guideline was issued by the European Commission in cooperation with EUREF (European Reference Organization for Quality Assured Breast Screening and Diagnostic Services), EBCN (European Breast Cancer Network), and EUSOMA (European Society of Mastology).

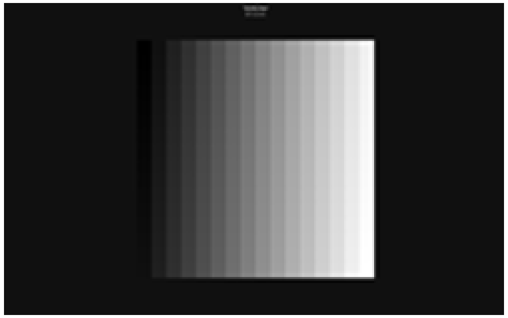


IPEM Report 91

"Recommended Standards for the Routine Performance Testing of Diagnostic X-ray Imaging Systems" formulated by the Institute of Physics and Engineering in Medicine in the UK.

DIN 6868-157

"Image quality assurance in diagnostic X-ray departments – Part 157: X-ray ordinance acceptance and constancy test of image display systems in their environment" formulated by the German Institute for Standardization (Deutsches Institut für Normung e.V).



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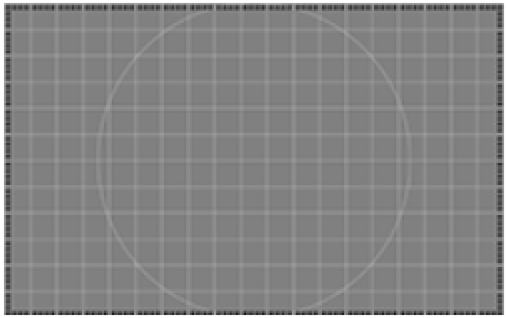
Calibration and QC

- QC standards

ONR 195240-20

"Image Quality Assurance in X-ray Diagnosis - Part 20: Acceptance test and consistency test for image display devices" formulated by the Austrian Standards Institute).



JESRA X-0093＊B-2017

"Quality Assurance (QA) Guideline for Medical Imaging Display Systems" formulated by Japan Industries Association of Radiological Systems (JIRA).

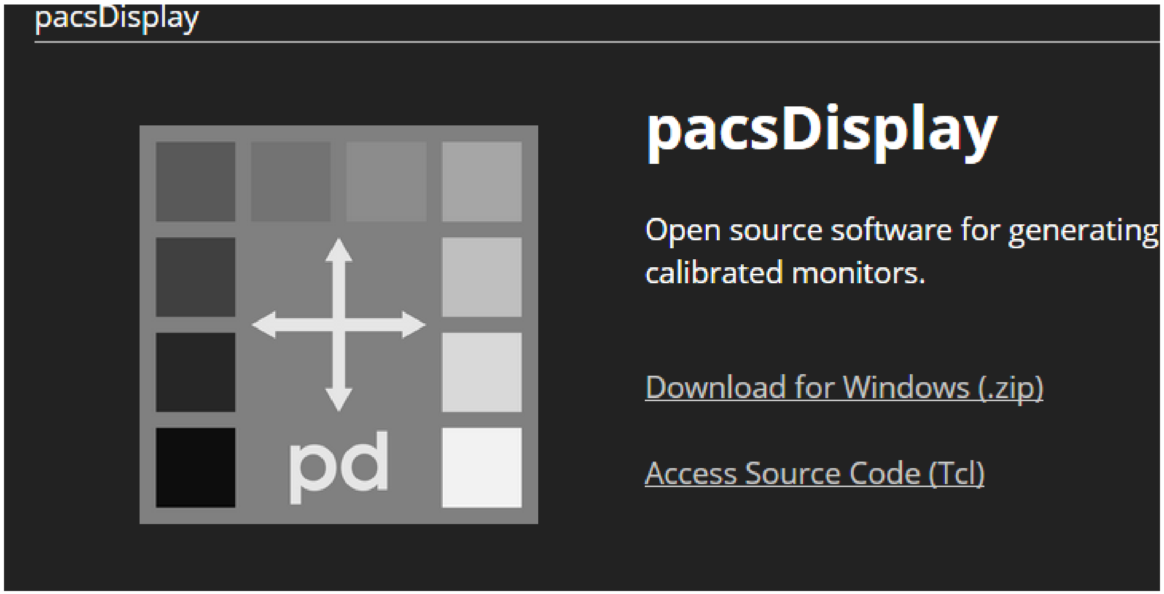
Quality Control Manual for Digital Mammography

A quality control manual for digital mammography systems written by the Japan Central Institute on Quality Assurance of Breast Cancer Screening, a nonprofit organization, in Japan. This NPO studies and manages quality control of mammography.

Displaying images

- Calibration

http://pacsdisplay.org/

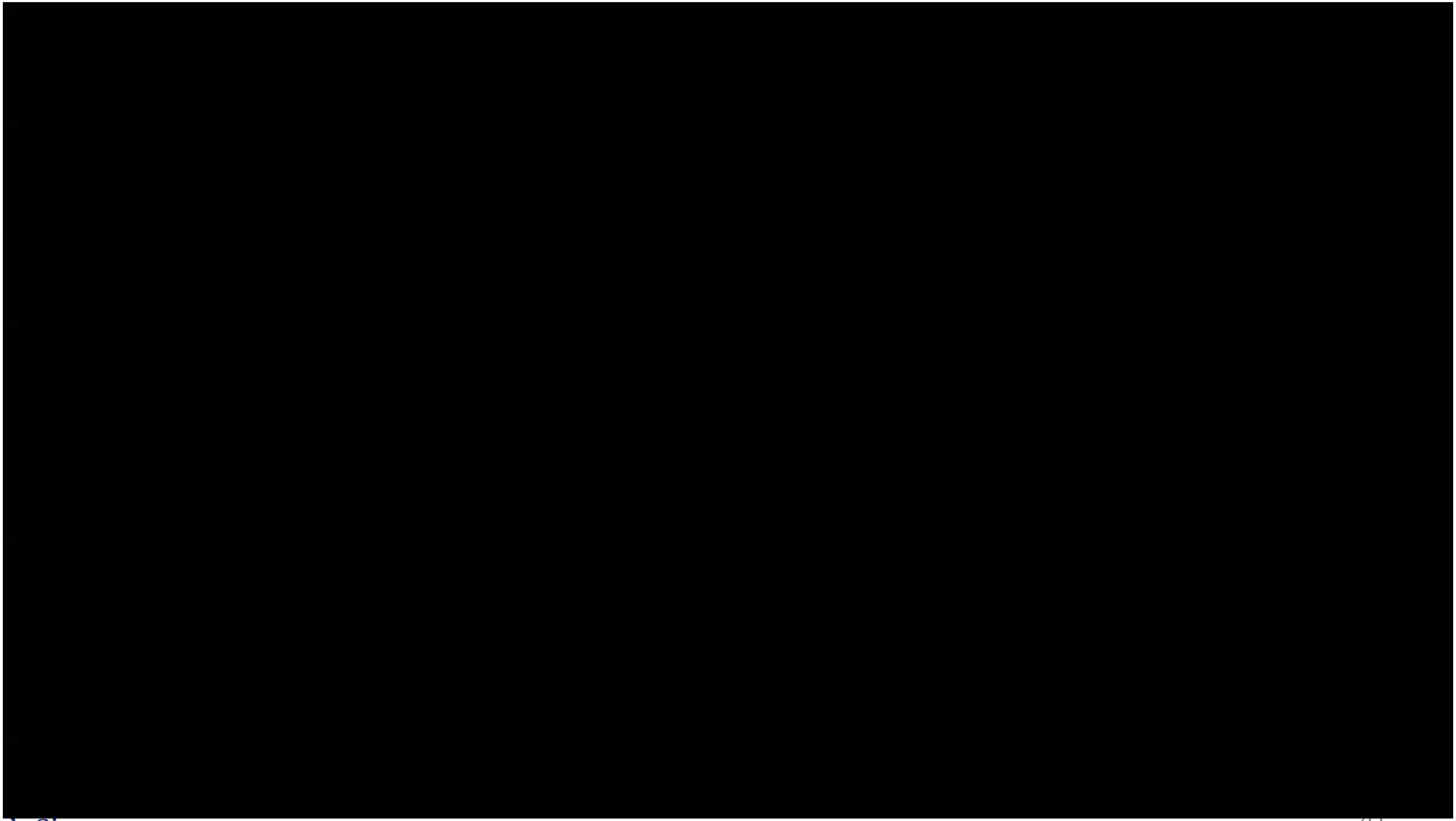


http://perfectlum.com/

Types of visualization

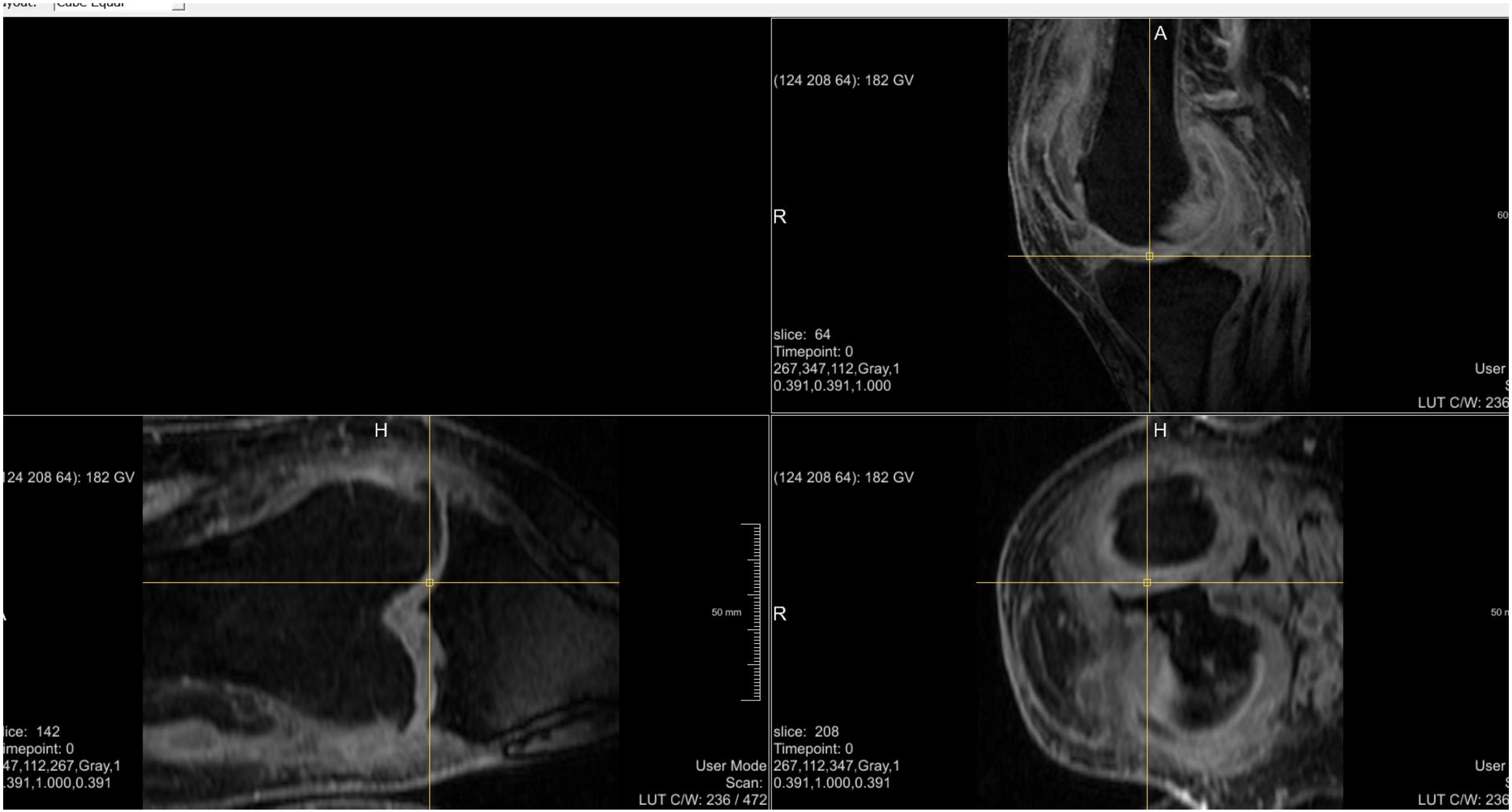
Displaying images

- Hanging protocols



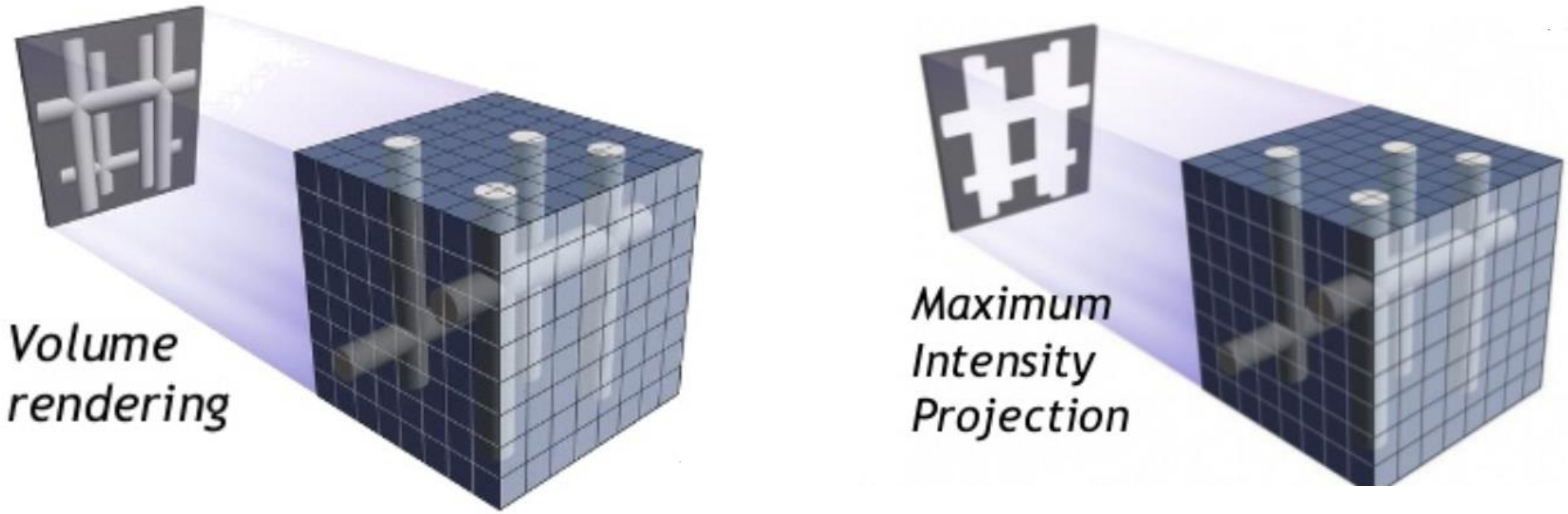
Displaying images

- Orthogonal views (synchronised).



Displaying images

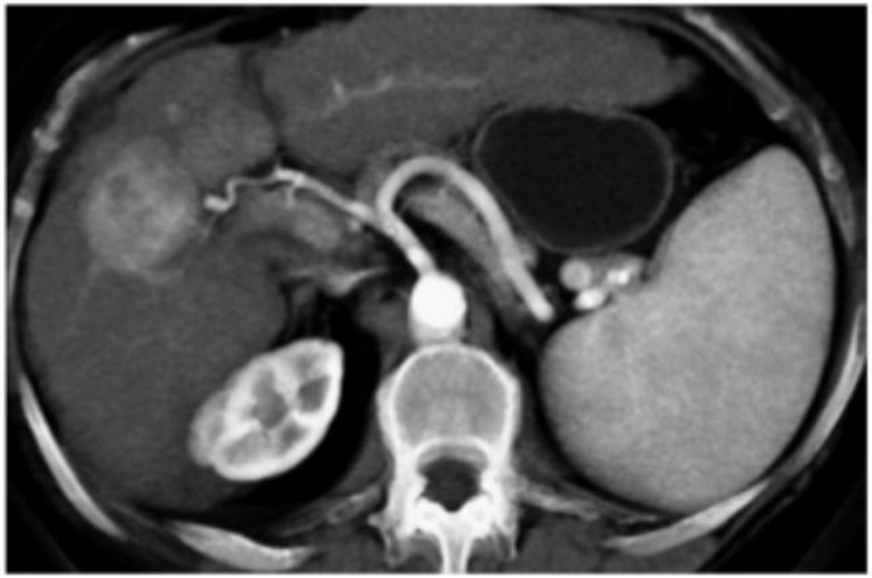
- In addition to slice by slice display



Displaying images

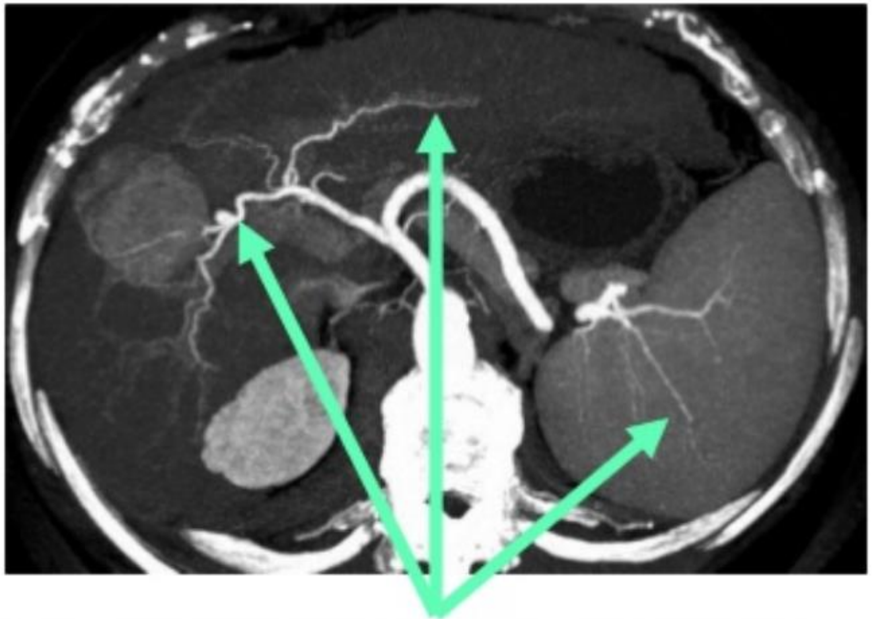
- In addition to slice by slice display

Volume Rendering



Provides more 3D feel by accounting for occlusion

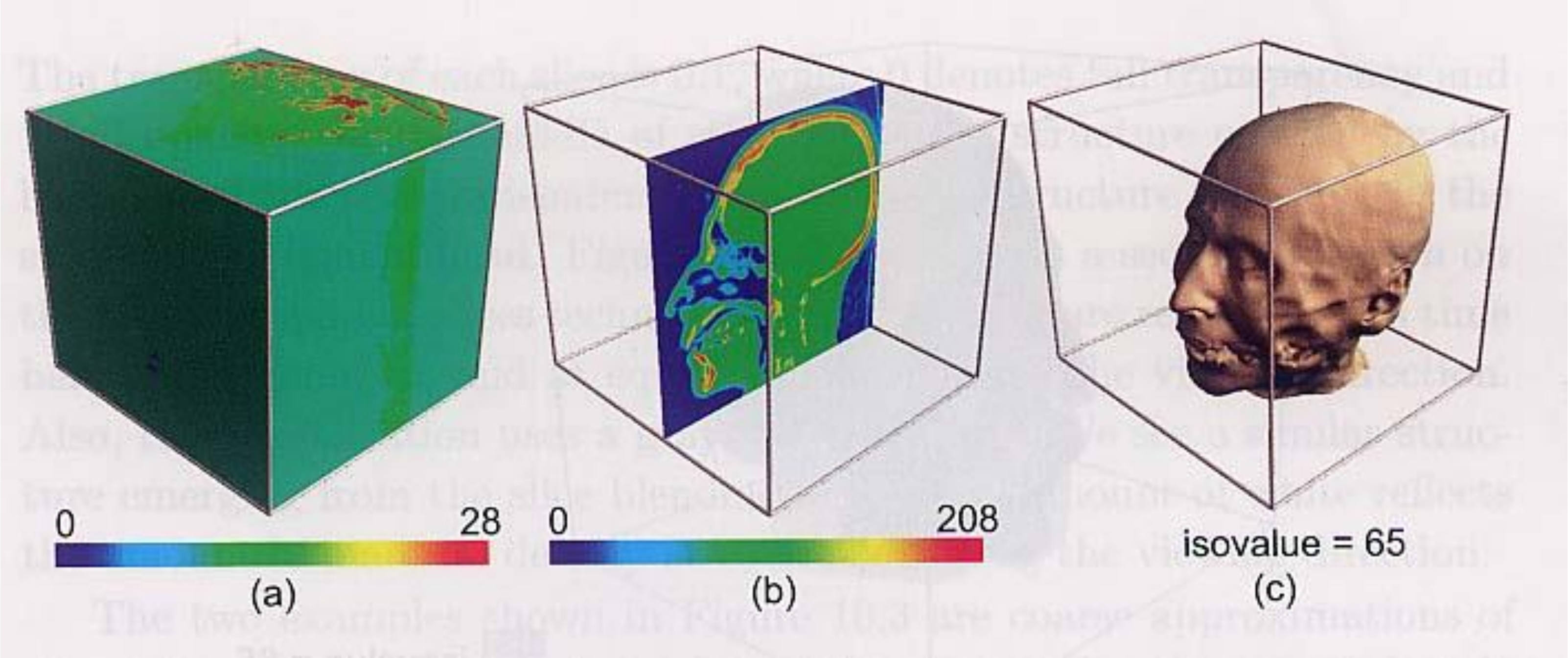
Maximum Intensity Projection



Good at mapping arterial structure, despite occlusion

Displaying images

- Displaying scalar values (3D image)
  - Surface, slice, or isosurface.



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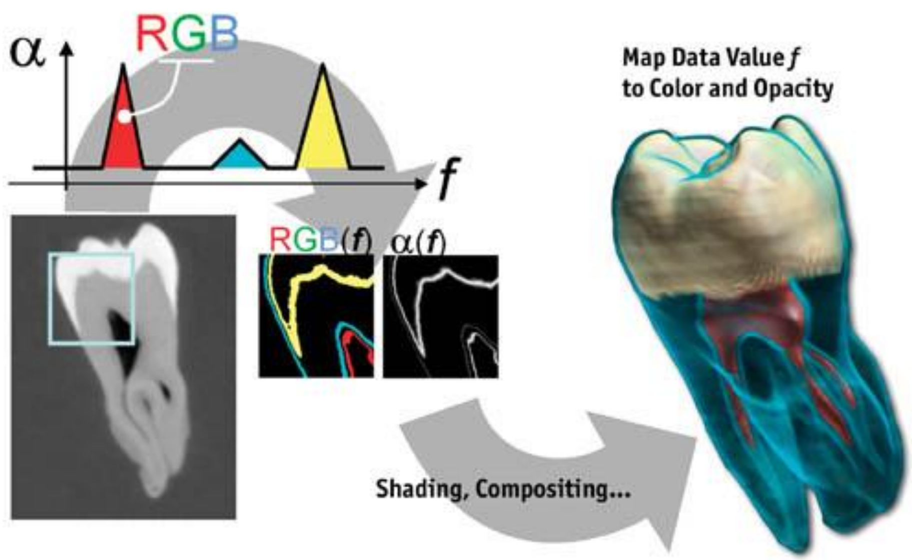
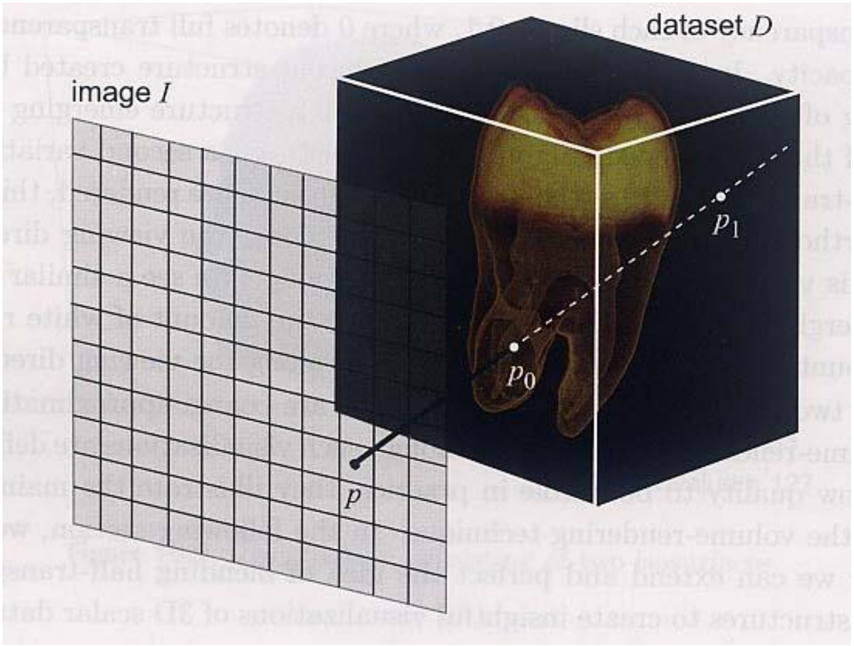
Displaying images

- Volume rendering
  - Transfer function (s): Mapping for each tissue type (scalar value) a colour and opacity.
  - Image projection (Ray casting): take into account (integrate) the voxels that each ray casts. Ray function (F)

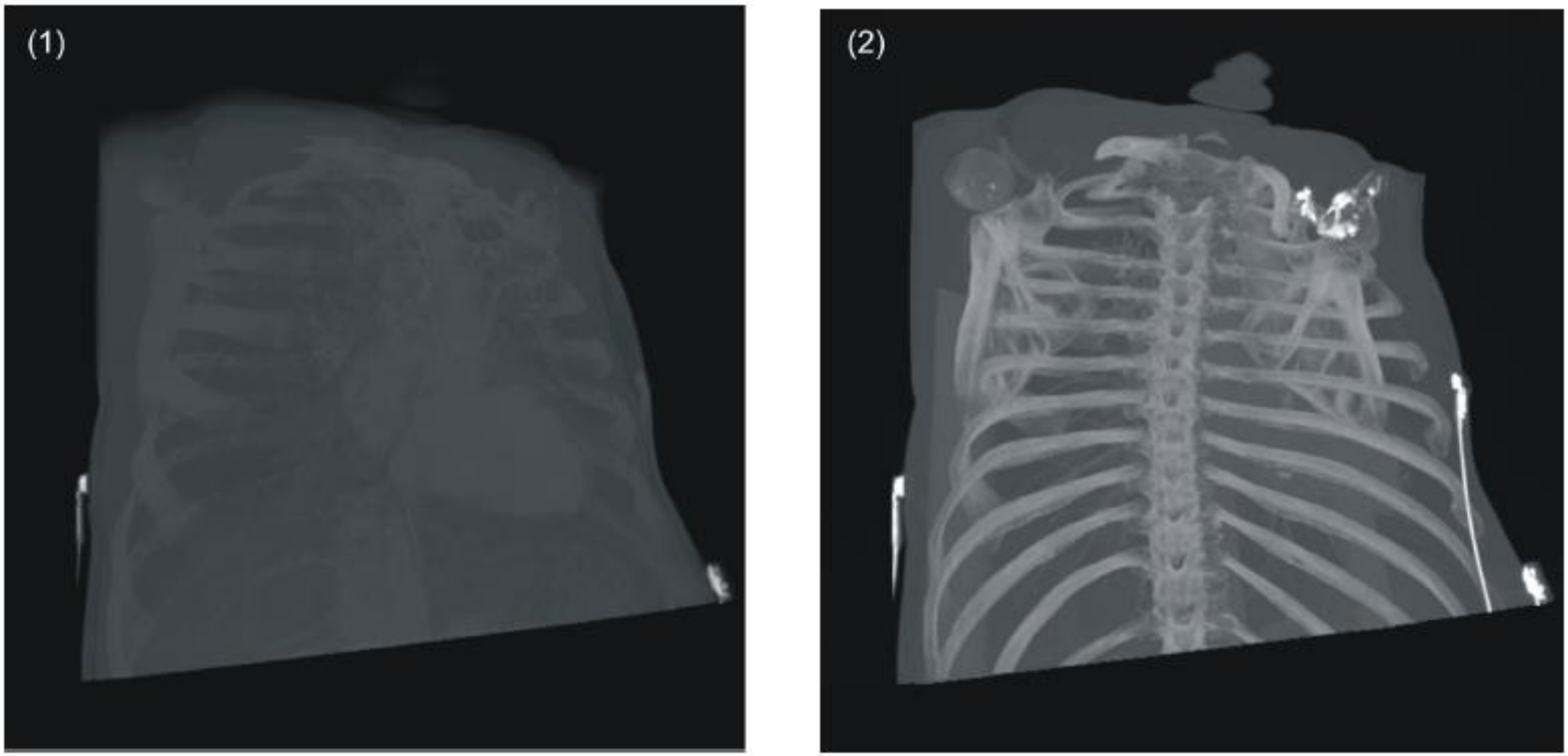




$$I(p) = F(s(t)), \quad t \in [0,1]$$

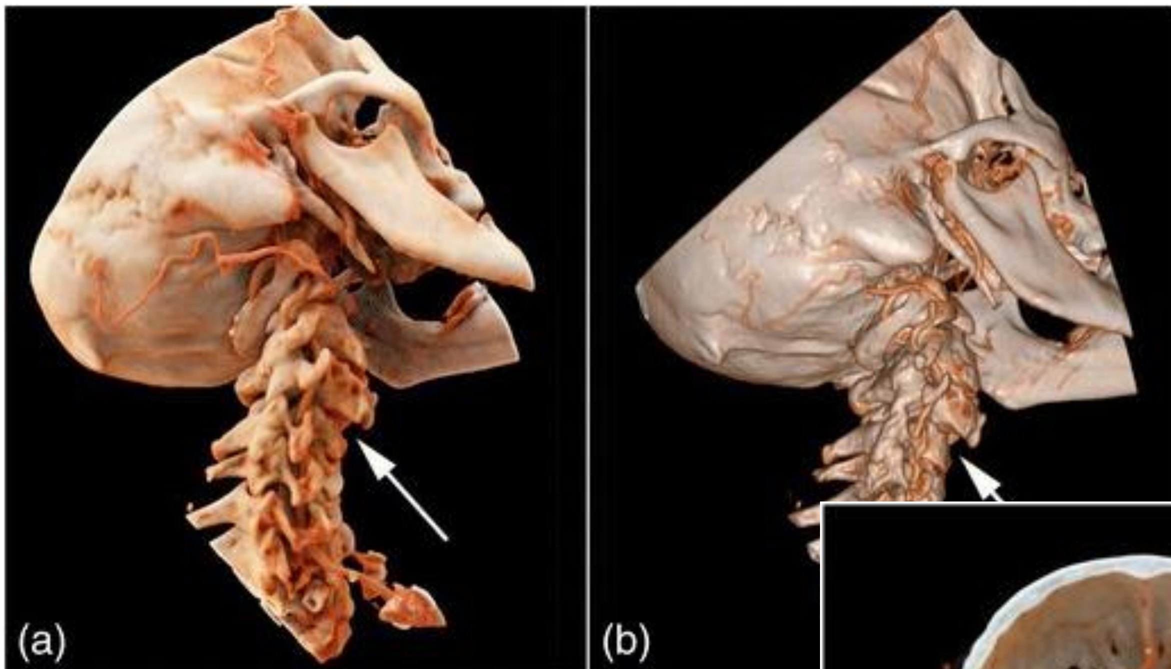
Displaying images

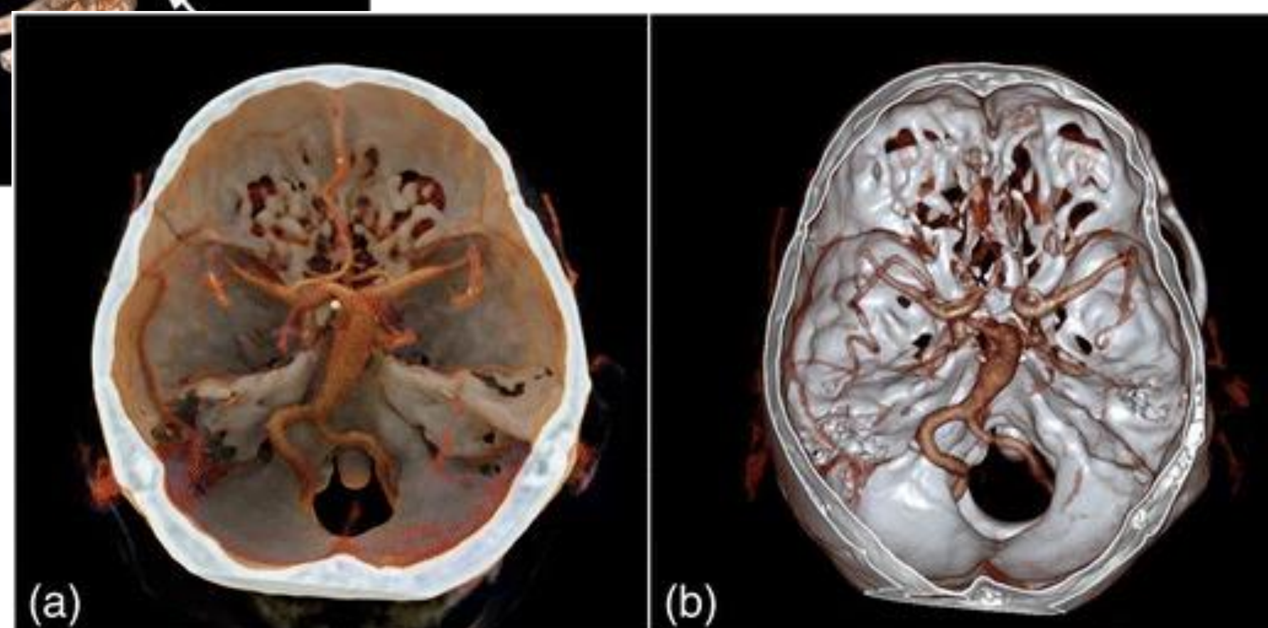
- Volume rendering
  - Ray casting: maximum, mean and minimum intensity.



Displaying images

- 3D Volume Rendering (VR) vs Cinematic Rendering (CR)





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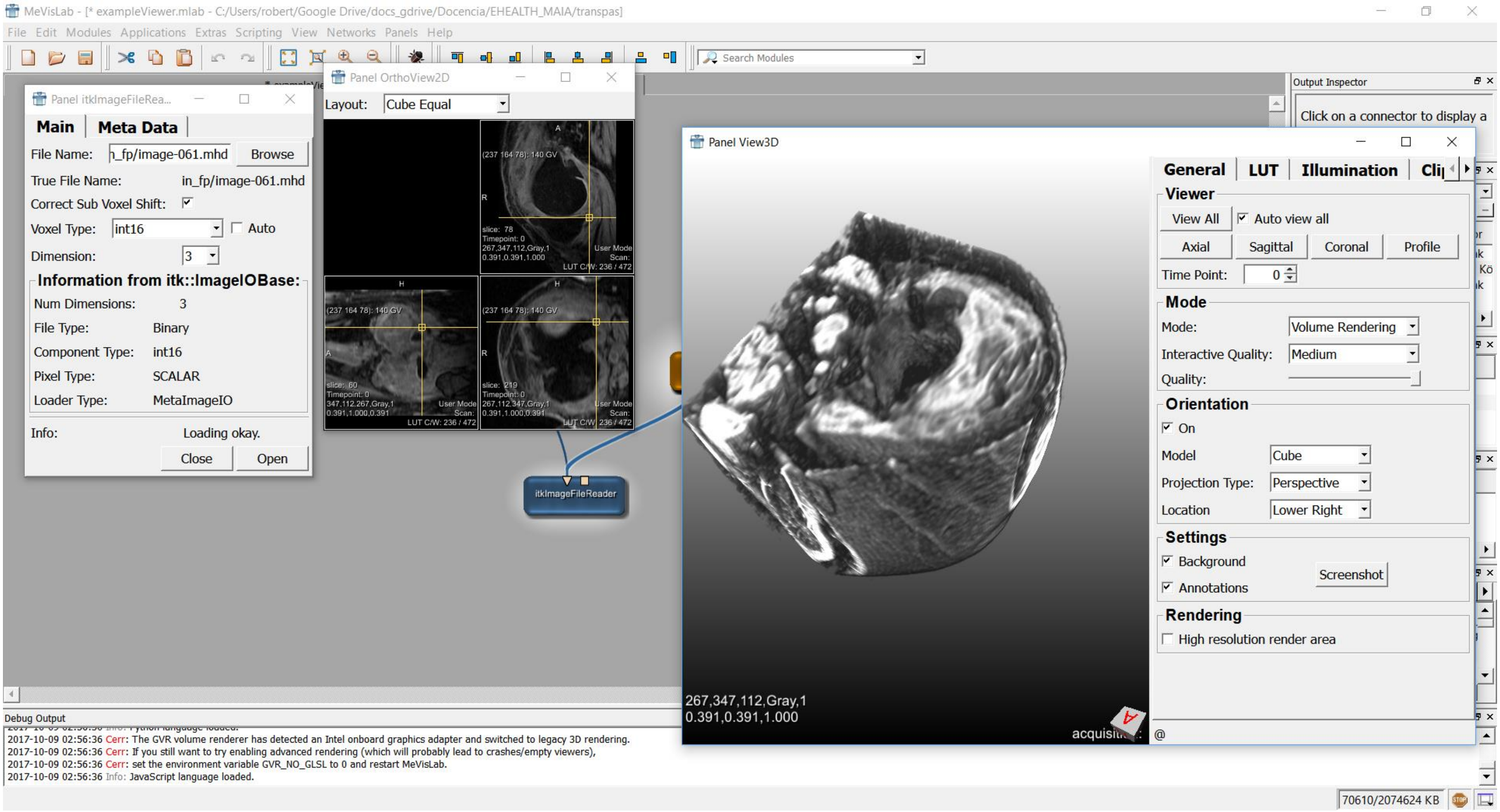
Displaying images

- Example Mevislab.



Bibliography

- *www.aycan.com/applications/mammography/advanced-hanging-protocols.html*
- *http://pacsdisplay.org/*
- *http://www.eizoglobal.com/products/radiforce/index.html*
- *Karssemeijer N., Snoeren P.R. (2010) Image Processing. In: Bick U., Diekmann F. (eds) Digital Mammography. Medical Radiology. Springer, Berlin, Heidelberg*
- Digital Imaging and Communications in Medicine (DICOM)
- Part 14: Grayscale Standard Display Function. *http://dicom.nema.org/dicom/2004/04_14pu.pdf*
- *Cinematic rendering – an alternative to volume rendering for 3D computed tomography imaging. https://link.springer.com/article/10.1007%2Fs13244-016-0518-1*