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Development and imaging optimization of X-ray intraoral imaging sensor for dental tomosynthesis applications

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In recent years, digital indirect X-ray imaging sensors have been widely used in many dental imaging applications such as intraoral, panorama and dental CT. These digital indirect detectors are based on the utilization of a complementary metal-oxide semiconductor (CMOS) array with different scintillating screens such as CsI, Gadox. Currently, a CMOS-based indirect X-ray imaging sensor with high spatial resolution has been widely utilized for dental intraoral-imaging applications. Diagnostic accuracy in standard intraoral imaging is very low for many routine clinical tasks due to overlapping structures of teeth, bone, restorative materials in 2D images. Digital multi-projection imaging techniques such as digital tomosynthesis with several projections and full-rotation tomography with hundreds of projection have been developed for 3D image display in dental application.

In this work, we have designed and developed the high-resolution and high-sensitive CMOS imaging sensor for intra-oral imaging tasks with low-dose and high-speed. The sensor consists of CMOS array with a 10um x 10um pixel size and a 24mm x 33mm active area, and 10fps readout rate in high-definition mode and with a 20um x 20um pixel size and a 24mm x 33mm active area, and 20fps readout rate in binning mode respectively. Different scintillation materials such as FOS(fiber optic plate with CsI scintillator) and Gadox were used. The fiber-optic plate is a highly X-ray absorption material that minimizes the X-ray induced noise. Their design parameters were optimized for high X-ray imaging performance at low radiation dose condition.

For evaluation and optimization of the X-ray imaging characterization, a thallium-doped CsI(CsI:Tl) scintillator with 100-200um thickness and Gadox screen with 50-70 um thickness were directly coupled on the CMOS photodiode array. The X-ray imaging performance such as the light response to X-ray exposure dose, signal-to-noise-ratio (SNR) and modulation transfer function (MTF), image lag etc. were measured under practical dental imaging systems with 70kVp tube voltage and 2mA tube current.

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