A Study on the Estimation of Gamma-Ray Source Positions Using Machine Learning with the Data of Different Activity Sources

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1. Introduction

- In the disposal process, LILW is classified into short, medium, and long-lived waste according to its decay time.
- One of the main issues has been monitoring the possible leakage of radioactive isotopes at the radwaste drums.
- Scanning the drums and tracing the location of any leak can reduce the risk of contamination to the environment as well as the operators.
- In this study, the positions of gamma-ray source are estimated from the system that consists of a PSOF, two photon counters.
- Using machine learning model, tests with 9 and 41 μCi Cs-137 sources are conducted to identify whether the machine learning model for the same gamma-ray source can estimate source positions with different radioactivity.

2. Materials and Experimental Setup

Plastic Scintillating Fiber
BCF-12

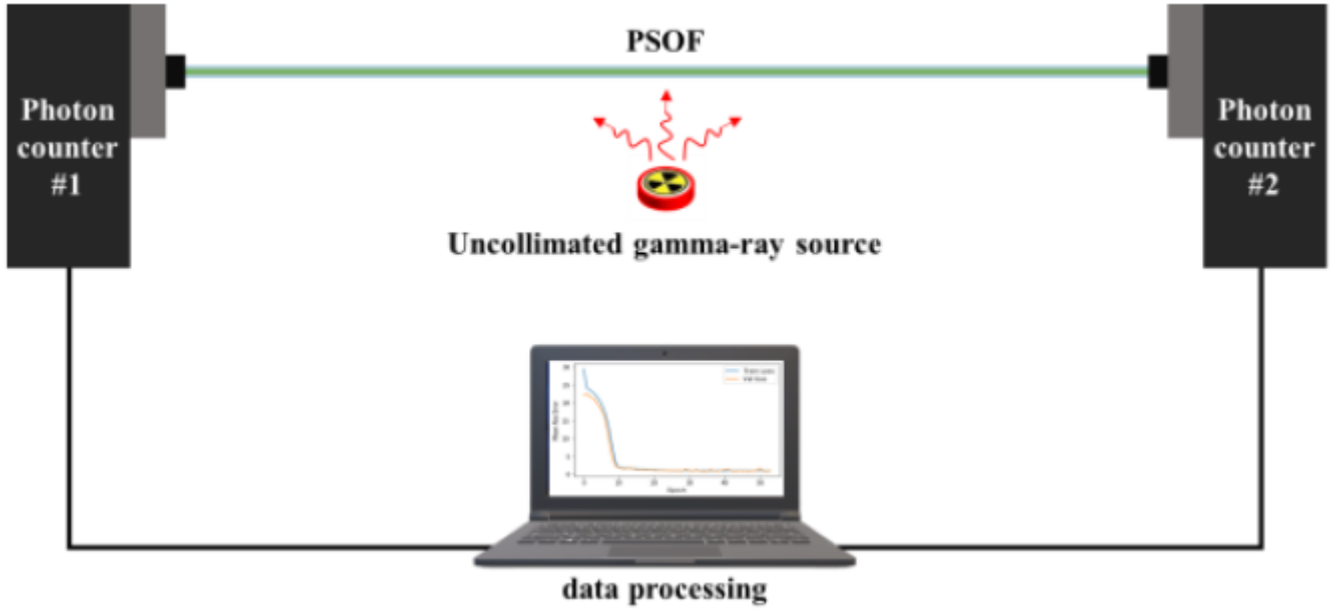
Specific properties	Value
Core diameter (mm)	3.0
# of photons per MeV	~8000
Refractive index of core / cladding	1.6 / 1.49
Emission peak (nm)	435
Decay time (ns)	3.2

Photon Counter
H11890-210

Specific properties	Value
Peak sensitivity wavelength (nm)	400
Spectral response range (nm)	230 ~ 700
Photocathode area diameter (mm)	8

2. Materials and Experimental Setup

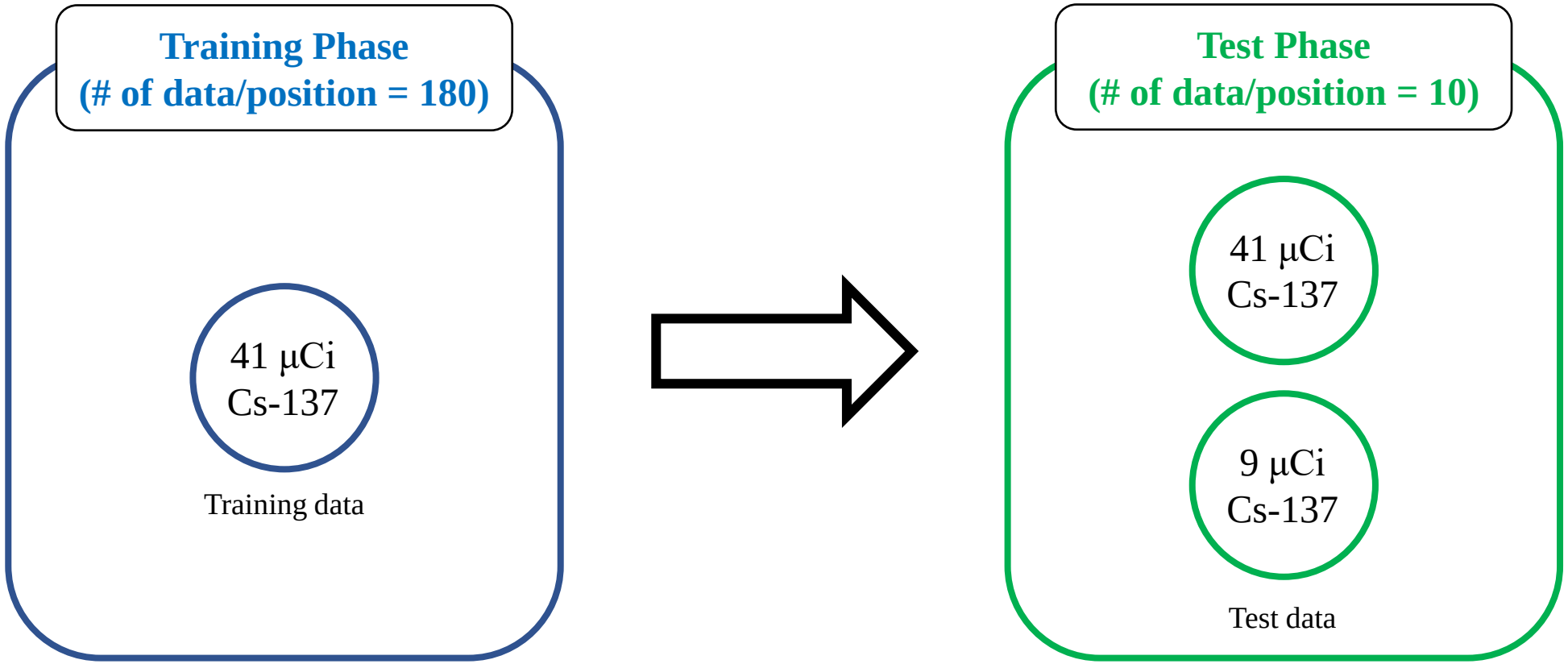
❖ 1-Dimensional radioactive source position estimating system



- Single strand of 1 m length BCF-12 is used.
- Two photon counters are connected at both ends of BCF-12.
- 41 and 9 μCi Cs-137 sources are used.
- Training data are obtained from 10 to 90 cm along the BCF-12 by 10 cm interval.
- Test data are obtained at the same position for training data, the central positions of the two training data and the three random positions.

2. Materials and Experimental Setup

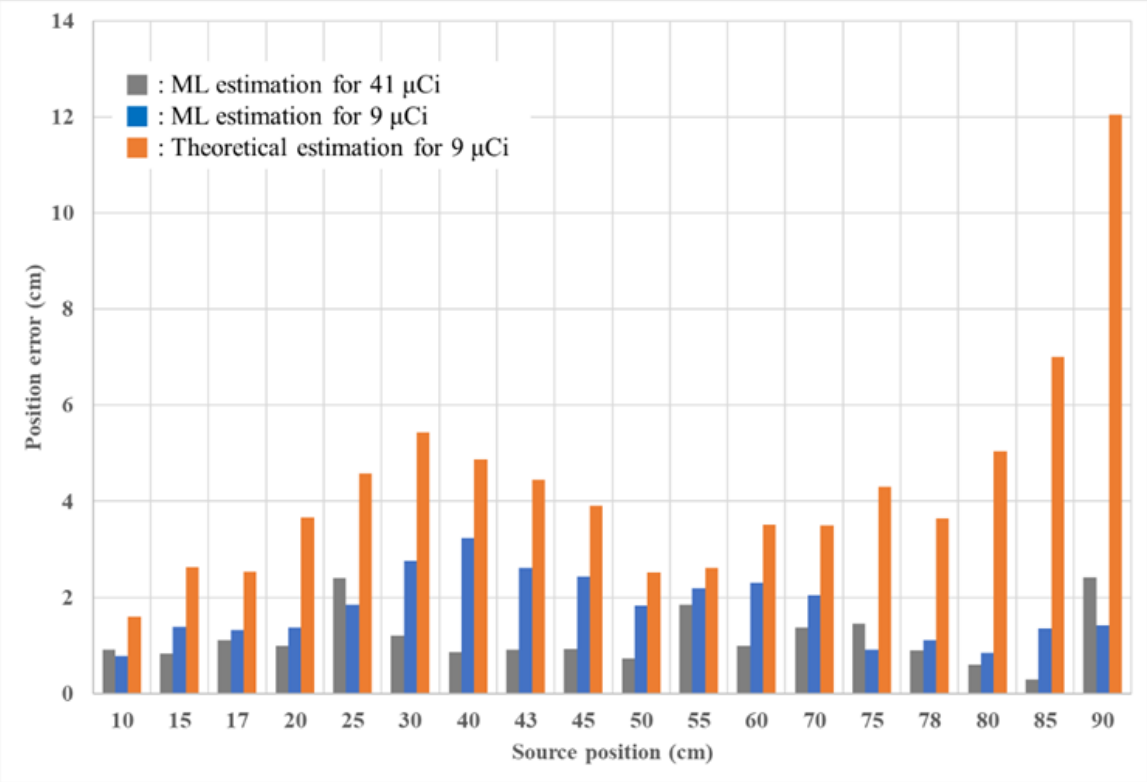
❖ Machine learning analyzing process



3. Results

❖ Comparison between the overall error values of machine learning test results and theoretical estimation

Graphical comparison



Overall error comparison

	ML estimation (cm)	Theoretical estimation (cm)
41 μCi Cs-137	1.15	4.27
9 μCi Cs-137	1.76	4.33

4. Conclusions

- The gamma-ray source position is estimated using a 1 m length PSOF, two photon counters and via machine learning data processing.
- 1,620 photon counting data made of 41 μCi Cs-137 source at nine source positions between 10 to 90 cm are used as machine learning training data.
- 180 photon counting data made of 41 and 9 μCi Cs-137 sources at 18 source positions are used as test data.
- The machine learning evaluation results show that it is possible to use the machine learning position estimation model to the position of source with different activities.
- Further studies will be conducted on the position estimation of gamma-ray sources using scintillation signals from complex geometry of PSOF.

Thank You