Medical Image Processing for Diagnostic Applications

Flat Panel Detectors

Online Course – Unit 14

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Topics

Flat Panel Image Receptors ...

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

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)

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.

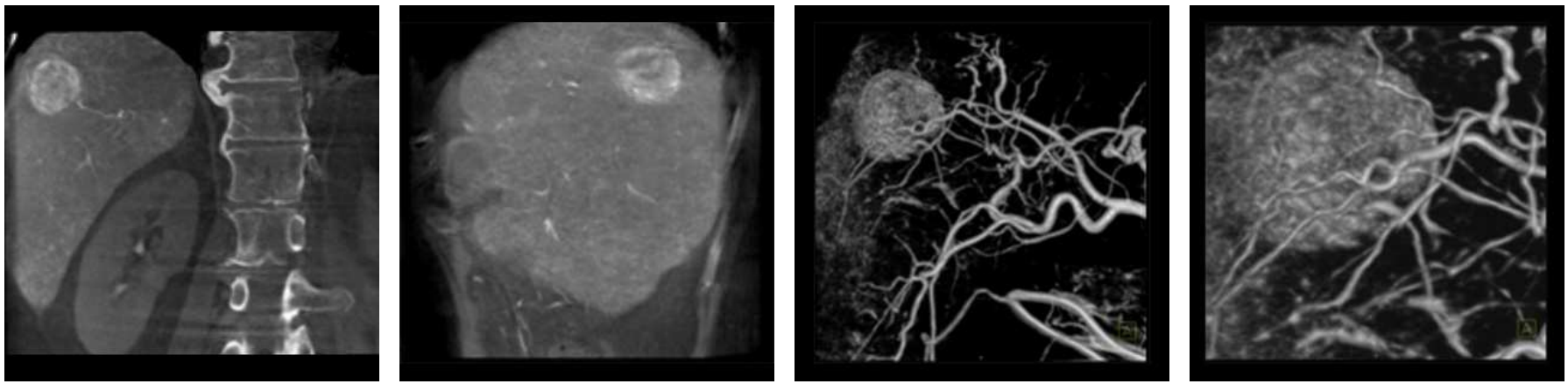

Figure 3: 3-D low contrast C-arm reconstruction of hepatocellular carcinoma (image courtesy of Siemens Healthcare)

Killer Applications of Flatpanel Detectors III

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
- Elimination of defects with digital image processing

Contrast Resolution

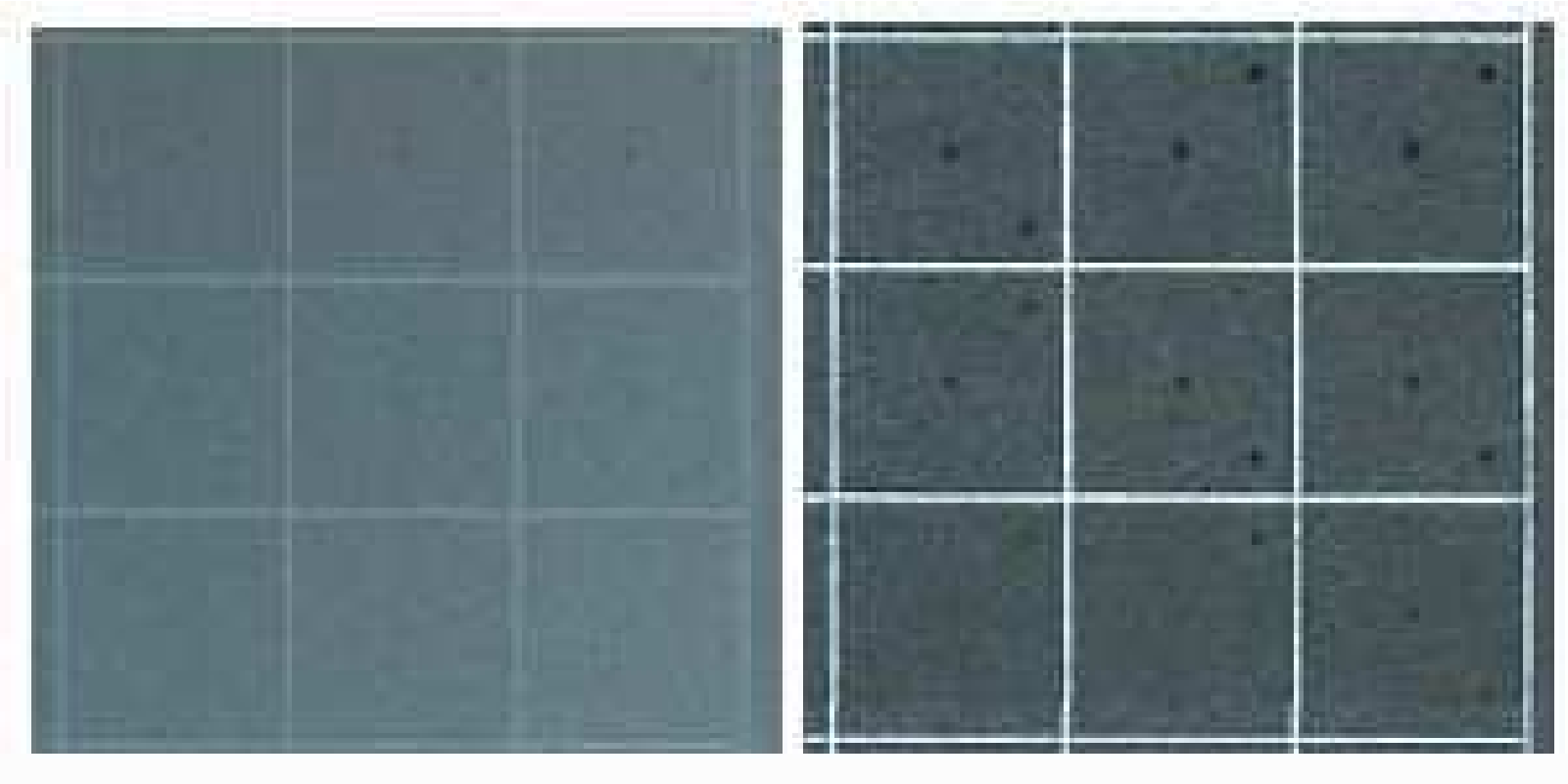

Figure 5: Higher contrast resolution using flat panel detectors: left image acquired on film, right image acquired with a digital detector (image courtesy of General Electrics)

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 cm $\times$ 40 cm
- Spatial resolution of pixels 50 µm to 150 µm

Flat Panel Detectors

Typical image data of a Pixium 4600:

- area: 43 cm $\times$ 43 cm,
- resolution: 3001 $\times$ 3001,
- pixel size: 143 µm,
- quantization: 14 bit (2 byte).

Figure 6: Pixium 4600

Flat Panel Detectors

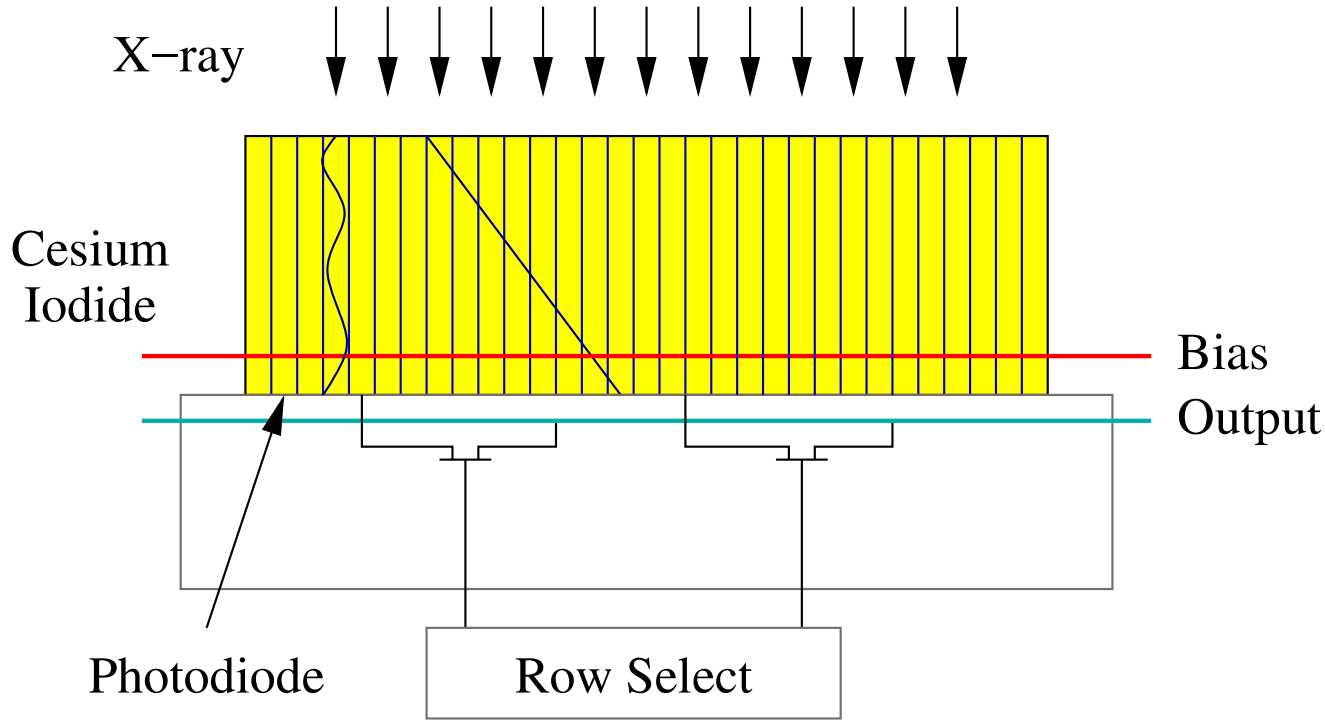

Figure 7: Scheme of a CsI based detector

Flat Panel Detectors

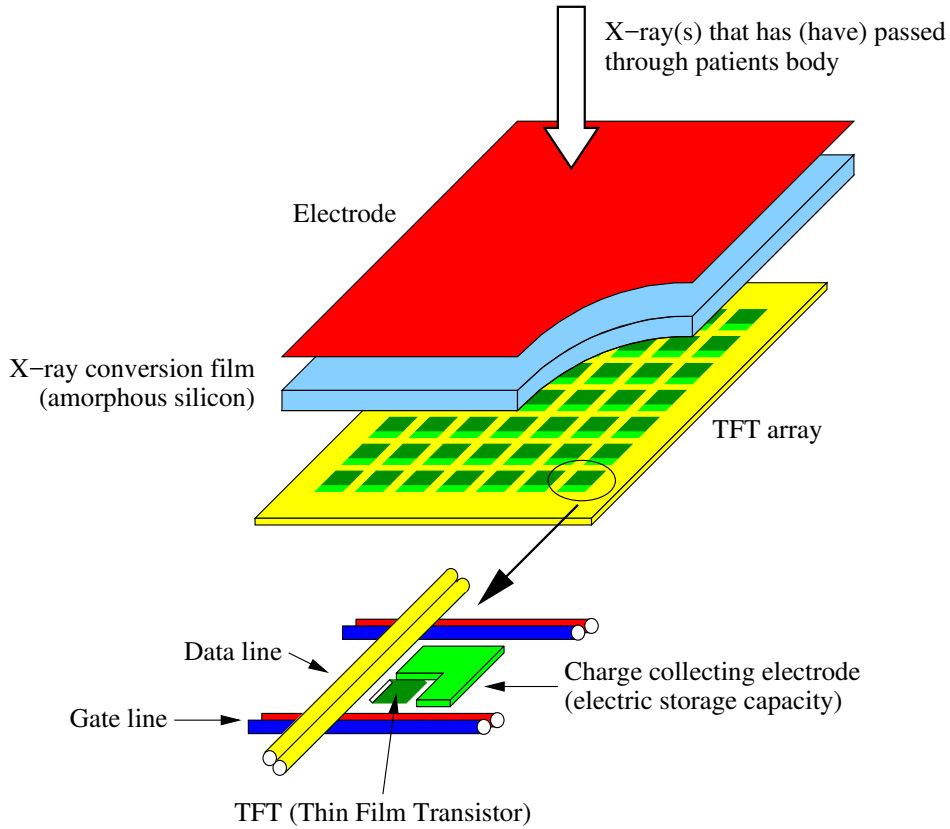

Figure 8: Direct conversion using amorphous silicon

Topics

Take Home Messages

- 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