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Looking for rare di-Higgs events at the LHC with Machine (Deep) Learning techniques

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Artificial intelligence (AI) algorithms applied to HEP analyses come to the rescue in scenarios in which implementing an efficient discriminant for separating a very low-rate signal from a huge background is extremely important. In this context, we investigate the usage of several Machine Learning (ML) and Deep Learning (DL) methods via the TensorFlow open-source platform to boost the sensitivity to double Higgs boson (HH) simulated events produced via vector-boson fusion (VBF) mechanism VBF in the 4 charged lepton + 2 b-jets final state at generator level.

This particle physics process had not yet been investigated at the Large Hadron Collider (LHC) experiment mainly due to the small value of its cross-section weighted with the branching ratios BRs (with the Higgs mass set to its best fit value of 125.09 GeV and at the center-of-mass energy of $\sqrt{s}$ = 13 TeV, the former is ~ 1.723 fb and the corresponding BRs are 2.79×10^{-4} for $H \longrightarrow ZZ^{*} \longrightarrow 4l$, with l = e, μ, τ, and 5.75×10^{-1} for $H \longrightarrow b\bar{b}$), thus requiring an exclusive event selection in order to efficiently perform a background rejection. This work uses the VBF HH rare physics process to show the advantages of AI algorithms' highly parallelizable implementation and to present their discriminant performance results in terms of several ML evaluation metrics. In this way, we propose a wider application of these multivariate analysis tools to current LHC analyses and generally to datasets potentially enriched with high-purity contributions from rare physics processes.

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