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Optimization of X-ray image acquisition and reconstruction for C-arm CBCT system with flat-panel detector

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The introduction of digital flat panel detector (FPD)-based C-arm CBCT (cone-beam computed tomography) system provides an attractive technology for real-time 2D image in standard fluoroscopy and 3D or cross-sectional visualization with higher spatial resolution. A modern CBCT system with C-arm gantry incorporating a large-area flat-panel detector is widely used as an important imaging tool for anatomical diagnosis and image-guidance in spine surgery, orthopedic and interventional suite and image guide radiation therapy. However, the increased scatter in CBCT system with wide-beam angle compared to conventional multidetector CT shows the degradation in image quality such as low contrast, contrast-to-noise (CNR) and CT number calculation. Because of the relatively long image acquisition (4-20seccond) of C-arm CBCT system, patient's motion artifact is induced and geometrical calibrations are required for precision image quality

In this work, the experimental prototype CBCT imaging platform consists of a benchtop system that is integrated with a cone-beam X-ray tube, filters, a collimator, an anti-scatter grid, and a large-area flat panel detector. This TFT FPD detector provides an active area of 400 x 300 mm2 including a 2,048 x 1,536 matrix array with 194-um pixel pitch as well as 7.5 fps and 30 fps. Usually, the x-ray projection data with scattered radiation produce many artifact in image quality of CBCT system. Anti-scatter grids are used in fluoroscopy and CT in order to reduce scattered radiation and improve the image quality such as low contrast resolution, spatial resolution. Different anti-scatter grids with a grid ratio (GR) of 8-10:1 with 200 lp/inch and carbon-fiber interspacing was used to evaluate imagine quality for specific tasks. The different projection images in C-arm CT system were usually acquired at limited angle scanning with a constant interval at a tube voltage of 40-120kVp, and current of 2-20mA. The performance characterization of CT imaging quality was carried out using the FDK and CS (compressed sensing) reconstruction algorithm through acquired 2D projection images at different scanning angle and projection numbers. The quantitative analysis of image quality was investigated by using the cone-beam CT phantom (QRM GmbH, Erlangen, Germany) for contrast resolution, spatial resolution, noise and modulation transfer function (MTF). The extensive performance characterization of images quality was investigated in terms of X-ray expsoure paramters, anti-scatter grids, limited scanning angle for many application protocols.

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