MCNP-X code in radioactive particle tracking using artificial neural network for industrial agitators

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This report presents a method based on the principles of the Radioactive Particle Tracking (RPT) technique. The basic principle of the technique is to use an array of radiation detectors, generally scintillator detectors, to locate a single radioactive particle inside a volume of interest with an appropriate mathematical reconstruction algorithm [1]. In this work, the reconstruction algorithm used is given by a 3-layer feedforward ANN with a backpropagation algorithm to calculate the instantaneous position of the radioactive particle [2]. Simulated geometry was performed with the MCNP-X code, and it consists of a Polyvinyl Chloride tube containing air in its interior, eight 2x2" NaI(Tl) detectors and the radioactive particle is a Cs-137 (662 keV) point source with isotropic emission. The eight detectors were distributed in two planes along the tube: P1 at z = 0 cm and P2 at z = -25 cm. Detectors are spaced at a 90° angle from each other. The distance between the detectors and the tube is 20 cm, as shown in Figure 1.

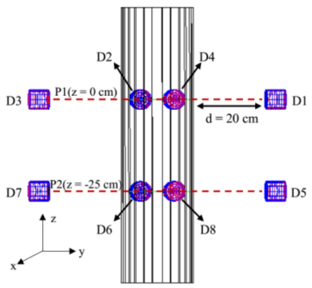

Figure 1. Geometry simulated with MCNP-X code.

Radioactive particle (RP) was positioned in 108 different positions (x,y,z) to train the ANN. The inputs of the ANN are the registered counts of the eight detectors and the outputs are the positions of the RP. Only counts of the region corresponding to the photoelectric absorption were used in the ANN training. Figure 2 represents coordinates x and y of the ANN in comparison with MCNP-X from the Validation set of the ANN.

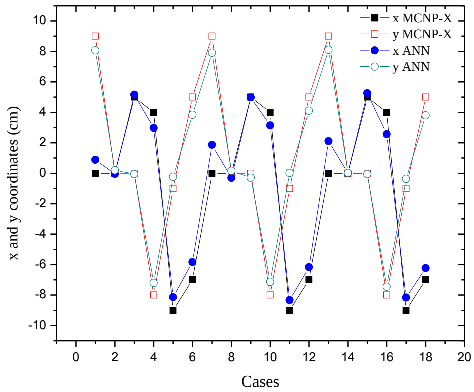

Figure 2. Validation set of the ANN.

It is possible to observe that the results show that the ANN follows the pattern from the simulations with MCNP-X code. In Table 1 is shown the processed data generated by the ANN, including relative errors and the correlation.

Table 1 – Processed data from the trained ANN.

Processed data	**Coordinates**		
Relative Error	**x**	**y**	**z**
< 5%	60.00	63.23	91.67
5% – 10%	23.33	18.38	5.55
10% – 20%	13.33	6.90	2.78
20% – 30 %	2.22	3.45	0
> 30%	1.12	8.04	0
Correlation coefficient	0.996	0.996	0.999

The results presented indicates that the ANN has a great potential to predict the instantaneous position of the RP. This methodology does not need many calibration points and the ANN is able to converge with 108 points.

References

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