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Empirical design criteria for improving image quality in grid-based phase-contrast x-ray imaging system

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Grid-based phase-contrast x-ray imaging technique (gPCXI) is capable of acquiring the absorption, refraction and scattering information of an object in a single exposure using the Fourier processing [1]. One of the important issues is that the use of anti-scatter grid causes the aliasing artifacts in the image domain. Previously the size of the x-ray source with magnification was only considered to eliminate the artifacts but it induced excessive magnification of the object, limiting the field of view and simultaneously reducing the image resolution [2, 3].

In this study, we derived the empirical design criteria that include the whole blurring effects of the imaging system. The purpose of this study was to design a system configuration that produces high-resolution images without aliasing artifacts using the criteria and to demonstrate the validity of the criteria through experiments. We employed a CMOS imaging detector coupled to structured CsI:Tl scintillating screens with pixel pitch of 49.5um and a microfocus x-ray tube with 35um, which limits the possible position of the object and the grid frequency. Figure 1 shows (a) schematic illustration of gPCXI and (b) the table-top setup we established for the experiment. To demonstrate the validity of the criteria, the imaging system was configured by adjusting the source-to-object distance (SOD) of 10, 14, 18, and 22 cm and the source-to-grid distance (SGD) of 35, 45, 55, and 65 cm with a fixed grid frequency of 200 lines per inch.

As shown in Fig. 2 (top row), artifacts were seen in the images acquired at SOD of 18 and 22 cm that unsatisfied the criterion, and the degree of the artifact increased as the object magnification decreased. As shown in Fig. 2 (bottom row), artifacts were seen in the images acquired at SGD of 35 and 45 cm that unsatisfied the criterion, and the degree of artifacts increased as the grid magnification increased. Importantly the decrease in resolution due to artifacts was more significant than the decrease in resolution due to the increase in magnification.

We demonstrated that an artifact-free image with larger field of view and higher resolution can be achieved with the empirical design criteria that includes not only the source size but also the detector characteristics. It is expected that these criteria are useful to optimize the system configuration with various type of detectors.

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