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P2.8: Effect of the shift-variant focal spot blur on the image quality in radiography

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Since Roentgen's discovery of X-rays, anode angulation technique has been widely used in medical X-ray tubes to reduce the focal spot size and transmit sufficient X-rays through the anode. Unfortunately, this technique inevitably produces the so-called shift-variant image blur that causes the focal spot to have a different shape, depending on the position of the detector plane [1, 2]. This effect becomes more pronounced as the distance from the center of the detector plane (or the source magnification) increases. However, it is neglected in traditional radiography because isolating and analyzing this effect from other effects, such as scattered X-rays produced through the object and detector-induced blur, are often difficult. The purpose of this study is to characterize the effect of the shift-variant focal spot blur on the image quality as a function of detector position with various X-ray imaging parameters in radiography, including magnification, focal spot size, and so on. Figure 1 shows the schematics of (a) an X-ray imaging geometry and (b) the formation of X-ray image of an ideal point object, depending on the direction of the finite focal spot of the X-ray tube. We used a simple model of the focal spot that decomposes it into three independent components. According to this model, shift-invariant image blur can be caused by the x and y-components (FS_x and FS_y) perpendicular to the beam direction; shift-variant image blur by the z-component (FS_z) parallel to the central beam direction. To validate the efficacy of the proposed method, we conducted a Monte Carlo simulation and an experiment using an X-ray imaging system that consisted of an X-ray tube with a focal spot size of 3 mm and a CMOS detector with a pixel size of 0.14 mm and an active area of 460 × 460 mm². Figure 2 shows the geometry of an X-ray imaging system used in the Monte Carlo simulation and the X-ray imaging system used in the experiment. Figure 3 shows the MTF curves measured at the center (i.e., beam angle = 0) and periphery (beam angle = 10°) of the detector for three different object magnifications of M = 1.00, 1.27, and 2.00. Our preliminary results showed that nonnegligible shift-variant image blur occurred especially when an X-ray tube with a large focal spot and a detector with a large area are used in radiography. More quantitative simulation and experimental results will be presented in the paper.

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