Deep neural network applied in radioactive particle tracking

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Radioactive particle tracking (RPT) is a minimally invasive nuclear technique that tracks a radioactive particle inside a volume of interest by means of a mathematical location algorithm. During the past decades, many algorithms have been developed including ones based on artificial intelligence techniques. Novelty of this report is the use of a location algorithm based on deep learning [1]. In this way, RPT technique is applied in a simulated test section that employs a simplified mixer filled with concrete, six NaI(Tl) detectors and a ^{137}Cs radioactive particle emitting gamma rays of 662 keV, as follows Figure 1 [1]. Test section was developed using MCNPX code [2], which is a mathematical code based on Monte Carlo simulation, and 3516 different radioactive particle positions (x,y,z) were simulated.

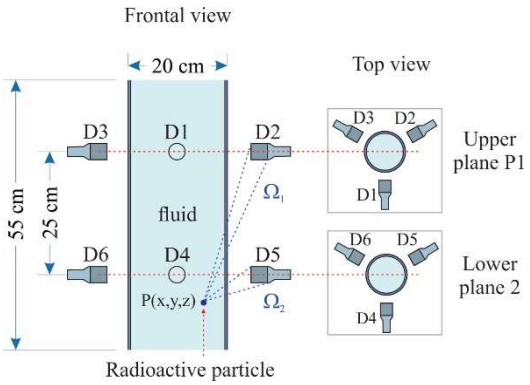

Figure 1. Simulated geometry

In the output file of the MCNPX code, tally card F8 gives the simulation response that represents the pulse height distribution (PHD) in each detector, which was used as an input feature of a deep rectifier neural network (DRNN). The outputs targets of the DRNN correspond to the radioactive particle instantaneous positions (x,y,z) within the mixer. The DRNN hyperparameters were defined using a Bayesian optimization method, which resulted in four hidden layers (300, 300, 900, 1000 neurons each) and Exponential linear unit activation function in the hidden layers. Moreover, DRNN uses Adam optimizer, 4000 epochs, means square error (MSE) as loss function and batch size of 32. Results comparing real data (MCNPX code) and predicted data (DRNN) for two different trajectories of the radioactive particle inside the concrete mixer is shown in Figure 2 [1].

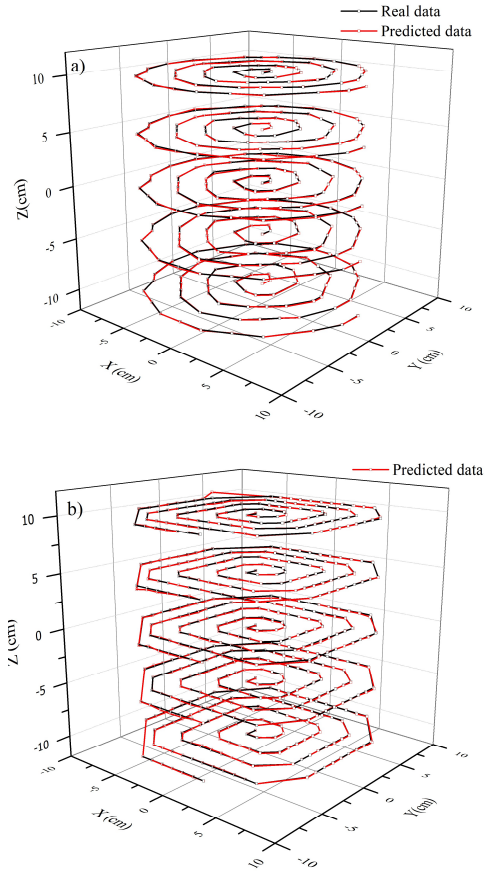

Figure 2. 3D trajectories: a) spiral; b) square spiral.

Results show the great accuracy of the DRNN in a RPT tracking system. More details can be found in DAM et al., (2021) [1].

References

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