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Metal artifact removal (MAR) analysis for the security inspections using the X-ray computed tomography

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HIGHLIGHTS

- The X-ray image is used for the nuclear inspections which are made by the image processing.
- Nuclear security has been performed for counterterrorism.
- Easy and fast inspections are needed.
- Metal shows the characteristics of the noises.

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ABSTRACT

Using the metal artifact property, it is analyzed for the X-ray computed tomography (CT) in the aspect of the security on the examined places like airport and surveillance areas. Since the importance of terror prevention strategy has been increased, the security application of X-ray CT has the significant remark. One shot X-ray image has the limitation to find out the exact shape to property in the closed box, which could be solved by the CT scanning without the tearing off the box in this work. Cleaner images can be obtained by the advanced technology if the CT scanning is utilized in the security purposes on the secured areas. A metal sample is treated by the metal artifact removal (MAR) method for the enhanced image. The mimicked explosive is experimented for the imaging processing application where the cleaner one is obtained. The procedure is explained and the further study is discussed.

1. Introduction

X-ray computed tomography (CT) analysis incorporated with metal artifact is applied to the security inspection in the examined places like airport and surveillance areas. Considering the importance of terror prevention strategy, the highly advanced equipment is very necessary. Especially, the enhanced image of the suspected object is needed in the secure moments. One shot X-ray image has the limitation to find out the exact shape to property in the closed box. This difficulty could be solved by the CT scanning without the tearing off the box. Cleaner images can be obtained by the advanced technology if the CT scanning is utilized in the security purposes in the secured areas.

In a previous case of terror incidents, on September 11, 2001, the terrorists had attacked on the World Trade Center in the United States by commercial airplanes. After this tragedy, the significant efforts to find out the suspected material in the check point have been done, where the potential terrorist should be detected. Common X-ray machine has its limitation in which just two-dimensional image could be made in taking one shot. Hence, much more tractable image is needed to improve the comprehensibility in dangerous stuff on the baggage claims of airport or secured areas. So, the advanced technology of detecting the shapes of the object, especially the surficial unseen stuff, is necessary to deploy in the sites of airports or other secure checking points. All baggage screens by X-rays had started after the terror attack trial by air plane in 1972 when the hijackers attempted to crash to nuclear reactor at Oak Ridge National Laboratory in the United States (Koerner, 2013). Current X-ray generator in airport uses the backscattering X-rays in which the Compton scattering is applied to detecting passengers (Rapiscan systems, 2014). The body should be close to the panel type detector where the less exposures and higher resolution are needed. Usually, the single backscatter scan uses from 0.05 to 0.1 *mSv* which is about 100 times less than dose of chest X-ray (Harrison, 2013). The baggage should be inspected

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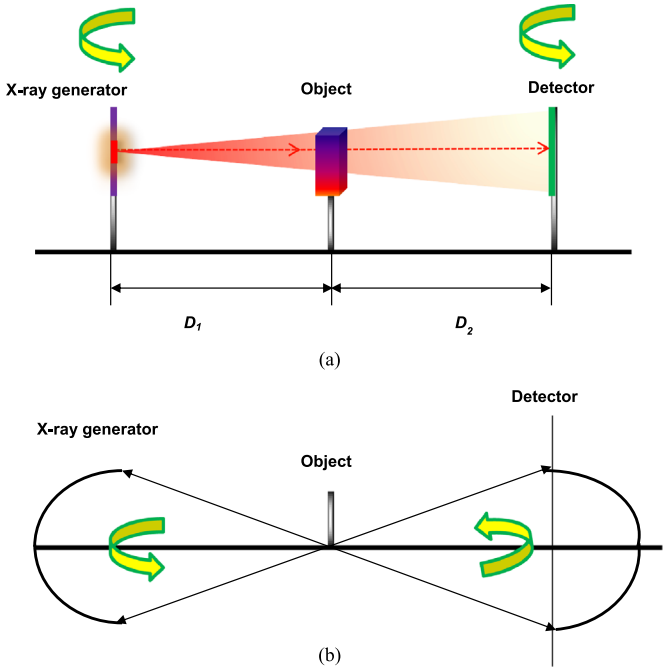

Fig. 1. Configuration of the two dimensional system layout as (a) side view and (b) upper view.

thoroughly and even the 3-dimensional shaped images should be made in order to find out the details feature, because the volume could contain the dangerous explosives or guns. So, the CT scanning is very important to the inspection purpose in the secured area where the inside contents are seen to the inspector.

In the security for the radiological inspections, one of the most important things is to distinguish the suspected material from the other stuffs. Hence, it is needed to make the easy way to set up the technology to compare some material with the other kinds of materials. The skill of finding the particular metal in the inspection could increase the possibility of the dangerous material. So, the MAR is very useful in the inspections, which could reduce the inspection processes or time.

For the higher characteristics of inspection capability of the X-ray radiation, it is needed to make the specialized imaging process in the particular material like the metal in the inspection. Metal is one of general material. So, the method to inspect for the metal is very useful in the security desk where the unseen baggage should be examined. Furthermore, the X-ray imaging could supply the information of the non-metallic material in which the inspector can consider the material in the aspect of the plastic, wood, or liquid as the non-metallic stuff.

In the previous studies, Kang worked for the radiation detection technology using the CT imaging (Kang, 2010). In addition, Gao et al. showed the radiation detection design of a liquid security inspection scanner was investigated and the beam hardening correction method was applied (Gao et al., 2007). Riveros worked that digital radiography and computed tomography were used for images of two types of explosive devices, model rocket engines and shotgun shells where the images were evaluated from an airport security systems (Riveros, 2002). The second section explains the materials and methods of the study. The third section describes results and discussion of the study. Finally, there are some conclusions in fourth section.

2. Materials and methods

The experiments for the study are performed by the X-ray generator and detection equipment. Fig. 1 shows the side view for

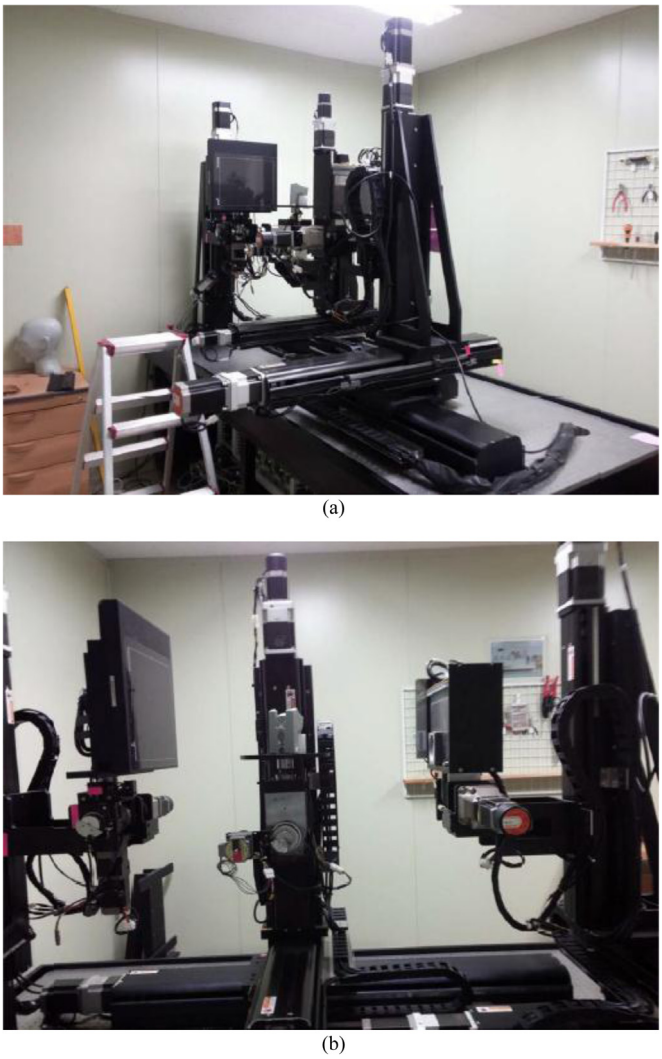

Fig. 2. Configuration for x-ray machine as (a) diagonal view and (b) side view.

Table 1
Specifications of Vysion Jig system.

Specification	Value
Detector size	1472 mm × 1176 mm
Pixel size	0.198 mm
Generator	60 kVp, 6 mA
Distance from source to object center	442.9 mm
Distance from detector to object center	288.1 mm

the experiment system in which the distance of three parts as X-ray generator, object, and detector are located by D_1 and D_2 distances. So, it is possible to change the focal distance, which could be applicable in the real inspection system. This distance should be changeable following the inspected materials shape. Fig. 2 has the diagonal and side views for the rotational movement of the X-ray generator and detection system. In Table 1, there are the specifications for the Vysion Jig which is X-ray treatment system of Fig. 2. Fig. 3 is the simplified configuration of explosive for this experiment which mimicked the shape of a bundle of dynamites. This explosive has the metal stuff in the electric wire which is usually used in the conventional explosives, although there are some other explosives like the plastic or some liquid forms.

It is applied for the CT imager to be in the security checking