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Model Independent Searches for New Physics

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The Standard Model (SM) of particle physics, despite its success, leaves many key phenomena unexplained. Traditional searches for new physics at the LHC rely on model-dependent approaches, each probing only a specific Beyond Standard Model (BSM) hypothesis. However, a discovery is not guaranteed if the true solution lies outside the considered models, highlighting the need for model-independent strategies such as anomaly detection. In this work, a model-independent anomaly detection technique, New Physics Learning Machine (NPLM), is studied. It frames the search for BSM physics as a two- sample test between data (D) and the SM reference hypothesis (R), comparing their compatibility rather than probing the signatures of a specific alternative hypothesis. The framework incorporates systematic uncertainties as nuisance parameters a!ecting each reference sample. Control regions are simulated to enable background estimation using data-driven techniques. A fully supervised neural network is trained to learn the likelihood ratio between R and D as a discriminator, along with a t-statistic quantifying the deviations from R. Though currently based on simulated dataset, this approach is designed for future applications to ATLAS Run 2 and Run 3 data, particularly in the context of the ATLAS general search in multilepton final states. In this work, the NPLM technique is implemented and its viability as an anomaly detection technique is studied, establishing a flexible foundation for future model-independent analyses across a wide range of realistic ATLAS BSM searches.

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