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Machine learning predictions for cross-sections of evaporation residues produced in some alpha-induced reactions

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The estimation of nuclear reaction cross-section data is a complex and imperative method that requires professional researchers to provide complete recommended values through the analysis of experiments, and development of physical reaction models. The modern techniques of evaluation have overcome some limitations of traditional methods, such as the assumption of perfect models, linear error propagation, and the normal distribution of uncertainty, making the evaluation results more objective and accurate. Though the theoretical prediction is one of the foundations of nuclear data evaluation, high precision models imply the complexity, which may lead to unreliable extrapolation ability. In this work, we report that machine learning is making progress in the field of nuclear data to predict the nuclear reaction cross sections of radioisotopes produced in alpha induced reactions. In the present work, the production yield of radioisotope has been calculated using statistical nuclear reaction model code ALICE-91, EMPIRE3.2 and TALYS 2.0. The experimental data available in the EXFOR library, based on measurement carried out in various nuclear research laboratories across the world, is adopted for analysis. A set of four authoritative machine-learning algorithms is deployed in this study, including XGBoost (Extreme Gradient Boosting), SVR (Support Vector Regression), RF (Random Forest), and Cubist. Each algorithm offers unique advantages in handling complex data structures and capturing nonlinear relationships. The results of this study are evaluated using a range of statistical metrics, including Root Mean Square Error (RMSE), Standard Deviation (SD), and Pearson Correlation Coefficient (r). Comparative analysis with experimental data further elucidates the performance of the proposed machine learning models, highlighting their effectiveness in predicting cross-section data. It is important to note that this research work contributes to advancing computational methodologies in nuclear physics and highlights the potential of machine learning in enhancing predictive capabilities for complex nuclear data.

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