Transitioning to Digital Radiography Detectors

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Abstract: Recently, digital radiology systems have been replacing screen film technology. During the last two decades, digital radiology applications have a wide acceptance in healthcare facilities. Manufacturers provide different types of digital detectors that improve image capture, image quality, readout, archiving, post-processing and communication system. Digital images detectors based in converting X-ray images into digital form combined with computer aided application which is open the door for new diagnostic procedures.

Keywords: Digital Radiology, Digital Detectors, Image Intensifier, Flat Panel Detector.

I. Introduction

Digital radiology systems have been increasingly replacing the traditional systems which based on films and cassettes. Over the last two decades, digital radiology technology has been gained a wide acceptance in human radiology applications. Technically, digital radiology offers many advantages over the conventional system. Since the fact that, digital radiology based on digital acquisition and reconstruction of obtained images, it influences work process by reducing time of procedures, decrease the cost, increase images quality and promote better safety for patients and operators regarding to decrease the required dose. On the other hand, another factor that promotes the widespread of digital radiology is the increasing numbers of manufacturers and vendors who are invested in this field such as Siemens, Philips, Agfa, Fuji, GE, Toshiba and Hitachi. Where the high level of competition between vendors across the world market significantly reduces price of digital radiology systems.

Basically, conventional radiology systems consist of silver halide–based films and cassettes. X-ray films usually made of silver bromide (AgBr2) as a photosensitive compound. When the X-ray photons hit the film, Br ions released and captured by Ag ions. This situation called latent hidden image, but cannot be detected by ordinary method, therefore chemical solution known as developer is required to form black, metallic silver image based on the absorbed energy of X-ray.

Transition to digital radiology systems firstly obtained by the principles of computed radiology (CR) in 1990s. CR systems emulated the tradition films and cassettes by using a large field of view readers based on X-ray photostimulable phosphor sensitive materials and optical lenses to focus obtained X-ray into small area of array consisted of charge coupled device (CCD) photodetector.

Digital radiology systems are mainly consisting of digital detectors that absorb X-ray energy exit from patient body. Then, the absorbed X-ray energy is converted to electrical charges that are digitalized and quantified into gray scale image proportional to the amount of absorbed energy [1].

II. Methodology

Incident X-ray in digital radiology systems the must be sampled in both dimensions spatial and intensity. Significantly, the generation of digital image detectors combined with thin film transistors greatly influence the access into digital radiology images. Mainly, there are two type of digital image detectors classified into direct flat panel detector which are based on direct conversion of X-ray beam toward photoconductor layers to generate electrical charge proportional to obtained X-ray. The second type is indirect flat panel detector which is based on phosphor layer to convert obtained X-ray into visible photons. Both direct and indirect flat panel detectors are illustrated in figure 1.

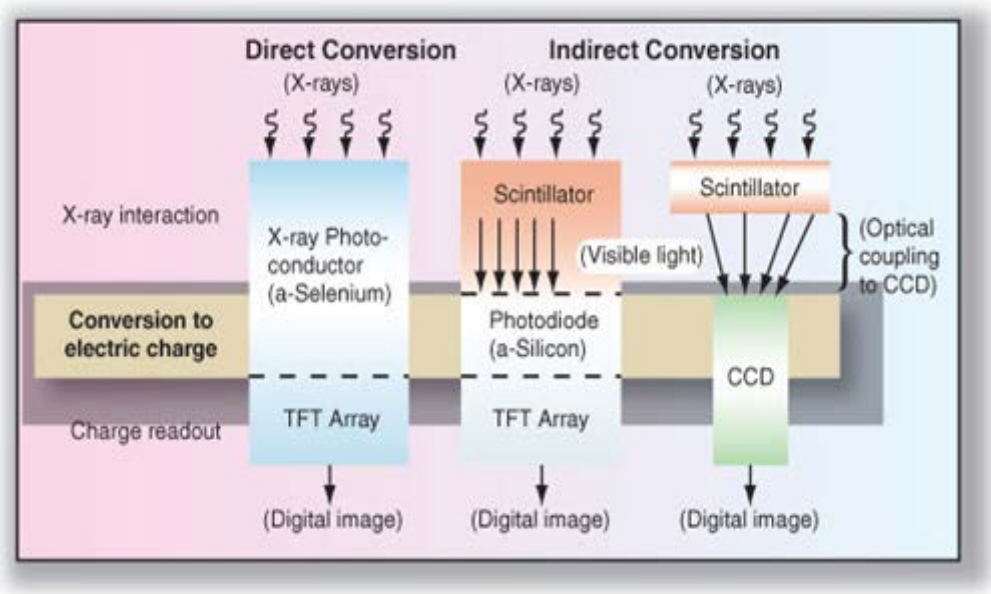

Figure 1: Direct and Indirect X-ray Detectors

The technology behind direct conversion flat panel detector can be described as selenium coated thin film transistor (TFT) absorb or capture the incident X-ray and convert it directly to electrical signal. Selenium layer produce electrons-holes pairs based on the bias voltage applied across the detector and incident X-ray. Then the generated electrical charges are captured by a matrix of storage capacitors to form detector elements (pixels) array.
While the indirect conversion flat panel detectors are made of amorphous silicon integrated with thin films of silicon and coated photodiodes with crystalline cesium iodide scintillator. When X-ray hit scintillator, a visible light is generated proportional to the energy of X-ray beam. Then the visible light photons absorbed by photodiodes array and generate electrical signal. Also, indirect flat panel detectors utilize charge coupled devices (CCD) to capture the visible light photons generated by scintillator. In this type of flat panel detectors, optical lenses system is required to transfer and focus visible light from input side to the output side of CCD [2].

III. Discussion

The principles of direct and indirect X-ray detectors are widely used in modern digital radiology applications. Radiology department in healthcare facilities play a significant role in disease diagnosis, treatment and decision making as well as in surgical procedures. Approximately 30% of medical cases in healthcare facilities are diagnosed by radiology applications. Nowadays, general purpose X-ray systems, Fluoroscopy, Mammogram and Computed Tomography are based on digital image detectors of X-ray. The advantages of using digital technology in radiology department are associated to increase image quality, reduce procedures time and reduce the cost. As well as digital radiology promotes a unique access to hospital information system (HIS) and radiology information system (RIS) that offer an excellent tool to archive patient's data on either hard disc or CD's.

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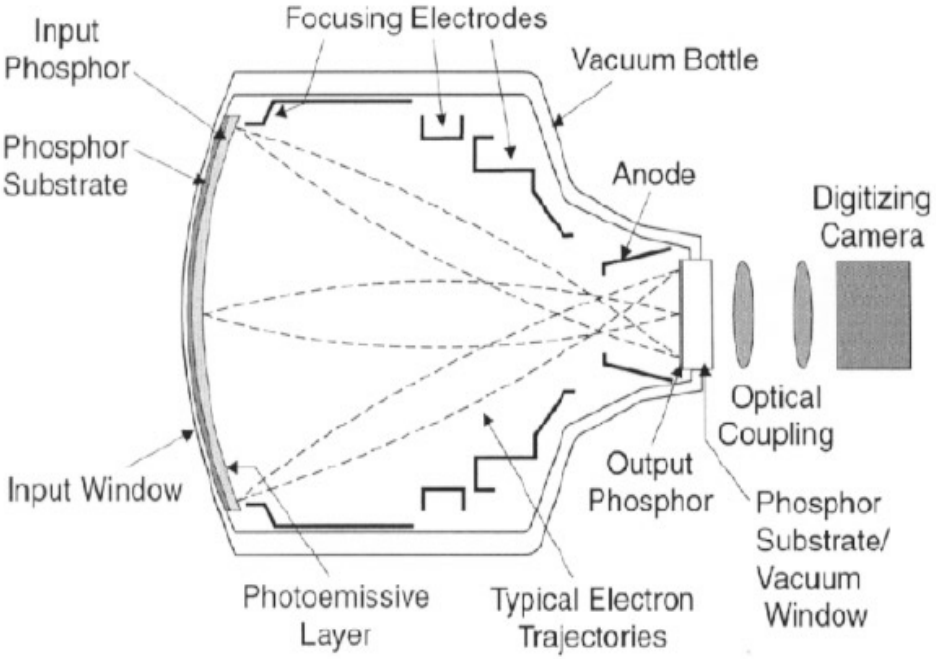

Figure 2: Schematic Diagram of Image Intensifier

One of the most common applications for digital radiology is fluoroscopic X-ray system. Which is extensively coupled with surgical procedures such as interventional, catheterization or vascular surgery. Images digitalization of fluoroscopic X-ray system based on image intensifier (I.I) which is the most popular type of indirect image detectors providing real time visualization as shown in figure 2. In practice, I.I absorbed the incident X-ray beam and converted to light through a wide input phosphor screen usually (12 to 50) cm. the fluorescence layer generates visible photons illuminating photocathode and liberate electrons. Then liberated electrons are accelerated by the effect of high voltage difference applied to both terminal of evacuated tube of I.I. Focusing of electrons achieved by electronic lens system toward small output phosphor screen (2.5) cm. after that CCD camera and TV system are used to pick up the electrical signal at the output phosphor screen and convert it to digital form as shown in figure 3. [3]

Figure 3: Typical Unit of Image Intensifier

On the other hand, flat panel detectors are the common type of direct digital image detector. Large number of individual detectors which are capable to store electrical charge according to incident X-ray beam. Each detector element associated with transistor,

when exposure performed, electrical charge is produced and store to capacitors. The drain gates of transistors (switches) are connected to TFT, therefore when positive voltage is applied to the gate, the transistor is turned on enabling the source to connect to drain as shown in figure 4. [4]

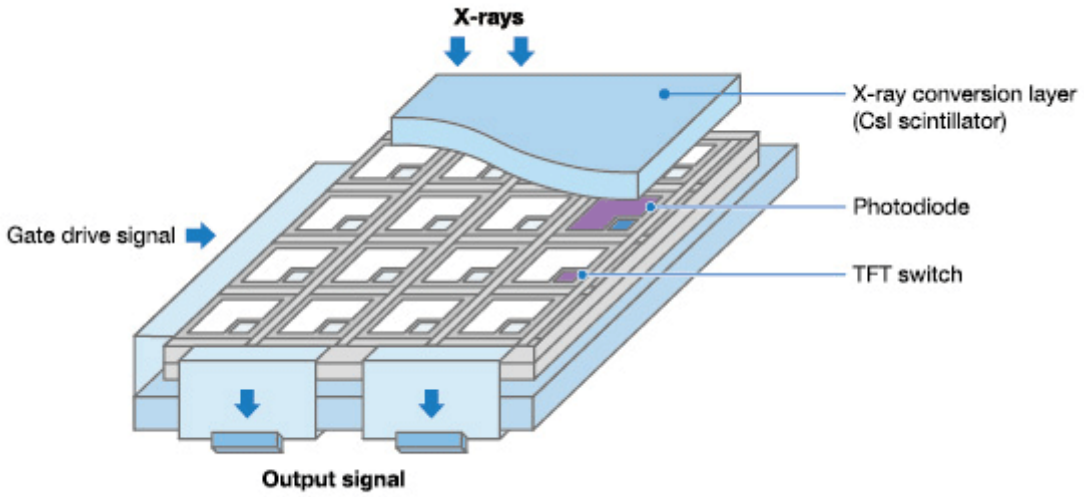

Figure 4: Schematic Diagram of Flat Panel Detector

The technology of flat panel detector is widely implemented in different application of radiology including, general purpose X-ray, mobile X-ray machines, Fluoroscopy and Computed Tomography. Also, flat panel detector can be used in digital radiology as wire or wireless detector that support free movement of detector and help operators to work more easily. The below figure shows the different type of flat panel detectors.

Figure 5: a- Wire Flat Panel Detectore **b- Wirrless Flat Panel Detectore**

IV. Conclusion

Digital radiology applications significantly offer many advantages over conventional radiology systems. Clearly, digital radiology reduces the time and the cost of work process since it is based on filmless procedures without the need for X-ray developing and processing machine to generate X-ray images. In addition to that, digital detectors of X-ray can promote image quality for diagnosis and treatment applications, which minimize the errors during work process. As well as, digital radiology images offer more flexible applications for post-processing including, digital archiving on hard disk or CD's, enable sharing images remotely by HIS or RIS systems.

V. References

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