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Higgs Signal Strength Estimation with a Dual-Branch GNN under Systematic Uncertainties

In this talk, we present a dedicated graph neural network (GNN)-based methodology for the extraction of the Higgs boson signal strength, incorporating systematic uncertainties. The model features two branches: a deterministic GNN that processes kinematic variables unaffected by nuisance parameters, and an uncertainty-aware GNN that handles inputs modulated by systematic effects through gated attention-based message passing. Their outputs are fused via skip connections and learnable gating to produce classification scores for signal-background discrimination. During training, systematic variations are explicitly injected by scanning the nuisance parameter space and updating model parameters at each point, enabling the network to learn a smooth dependence of classifier outputs on systematic shifts. To model systematic effects, classifier outputs are recomputed under varied nuisance parameters, and the resulting weighted score distributions for signal and background are interpolated using template morphing. The resulting surrogate likelihood functions enable profile likelihood scans over signal strength, with nuisance parameters profiled out via numerical optimization. This framework yields accurate estimation of μ and its 68.27% confidence interval, achieving competitive coverage and interval widths in large-scale pseudo-experiments compared to traditional binned approaches.

Secondary track

T08 - Higgs Physics

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Session Classification: Joint T08+T16

Track Classification: T16 - AI for HEP (special topic 2025)