Preliminary results of nuclear monitoring system based on multi-sensor network and artificial intelligence

Min Kyu Baek[1], Chanwoo Park[1], In Soo Kang[1], Seongyeon Lee[1], Min Seok Seo[2], Jae Joon Ahn[2], and Yong Hyun Chung[1]*

[1]Department of Radiation Convergence Engineering, College of Health Science, Yonsei University, Wonju, Republic of Korea
[2]Department of Information and Statistics, Yonsei University, Wonju, Republic of Korea
*E-mail: ychung@yonsei.ac.kr

Keywords: multi-sensor network, early warning system, automatic location tracking, artificial intelligence, nuclear facility

The importance of monitoring and management of nuclear activities such as development of illegal nuclear weapons, nuclear terrorism and the transportation of nuclear materials, is rapidly increased. The radiation monitoring system for fast and accurate detection of nuclear materials is required to manage nuclear facilities safely.

In this study, we designed a fast nuclear material monitoring system based on multi-sensor network and artificial intelligence algorithm for automatic location tracking and early warning. This monitoring system consists of a number of spectroscopic detectors arranged over a large area and the number of detectors and their arrangement may vary depending on the monitoring range. The location of the nuclear material is determined by analyzing the total counts distribution of each detector using an artificial neural network.

To evaluate the performance of multi-sensor network, a test waste-storage facility with an area of $80 \times 80 \times 80$ cm^3 in which 5×5 array of radioactive waste drums(diameter 12 cm, height 14 cm) were uniformly arranged was modeled. The monitoring system consisting of a 2×3 array of detectors was placed on the ceiling of the test facility and its performance was characterized by GATE simulation and validated through experiments. Each detector is composed of a crystal with a diameter and thickness of 2.54 cm coupled to a photomultiflier tube with a diameter of 2.54 cm. To generate training and validation data(7:3) for missing drum tracking, total count data for each detector was obtained by removing the drum at various positions.

In case of the simulation, the accuracy of the missing drum tracking was 85.7% in the training data and 83.0% in the validation data. The experiment results showed similar results to the simulation. These results demonstrate the feasibility of an early warning system based on this technology which is expected to contribute to enhanced the nuclear safety.
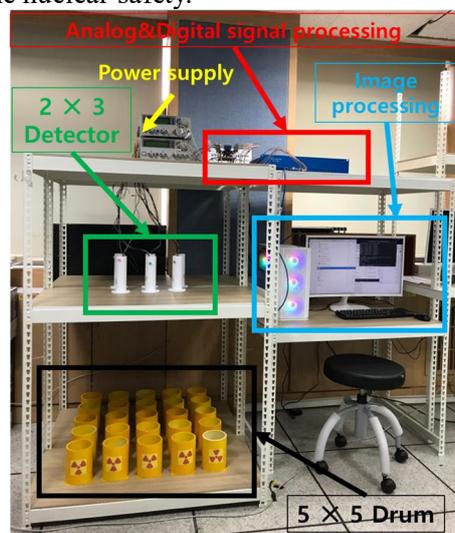

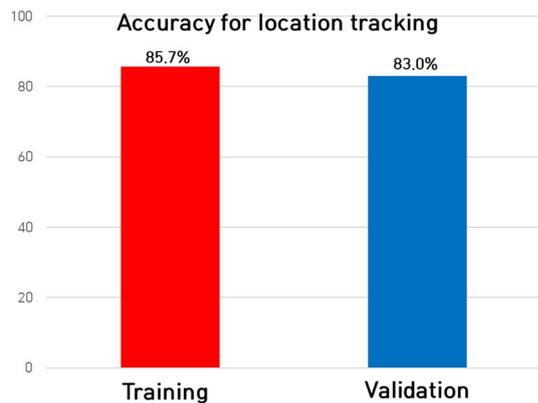Fig. 1. Configuration of monitoring system and measurement setup

Fig. 2. Accuracy of location tracking using artificial neural network based algorithm