

Jet Image Tagging Using Deep Learning: An Ensemble Model

Tuesday 2 December 2025 16:20 (20 minutes)

Jet Classification in high-energy physics is essential for probing fundamental interactions and for searches beyond the Standard Model. In this work, we introduce the Ensemble Model (EM) combining ResNet50 and InceptionV3 architectures for jet tagging, where jets are represented as two-dimensional histograms in the (η , ϕ) plane. This ensemble approach leverages complementary feature extraction mechanisms of the constituent networks (ResNet50 and InceptionV3) to enhance classification performance.

Using the JetNet dataset, our results demonstrate that EM consistently surpasses the performance of the individual networks in both binary and multi-class classification. For binary tasks, the EM achieves testing accuracies up to 91.7% with area under the curve (AUC) values of 0.97 in distinguishing gluon jets from W boson jets, exceeding the performance of standalone ResNet50 (91.0% and 0.96) or InceptionV3 (90.1% and 0.96). In the multi-class scenario with five jet categories (gluon, light quark, top quark, W, and Z bosons) EM reaches a testing accuracy of 75.1% and an average AUC of 0.93, reflecting stable generalization under 5-fold cross-validation, compared to 72.5% and 0.92 for ResNet50, 73.7% and 0.92 for InceptionV3. These gains were confirmed by component-wise analysis, and Grad-CAM visualizations, which reveal that the ensemble integrates fine-grained local structures and broad spatial patterns more effectively than either model alone.

Beyond its application to the JetNet dataset with 2D histogram jet images, we have now adapted our system for higher-dimensional jet representations that incorporate richer information about the collision process at the LHC. This extension enables the ensemble framework to exploit detailed particle-level and event-level features, paving the way for improved classification performance in more realistic experimental settings with potential for broader applications in LHC analyses or beyond.

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Session Classification: LHC