

Medical Image Processing for Diagnostic Applications

Flat Panel Detectors

Online Course – Unit 14

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Pattern Recognition Lab (CS 5)

Topics

we need preprocessing for specific modalities

Flat Panel Detectors

About the Concept of Flat Panel Image Receptors

Properties of Flat Panel Detectors

Hardware Details

Summary

Take Home Messages

Further Readings

Flat Panel Image Receptors ...

- ... replace image intensifier technology and film.
- ... implied profound changes in radiology.
- ... are well established in
 - digital radiography,
 - cardiology, and
 - mammography.

works similar to old xray film tech result gets directly recorded digitally

Killer Applications of Flat Panel Detectors

With the introduction of flat panel detector technology, standard radiography systems could **increase patient throughput**, and they experienced a **significant simplification of image archiving and image exchange** with other hospitals and physicians.



Figure 1: Radiography system using flat panel detectors (image courtesy of Siemens Healthcare)

Killer Applications of Flatpanel Detectors I

- **Cardiology:** In cardiology, flat panel detectors were introduced in 2002.
- **Neuroradiology:** Biplane flat panel detector C-arm systems are available on the market since 2006.



Figure 2: Cardiac system using a flat panel detector (left), biplane neuroradiology system (right) (image courtesy of Siemens Healthcare)

e.g. cure arrhythmia by scarring vessels from inside to electrically insulate them - x-ray guided

Killer Applications of Flatpanel Detectors II

Flat panel detectors allow for 3-D reconstruction of static, low contrast objects using C-arm systems.

The following images show examples of the contrast resolution achieved by today's C-arm CT devices and algorithms.

this image is contrast agent image
minus normal image -> only contrast

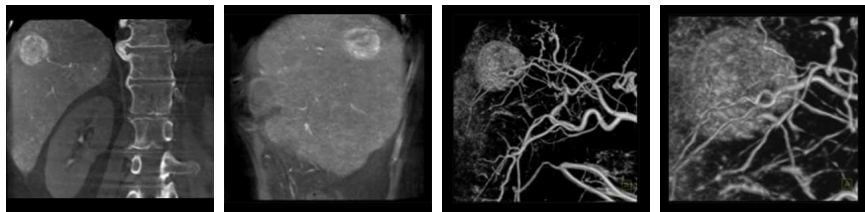


Figure 3: 3-D low contrast C-arm reconstruction of hepatocellular carcinoma (image courtesy of Siemens Healthcare)

Killer Applications of Flatpanel Detectors III

flat panel not affected by magnet field

this machine steers a catheter with a big mag field ->
use ct to check position and guide mag.

In **magnetic navigation systems** the catheter is directed by a magnetic field. The manual control of its orientation is based on X-ray images.

Obviously it is impossible to operate an image intensifier in a magnetic field, thus flat panel technology is mandatory.



Figure 4: Niobe system for magnetic navigation (image courtesy of Siemens Healthcare)

Advantages of Flat Panel Detectors

- Simple assembly and readout
- Higher contrast resolution (high dynamic range)
- Not sensitive to magnetic fields (no magnetic distortion)
- More robust with respect to under- and overexposure
- Reduced space requirements (do not underestimate this advantage!)
- Optimization of the clinical workflow
- Mechanically rugged

Disadvantages of Flat Panel Detectors

- Relatively slow readout
- Still an expensive technology (will change over time)
- High rejection rate in production **defect pixels to high**
- Elimination of defects with digital image processing

Contrast Resolution

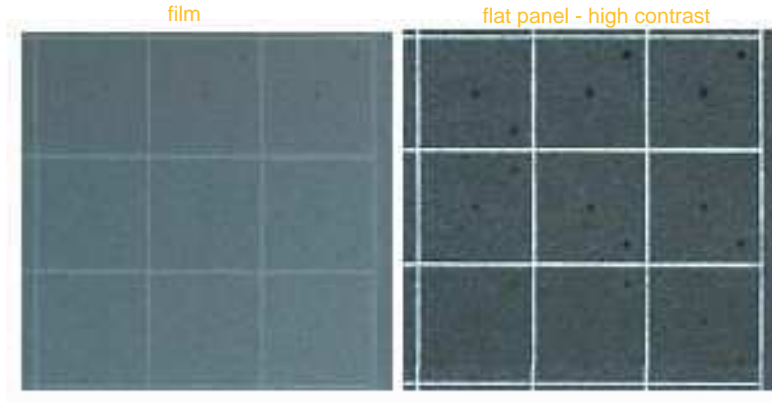


Figure 5: Higher contrast resolution using flat panel detectors: left image acquired on film, right image acquired with a digital detector (image courtesy of General Electric)

Goals of Flat Panel Design

- Digital imaging in all areas of radiology (replace film & image intensifiers)
- Cost reduction in health care (elimination of film!)
- Improved image quality
- Waste minimum amount of incoming X-ray (fill factor $\sim 40\%$)
- Detection area sizes more than $40\text{ cm} \times 40\text{ cm}$
- Spatial resolution of pixels $50\text{ }\mu\text{m}$ to $150\text{ }\mu\text{m}$

Flat Panel Detectors

Typical image data of a Pixium 4600:

- area: $43\text{ cm} \times 43\text{ cm}$,
- resolution: 3001×3001 ,
- pixel size: $143\text{ }\mu\text{m}$,
- quantization: 14 bit (2 byte).



Figure 6: Pixium 4600

Flat Panel Detectors

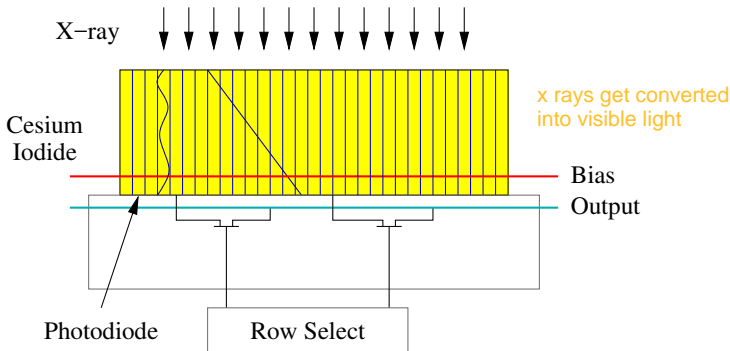


Figure 7: Scheme of a CsI based detector

Flat Panel Detectors

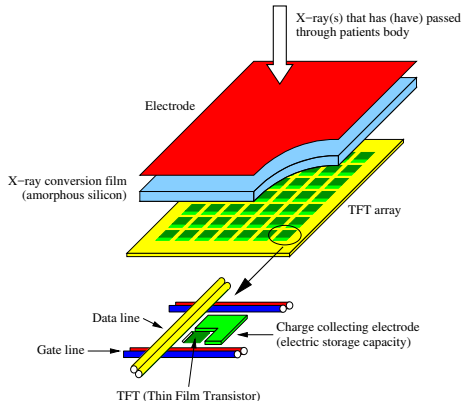


Figure 8: Direct conversion using amorphous silicon

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flat panel is state of the art

- Flat panel detectors are the modern detector technology in digital X-ray systems.
- There exist different principles to realize a flat panel image receptor.
- Applications for flat panel detectors are manifold, and the technology has a lot of advantages including a higher contrast resolution compared with film.
- However, digital **image processing is necessary** to **compensate for manufacturing flaws**.

Further Readings

- One starting point for more information on flat panel detectors could be vendor webpages like, e.g., from Varian, or Trixell.
- The method presented for defect pixel interpolation in the frequency domain was published by Til Aach and Volker Metzler in 2001:

Til Aach and Volker Metzler. “Defect Interpolation in Digital Radiography: How Object-Oriented Transform Coding Helps”. In: *Proc. SPIE 4322, Medical Imaging 2001: Image Processing*. Vol. 4322. San Diego, CA: SPIE, Feb. 2001, pp. 824–835. DOI: 10.1117/12.431161

- A recent article about defect pixel interpolation with respect to image quality issues can be found here:

Jan Kuttig et al. “Effects of Defect Pixel Correction Algorithms for X-ray Detectors on Image Quality in Planar Projection and Volumetric CT Data Sets”. In: *Measurement Science and Technology* 26.9 (Aug. 2015), 095406 (14pp). DOI: 10.1088/0957-0233/26/9/095406