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A Neural-Network-defined Gaussian Mixture Model for particle identification applied to the LHCb fixed-target programme

An innovative approach to particle identification (PID) analyses employing machine learning techniques and its application to a physics case from the fixed-target programme at the LHCb experiment at CERN are presented. In general, a PID classifier is built by combining the response of specialized subdetectors, exploiting different techniques to guarantee redundancy and a wide kinematic coverage. At analysis level, the efficiency of PID selections changes thus as a function of several experimental observables, notably the particle momentum, the collision geometry and the experimental conditions. To precisely model the distribution of the PID classifier overcoming the unavoidable imperfections of the simulation, large samples of calibration channels reconstructed and selected in data are needed.

In the presented approach, conceived for all applications where the collection of sufficiently-large-size calibration samples is not possible, the PID classifier is modeled on another high-statistics training sample using a Gaussian Mixture Model whose parameters are determined by Multi Layer Perceptrons. These are fed with the relevant experimental features and the non-trivial dependencies of the PID classifier are learned and predicted for the lower-statistics sample. Thanks to its speed and easy configuration, the presented approach, demonstrated on a proof-of-principle physics case to perform as or better than the detailed simulation, is expected to be employable on a large variety of use cases dealing with experimental observables depending on a sizeable number of experimental features.

Significance

The combination of the well-known maximum-likelihood technique with state-of-the art machine learning libraries and methods provides an innovative approach to particle identification analyses. For the fixed-target programme at the LHCb experiment, where the collected amount of calibration data is limited, this results into the mitigation of one of the dominant experimental uncertainties.

References

Paper in collaboration review.

Speaker time zone

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