Development of Exposure Reduction Technologies by Digitalization of Environment and Radioactive Source Distribution
(3) LASSO Theory and Demonstration for Inverse Estimation on Radioactive Source Distributions

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A mathematical criterion on the number of monitoring points to correctly predict source distributions based on LASSO theory is developed for ill-posed radioactive source reconstruction. We employ Monte Carlo simulation to demonstrate and verify the feasibility of LASSO. Moreover, an influence factor like detector-source distance to enhance the predicting possibility in the inverse estimation is also examined.

Keywords: Inverse Estimation on Radioactive Source Distributions, Air Dose Rate Measurement, Least Absolute Shrinkage and Selection Operator, Monte Carlo Simulation for Gamma Ray

1. Introduction

Radiation exposure is a primary risk for site workers engaging in decommissioning in heavily radioactive environment inside buildings. Therefore, distribution maps of air dose rate are strongly required together with those of radioactive sources for radiation exposure evaluations. However, monitoring to create their source distribution maps is limited due to some reasons such as accessing difficulties owing to high radioactivity. Namely, it is a rather difficult task to obtain full information in order to create the contamination source maps as well as the air dose rate ones. Such a difficulty is remarkable inside both general nuclear facilities and accident reactor like Fukushima Daiichi nuclear power plants.

2. Inverse estimation scheme using LASSO on radioactive source distributions and its demonstrations

It has been well-known that least absolute shrinkage and selection operator (LASSO) scheme has a strong advantage in solving ill-posed inverse problems under sparse conditions. It shows high possibility of finding hotspots and prioritize them. Based on the theory of Candes and Tao [1], we find an upper bound for the number of measurements, above which the source distributions are highly predictable even in ill-posed conditions. Then, we actually perform several feasibility tests of LASSO scheme to explore unknown radiation source distributions inside building rooms. In addition, we verify that the scheme is applicable even in remote sensing conditions as monitoring is prohibited due to high radioactivity inside the contaminated room and is permissible only from distant places like less contaminated neighbor spaces. Furthermore, we discuss measurement methods to make the scheme more successful to predict the source distributions. From the above demonstrations, we confirm that the LASSO scheme is quite useful for inverse estimations as a hot spot finder based on limited air dose rate monitoring.

3. Conclusion

LASSO scheme is a quite useful way to explore hot spots as seen in radioactive buildings. A mathematical criterion based on LASSO is developed for the correct source distribution prediction, and our theory is verified and demonstrated.

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References

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