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High Resolution Digital Flat-Panel X-ray Detector Based on Large Area CMOS Image Sensor for Mammography and Fluoroscopy

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With the help of steady efforts to overcome the size limitations of CMOS image sensors, the development of high resolution flat-panel x-ray detectors based on CMOS technology have been greatly valued. Especially, CMOS active pixel sensors (APSs)-based detectors, which have low-noise, high-speed characteristics, are considered to be appropriate for mammography and fluoroscopy applications. This paper introduces a high resolution X-ray detector to acquire high quality images for real-time display.
The high resolution x-ray detector consists of three components: the 12 x 12 (cm2) three-side-tileable CMOS images sensor integrating ADC, a control component, and a host program. The sensor comprises 1200 x 1200 pixels and column-parallel 14 bit digital output. The control component includes on FPGA-based controller to generate control signals for integrating ADC and to acquire and transmit high-resolution image data. This controller is designed to be optimized for a special structure of sensor, which has physically repeated pattern caused by stitching process. Also, it is able to deal with simple image data processing in real time. Lastly, the acquisition data transmit to the host program via Hi-speed USB 2.0 port. In the full-resolution mode, 1 frame data (2.5MB) can be deal within 33.3ms (30fps). In 2 x 2 binning mode, sensor provided, 1 frame data become a quarter of full-resolution data and transmit to end program within 16.7ms (60 fps).
The experiment to evaluate the detector was conducted in two stages: the optical response and performances under the visible light conditions and then x-ray imaging analysis using scintillator. At first, with a visible light source at a wavelength of 550nm, we measured optical characteristics of the CMOS image sensor. Using Photon Transfer Curve (PTC), the performance parameters of the sensor including read noise, full well capacity, and dynamic range were evaluated under specific operating conditions. Also, temporal image characteristics such as Image lags were measured using a visible light source at the maximum frame rate. The parameters from this experiment should be highly regarded for the fluoroscopy and high-frame-rate applications. For the next step, we obtained the x-ray images by attaching on the active pixel area, which converts x-ray to visible light of wavelength 550nm. The x-ray source operating condition was operated at 75 kVp, 64 mA. Additionally, the spatial resolution of our x-ray detector system was evaluated by calculating MTF performances from images of the line pair set
In this paper, we provide details on the architecture of the high resolution flat-panel x-ray detector and present the results of evaluation for characteristics.

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