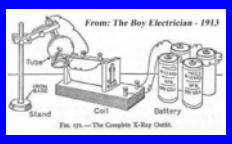
EVOLUTION of FLUOROSCOPY 1895- 2019

Technology, Vision, Cognition



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Columbia University, New York City

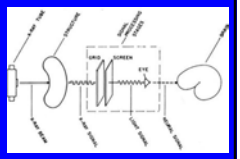
AAPM Refresher Course – July 2019

1

Requirements drive technology

Factors influencing utilization of images

- Nature of the object of interest and its surrounding
- Imaging technology
- Interactions between object and surroundings with beam (Image formation)
- Information transfer to observer's eye (image processing and display)
- Observer's cognition and action



Morgan 1966

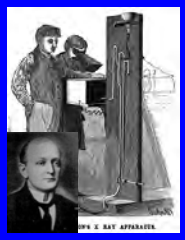
2

[1896-1899] Early days

 DQRQ

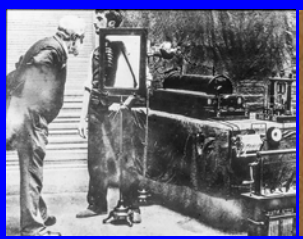
3

c 1900 Fluoro QA Tools



4

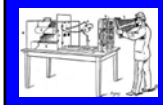
[c 1897] Fluoroscopic examination



 DQRQ ################ hdfrp hiWucvw

5

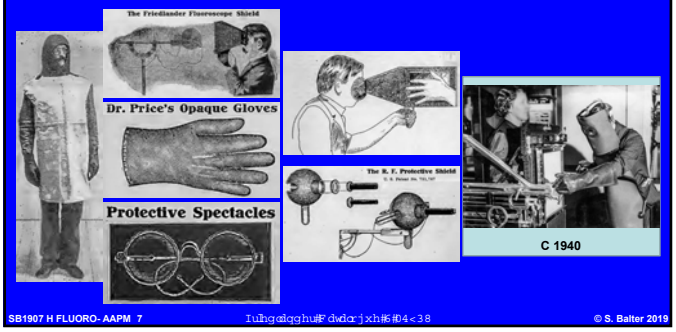
[1897] Customs inspection



 VflhqwlfDp hulfdq

6

[1905] Fluoroscopy radiation protection



SB1907 H FLUORO- AAPM 7 Iuhgdqgghu#Pdwdorjxh#6#D4<38 © S. Balter 2019

7

[1905-1910] Fluoro set with a QA tool

SB1907 H FLUORO- AAPM 8 Iuhgdqgghu#ORdn#Ulgjh#Khdok#Sk|vlfv#Pxvhxp © S. Balter 2019

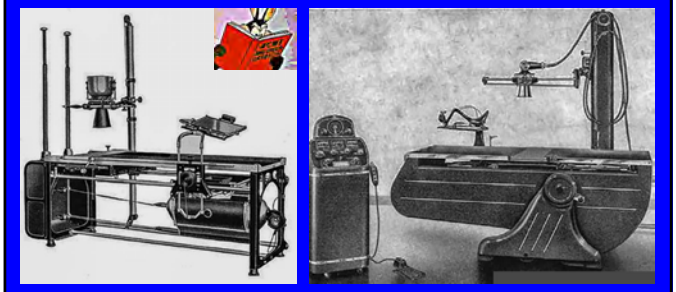
8

[1910] Clinical

SB1907 H FLUORO- AAPM 9 Wrxvh| 5343 © S. Balter 2019

9

[1926, 1940] Radiographic/Fluoroscopic table



SB1907 H FLUORO- AAPM 10 Udglrrj|#Dgyhuwlvhp hqw#ÛDFPH/#SIFNHU © S. Balter 2019

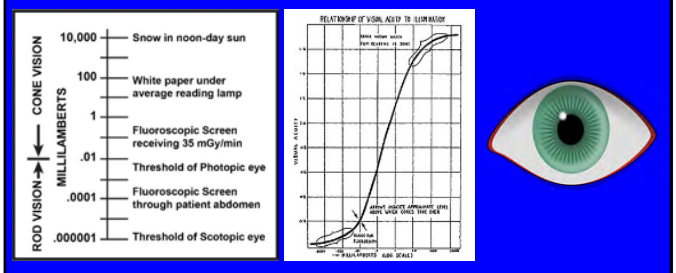
10

[1947] Chest Fluoroscopy

SB1907 H FLUORO- AAPM 11 Rdn#Ulgjh#Khdok#Sk|vlfv#Pxvhxp ###### © S. Balter 2019

11

[1942] Light sensitivity of the eye

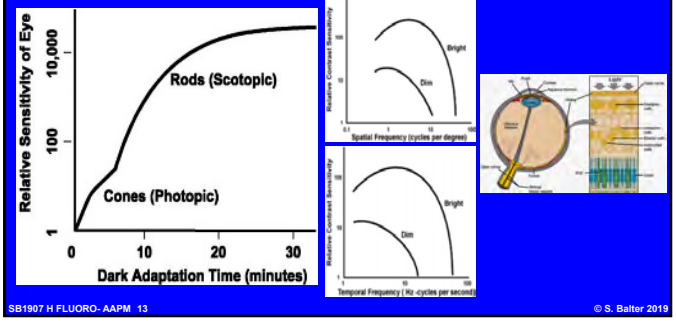


Dynamic range = 10^{10}

SB1907 H FLUORO- AAPM 12 Fkdp ehuqj#<75 © S. Balter 2019

12

Dark adaptation effects



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13

[c 1950] Dark adaptation

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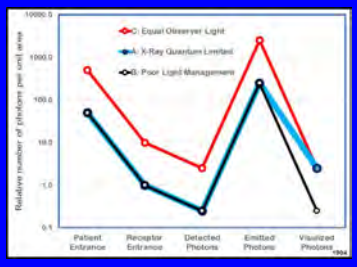
14

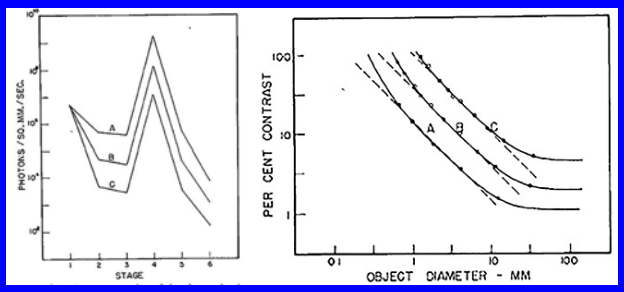
Fluoro screen photon-flux diagram



SB1907 H FLUORO- AAPM 15 © S. Balter 2019

15

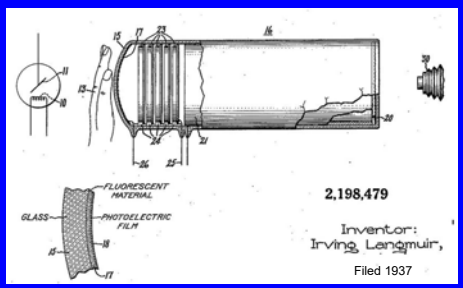
[1949] Dose limited perception



SB1907 H FLUORO- AAPM 16 Vwcup # #Prujdq##<7< © S. Balter 2019

16

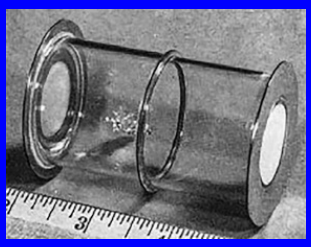
[1940] Image intensifier patent (GE)

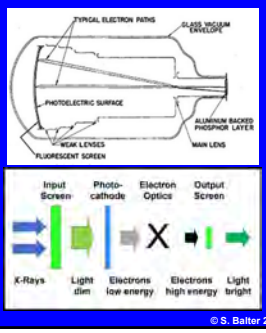


SB1907 H FLUORO- AAPM 17 XV#Sdwhqw#Rilfh © S. Balter 2019

17

[1948] Image intensifier

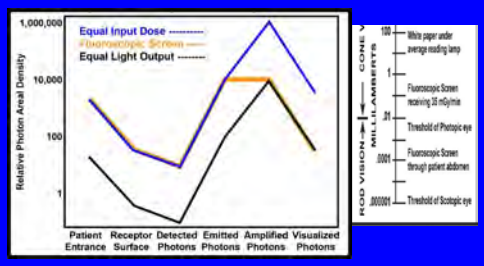




SB1907 H FLUORO- AAPM 18 Frqp dq 4<7; © S. Balter 2019

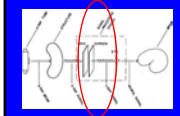
18

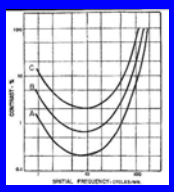
Brightness gain: Quantum Sinks

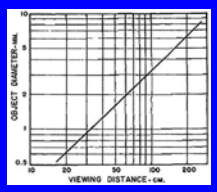


19

[1966] Perception Viewing Distance



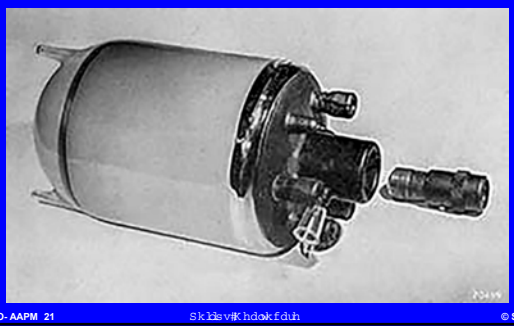




 Prujdq#<99

20

[c 1955] 5" Intensifier tube and optic



 Skklsvi#Khdokfduh

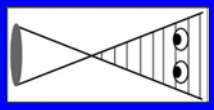
21

[1956] Mobile II with monocular viewer

 Skklsvi####Edohuiℂ #Skklsvi#5349

22

[c 1965] Mirror optics



Skklsvi#Khdokfduh##################Bfnhu

23

[1966] Fluoroscopic systems

[1965]

[2013]

 Edohuiℂ ##<99#UVQD##########UDGIROR J\#dg#<98

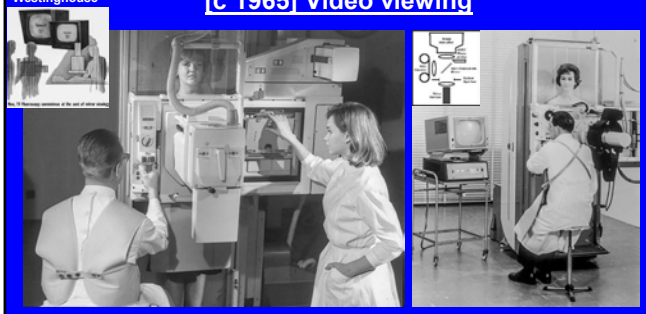
24

Video tubes and cameras

25

[c 1965] Video viewing

Westinghouse



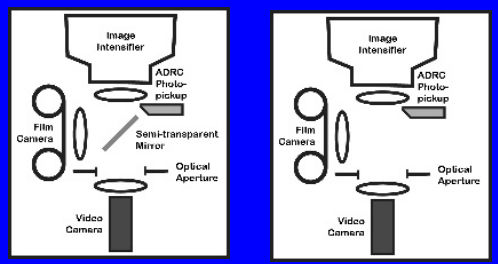
26

[c 1965] Cine + video + mirror

- Camera is likely to be a vidicon.
  - Target technology causes ghosting (due to signal decay).
  - Orthocons used for broadcast TV to eliminate ghosting artifacts.
  - Beneficial for fluoro because lag integration reduces image noise.
- Plumbicons (later tech) had faster targets and almost no lag.
  - Complaints about noisy images (SVH-1972)
  - Lag reintroduced via digital processing. (recursive filtering)

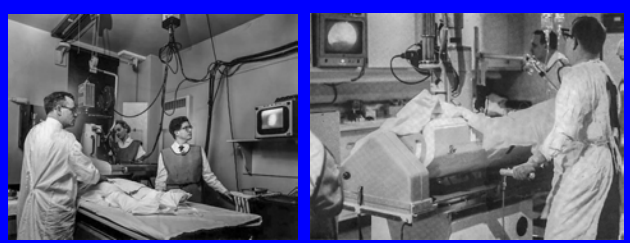
27

Optical distributer with film camera



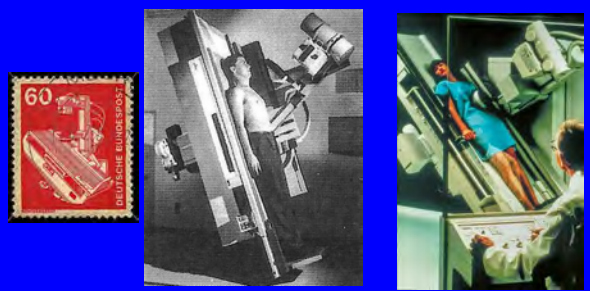
28

[c 1965] Cardiac Catheterization Labs



29

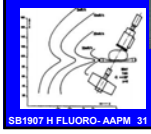
[c 1970] Under table image intensifiers



30

[c 1970 – 2000] II based C-arms



f#<:3#Sklasv#Khdokfduh######f#5333#Vhp hqv#Khdokqhhuv#

31

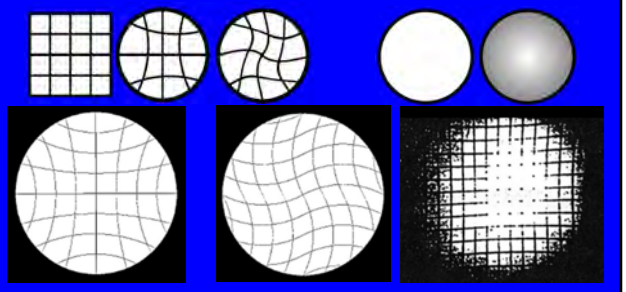
[1975] Dual mode II tube & II factory




Sklasv#Khdokfduh

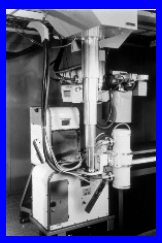
32

Image Intensifier / Optical - Artifacts



33

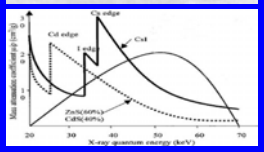
[c 1970] Radiographic rapid film changers

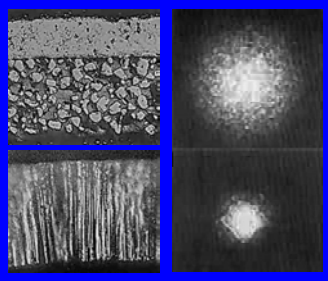


Shonander St. Vincent (Worcester MA) Sanchez-Perez

34

[c 1975] ZnCdS – CsI Input screens

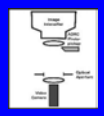



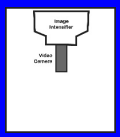


Sklasv#Khdokfduh

35

[1980] Close-coupled video pickup

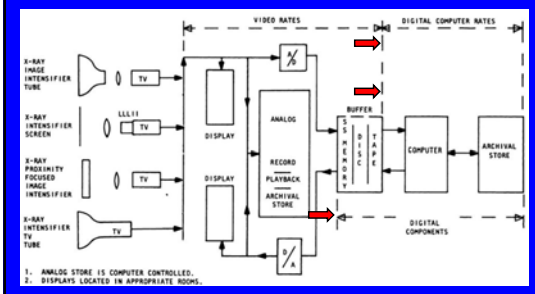






Sklasv#Khdokfduh

36

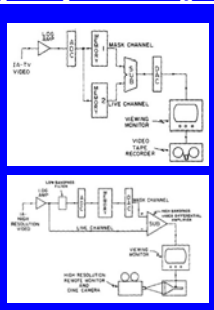
[1980] forecast for 2000

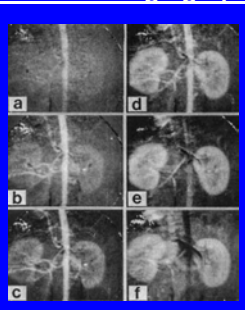


1981 IBM PC
about $ 2,500
($21,000 in 2019 $
Intel 4.77 MHz
16 K - 640 K
24 lx 80 characters
Dual 160 KB 5.25 floppy

37

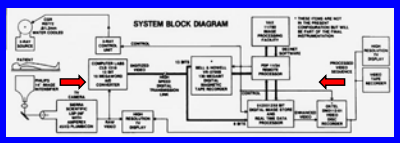
[1979] IV Analog Subtraction Angiography





38

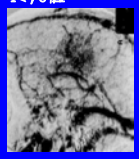
[1980] Digital Subtraction (DSA)



39

[c 1980] DSA Hardware

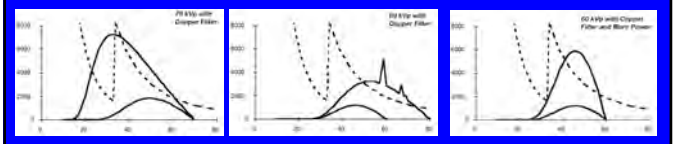
4<;6#X



534<#D

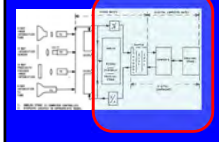
40

[c 1990] Spectral shaping



41

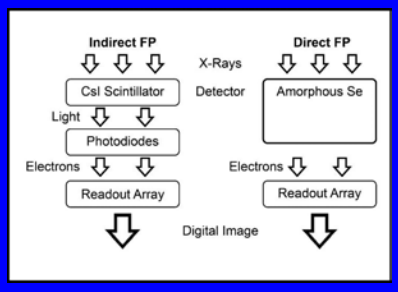
[c 2000] Digital fluorography replaces film and analog



DICOM
Digital Imaging and Communications in Medicine

42

[2000] FP Detector technology



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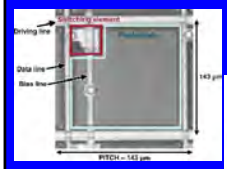
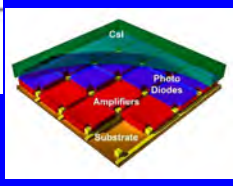
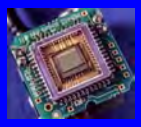
43

[2000] Indirect FP components







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Spatial Resolution = *f*(detector & image handling)

TABLE 1: Illustrative specifications of two current (2019) Flat Panel Fluoroscopic Image Receptors. (adapted from published specifications of commercially available devices)

DEVICE CLASS	Large (nominal 43 cm diagonal)		Small (nominal 25 cm diagonal)	
Nominal pixel size	0.15 x 0.15 mm		0.18 x 0.18 mm	
Field of View	FOV	Matrix	FOV	Matrix
Usually labeled as diagonal	43 cm (30 cm)	2,000 x 2,000	---	---
(corresponding edge of field)	30 cm (21 cm)	1,400 x 1,400	25 cm (18 cm)	1,000 x 1,000
	21 cm (15 cm)	1,000 x 1,000	20 cm (14 cm)	800 x 800
	15 cm (10 cm)	660 x 660	13 cm (9 cm)	500 x 500
Digital Output Specification	Matrix	Binning	Matrix	Binning
Radiographic Output (< 6 fps)	2,048 x 2,048	no	1,024 x 1,024	no
Fluoro Output (@ 30 fps)	1,024 x 1,024	fluoro	1,024 x 1,024	no
Fluoro Output (@ 60 fps)	512 x 512	fluoro	512 x 512	fluoro

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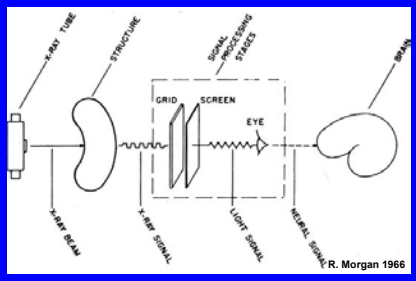
[2010] Fluoroscopic information flow



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32 x 32 (0.006%)

Pt. Gender?
Finding?

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Comparison with normal

SB1907 H FLUORO- AAPM 48 © S. Balter 2019

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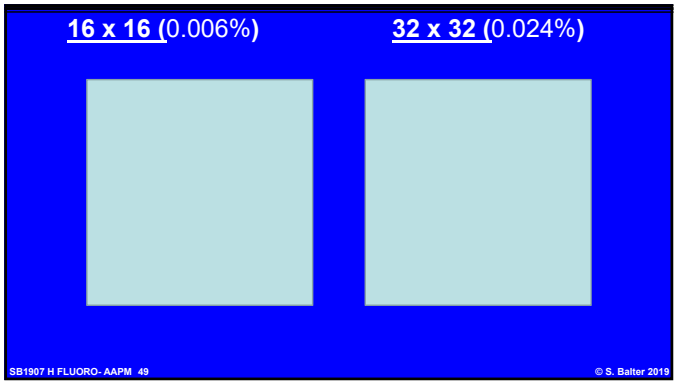
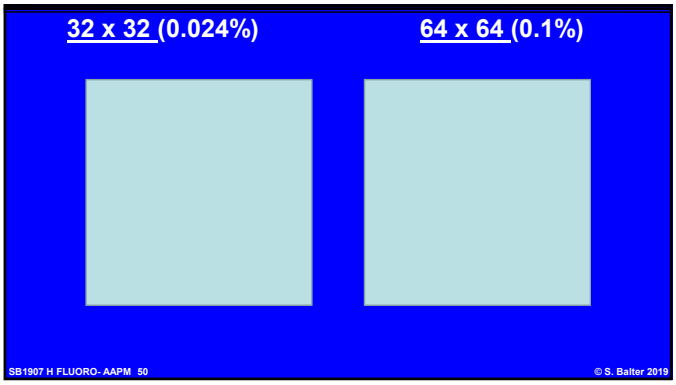


49



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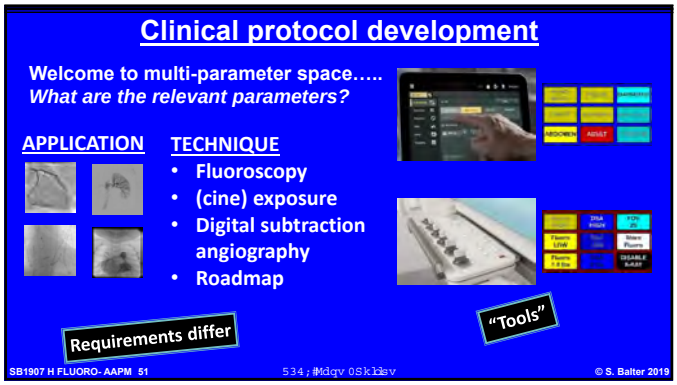
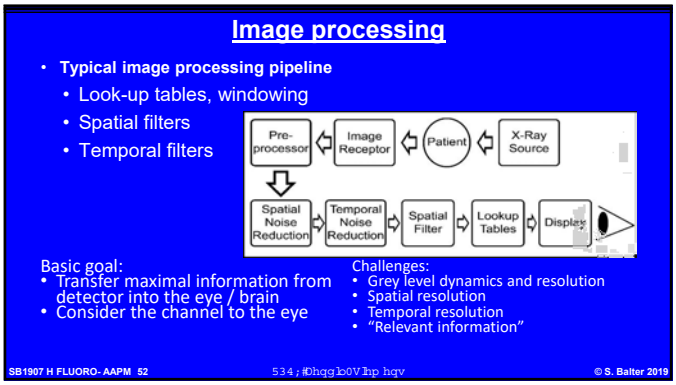


51



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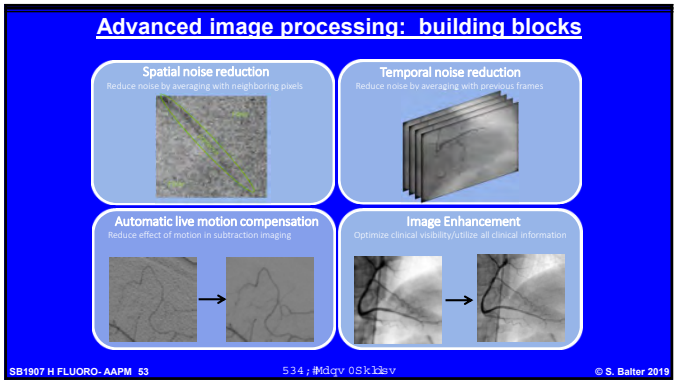

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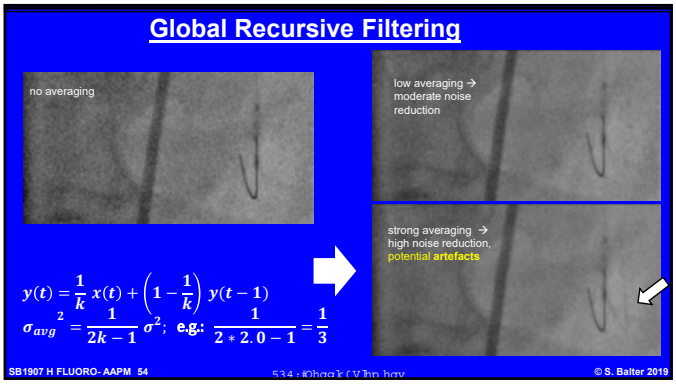

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Content-Aware Image Processing

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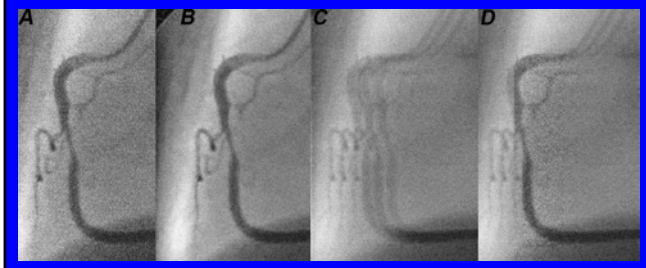
Simulation of Local Image Processing



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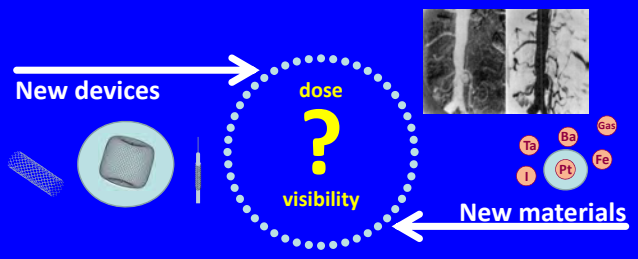
Optimization for material of objects of interest



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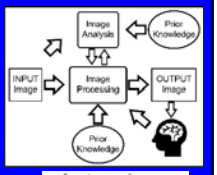
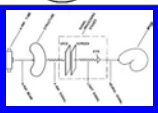
Goals for processing

- **Adjust image processing to the clinical task**
  - A-priori knowledge for the specific clinical task
  - Consider (image) context
  - Model-based approach (for finding devices, like wires and stents)
  - Configure image pipeline for dedicated protocols
- **Optimize image presentation to the eye / brain**
  - Grey level dynamics, contrast (coarse and detail), noise, size of structures
- **Create image presentation preferred by user**
  - Image presentation is subjective
  - There is no "one fits all"





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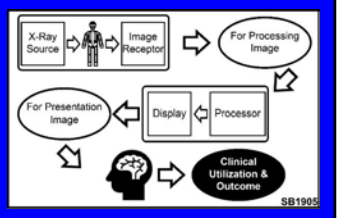
What's past is prologue*

- **1896 – 1925 Open systems requiring considerable operator interaction**
- **1920 – 1970 Closed systems with fluoroscopic screens**
- **1955 – 2000 Image intensifiers with analog image handling & film**
- **1980-2019 DSA**
- **1990 – 2019 Image intensifiers with X-ray spectral management, digital image handling & PACS**
- **2000 – 2019 Flat Panel detectors, IEC standards for fluoro**
- **2010 – 2019 Adaptive processing**



* Shakespeare – Tempest

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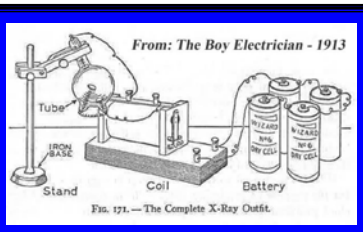

Questions ?

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