Research on Position Resolution Method of Scintillation Signal Based on CNN+LSTM Network

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This study investigates the application of silicon photomultiplier (SiPM) in plastic scintillator detectors, and develops a SiPM based position-sensitive detection system. When neutrons or gamma rays enter the scintillator from the end face, the scintillator emits light. By placing multiple SiPMs on the side of the scintillator and utilizing the difference in spatial angle and distance of each SiPM corresponding to the emitting point, the relationship between the readout signal and the particle incidence position can be established. The light signal distribution generated by 1MeV neutrons in an EJ230 scintillator at different positions was simulated using Geant4, and the signal was received by four SiPMs with a size of 12 mm ×12mm. To avoid the problem of uneven response caused by the luminescence of the edge and too weak signals of individual SiPMs, the SiPMs were biased a certain distance relative to the central axis, and a total of five spatial layouts were designed. By comparing the influence of the bias distance on the inversion results, the size of the bias distance was determined. This paper designs a neural network model that outputs corresponding two-dimensional position signals when four-dimensional detector signals are input. The neural network model includes three hidden layers, and the hyperparameters such as the units per layer, learning rate, and batch size are adjusted according to the Bayesian optimization and hyper band (BOHB) algorithm. The analysis of 34,093 sets of data collected from Geant4 simulation shows that using a detector position further away from the central axis is more advantageous to improve the reconstruction accuracy. Experiments were conducted using a collimated Cs-137 radiation source, and data were reconstructed using sequence analysis algorithm and CNN+LSTM network. The experimental results show that the average absolute error of the neural network in reconstructing the incident particle position is about 8mm, which proves the feasibility of using a neural network to reconstruct the incident particle position.