Contribution ID: **64** Type: **Poster**

Design Optimization of Backscatter X-ray Security Scanner Based on Pencil Beam Scanning

Monday 27 June 2022 16:34 (1 minute)

Security screening is conducted at national borders and high-security facilities to block the importation of illegal goods. Currently, Korea Customs Service conducts a transmission X-ray security screening using fixed energy. However, with the current system, the detection efficiency of drugs or explosives composed of organic substances is rather low. The backscatter X-ray detection system is sensitive to materials with low atomic numbers [1]; therefore, it can play a complementary and essential role in security screening.

For the backscatter X-ray image, there are several collimation methods that can be applied to the detector or the source for determining an image pixel. In the case of the detector collimation method, because the detector should be highly segmented to obtain accurate position information, it is relatively noisy due to its low efficiency [2]. In contrast, the source collimation method has a high intensity per pixel with the pencil beam scanning technique. This pencil-beam-based backscatter X-ray detection system consists of an X-ray generator, a rotating collimator, and large area detectors.

In this study, the design of a backscatter X-ray security scanner was optimized and, then, its performance was estimated for various conditions using the Monte Carlo simulation technique (Figure 1). For the X-ray generator, we optimized the tube voltage and the geometry of the chopper wheel collimator. The detector parameters of its area, thickness, and distance between the detectors were also optimized in terms of the detection efficiency. Finally, the performance of the optimized system was estimated for various object conditions (i.e., material compositions and thicknesses).

It is expected that this study will contribute to developing backscatter X-ray security scanners and thereby enhancing national security.

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Session Classification: Poster