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Implementation of machine learning techniques to predict impact parameter and transverse spherocity in heavy-ion collisions at the LHC

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Machine learning techniques have been quite popular recently in the high-energy physics community and have led to numerous developments in this field. In heavy-ion collisions, one of the crucial observables, the impact parameter, plays an important role in the final-state particle production. This being extremely small (i.e. of the order of a few fermi), it is almost impossible to measure impact parameter in experiments. In this work, we implement the ML-based regression technique via Gradient Boosting Decision Trees (GBDT) to obtain a prediction of impact parameter in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV using A Multi-Phase Transport (AMPT) model. After its successful implementation in small collision systems, transverse spherocity, an event shape observable, holds an opportunity to reveal more about the particle production in heavy-ion collisions as well. In the absence of any experimental exploration in this direction at the LHC yet, we suggest an ML-based regression method to estimate centrality-wise transverse spherocity distributions in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV by training the model with minimum bias collision data. Throughout this work, we have used a few final state observables as the input to the ML-model, which could be easily made available from collision data. Our method seems to work quite well as we see a good agreement between the simulated true values and the predicted values from the ML-model.

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