DESIGN, CONSTRUCTION, AND EVALUATION OF NEW HIGH RESOLUTION MEDICAL IMAGING DETECTOR/SYSTEMS

by

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Abstract

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Increasing need of minimally invasive endovascular image guided interventional procedures (EIGI) for accurate and successful treatment of vascular disease has set a quest for better image quality. Current state of the art detectors are not up to the mark for these complex procedures due to their inherent limitations. Our group has been actively working on the design and construction of a high resolution, region of interest CCD-based X-ray imager for some time. As a part of that endeavor, a Micro-angiographic fluoroscope (MAF) was developed to serve as a high resolution, ROI X-ray imaging detector in conjunction with large lower resolution full field of view (FOV) state-of-the-art x-ray detectors.

The newly developed MAF is an indirect x-ray imaging detector capable of providing real-time images with high resolution, high sensitivity, no lag and low instrumentation noise. It consists of a CCD camera coupled to a light image intensifier (LII) through a fiber optic taper. The CsI(Tl) phosphor serving as the front end is coupled to the LII.

For this work, the MAF was designed and constructed. The linear system cascade theory was used to evaluate the performance theoretically.

Linear system metrics such as MTF and DQE were used to gauge the detector performance experimentally.

The capabilities of the MAF as a complete system were tested using generalized linear system metrics. With generalized linear system metrics the effects of finite size focal spot, geometric magnification and the presence of scatter are included in the analysis and study. To minimize the effect of scatter, an anti-scatter grid specially designed for the MAF was also studied.

The MAF was compared with the flat panel detector using signal-to-noise ratio and the two dimensional linear system metrics. The signal-to-noise comparison was carried out to point out the effect of pixel size and Point Spread Function of the detector. The two dimensional linear system metrics were used to investigate the comparative performance of both the detectors in similar simulated clinical neuro-vascular conditions.

The last part of this work presents a unique quality of the MAF: operation in single photon mode. The successful operation of the MAF was demonstrated with considerable improvement in spatial and contrast resolution over conventional energy integrating mode.

The work presented shows the evolution of a high resolution, high sensitivity, and region of interest x-ray imaging detector as an attractive and capable x-ray imager for the betterment of complex EIGI procedures. The capability of single photon counting mode imaging provides the potential for additional uses of the MAF including the possibility of use in dual modality imaging with radionuclide sources as well as x-rays.