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Deep-learning techniques for VBF Higgs searches: a case study in the invisible decay channel

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Vector boson fusion production of the Higgs boson provides a relatively clean channel of investigation compared to the more abundant but rather chaotic gluon fusion production. It has been known for decades that the lack of QCD radiation in the central areas of the detector between the two tagging forward jets is a recognising feature of VBF processes. In this presentation, we discuss the possibility of Convolutional Neural Networks (CNNs) utilising this difference by looking at the inclusive event information in the form of the tower image. Taking the invisible decay of the Higgs boson as a proxy for a difficult signature due to the lack of knowledge of the Higg's decay products, we compare the performance of CNNs with univariate shape analysis of the dijet invariant mass and pseudorapidity separation, as well as with Artificial Neural Networks that take physics-motivated variables, and find that the CNN can put the most stringent bounds on the invisible branching ratio of the Higgs.

The use of inclusive event information, on the other hand, brings in the possibility of CNNs picking up artefacts of the simulation, which generally concentrate more on reproducing the physics of the reconstructed objects. We also study the dependence of the CNN on the parton shower recoil scheme (global and dipole) and the perturbative accuracy (LO and NLO) of the VBF Higgs production. Although there is a large difference in the training accuracies, we find that the validation accuracy of the dipole-NLO generated samples is very mildly affected by the type of signal data used during the training process, with a variation of 1.6% in the AUC. This points toward CNNs being able to learn the underlying physical differences regardless of the sub-par simulation used during training.

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