Localization of Radiation Sources Using Gamma-ray Detector in Simulated Environments

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ABSTRACT

Localization of radiation sources is an essential task for decontamination. For radiation sources that are inside of structures, it is hard to estimate an accurate position. In this paper, we propose an approach to estimate accurate localization of radiation sources using the gamma-ray CT method. Gamma-ray CT method estimates inner structures from the data obtained numbers of position and pose of detector surrounding objects. Therefore, location of radiation sources surrounded structures can be estimated. In conclusion, our approach successfully detects sources which are placed inside of structures.

KEYWORDS

Localization, Radiation source, Gamma-ray CT

1. Introduction

Damages of the Fukushima Daiichi nuclear power plant by the tsunami led to a nuclear fuel meltdown. By the Fukushima reactor decommission plan [1], taking out nuclear fuel debris is the first step in all process. Because of the high level of radiation inside the Fukushima nuclear power plant, access of human even robots to confirm the location of debris have been denied. Therefore, the location of nuclear fuel debris is still unknown. In this respect, there are a number of studies to investigate the location of nuclear fuel debris. Miyadera et al. employed an approach that by detecting muons which came from outer space and went through Fukushima nuclear power plant suggested absence of nuclear fuel debris inside of nuclear pressure vessel [2]. However, inaccurate localization performance is still remained as the problem in previous research. Therefore, we propose an approach applying gamma-ray CT method to localize of radiation source accurately using detector mounted on mobile robot which moves inside of the building. In this paper, we demonstrate localization of radiation sources by gamma- ray CT method in the simulation environment.

2. Simulation Experiment

2.1. Experimental Environment

In this paper, we simulate the proposed approach in a large-scale environment as shown in Fig. 1 (a). This environment briefly describes the inside of the Fukushima nuclear power plant. The radiation sources are located in the middle of the pedestal. We assume that a detector is mounted on robot and measures the radiation from the sources following the moving path in Fig. 1 (a).

2.2. Detecting Radiation

Detector records a position and number of collision with scintillator and radiation as output data. In addition, we put radiation shields to control the angle of incident radiation to the scintillators. By controlling the angle of incidence, the detector has a directivity and we are able to apply the back projecting to reconstruct an image with location of radiation sources.

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2.3. Reconstruction using Back Projection

To reconstruct the image which contains location of radiation, we use back projection. The data obtained from the detector moving on the designated path are back projected on 12 m × 12 m sized of the image plane. As shown in the Fig. 1 (b), light blue straight lines containing the measured data by the detector are drawn on the image plane. By drawing all the lines on every position that the data measured, the point of intersection which indicates the high potential of locating of radiation source appears.

2.4. Results

Four locations of the radiation sources were estimated using back projection as shown in Fig. 1 (b). We put an image of pedestal after reconstructing the image. Each estimated location contains approximately 0 m to 0.01 m of error. From this result, we can conclude that the proposed approach can estimate the localization of radiation sources accurately.

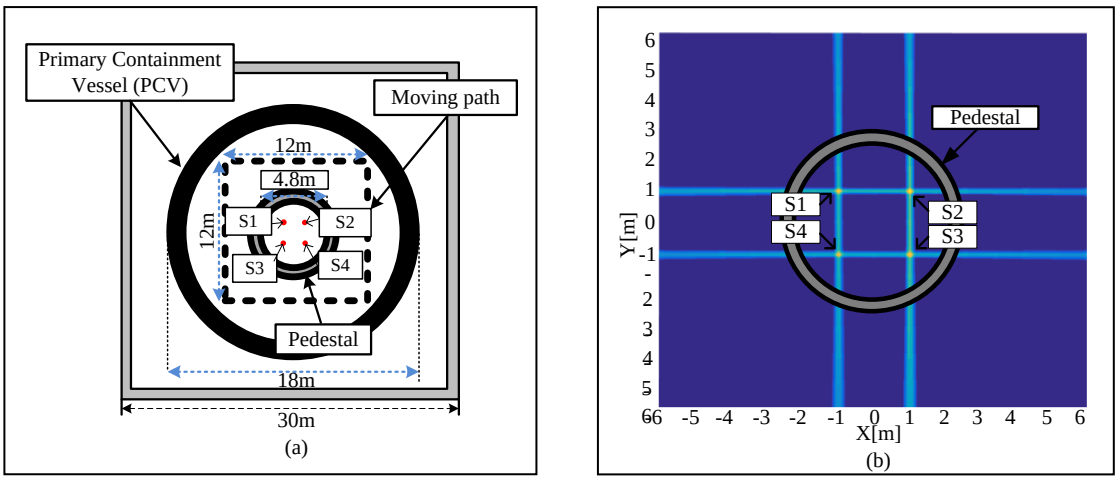

Fig. 1 (a) Top view of the inside the nuclear power plant with detector's moving path, (b) the result of localization of radiation sources used back projection inside of PCV.

3. Conclusion

In this paper, we proposed the localization of radiation source in large-scale simulation environment such as the Fukushima nuclear power plant. By back projecting the data from the detector with four angles of posture on the moving path, the positions of the radiation sources were estimated accurately.

References

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