$t\bar{t}H$ Events Classification with Graph Neural Networks in $2L(SS) + 1\tau_{had}$ Channel

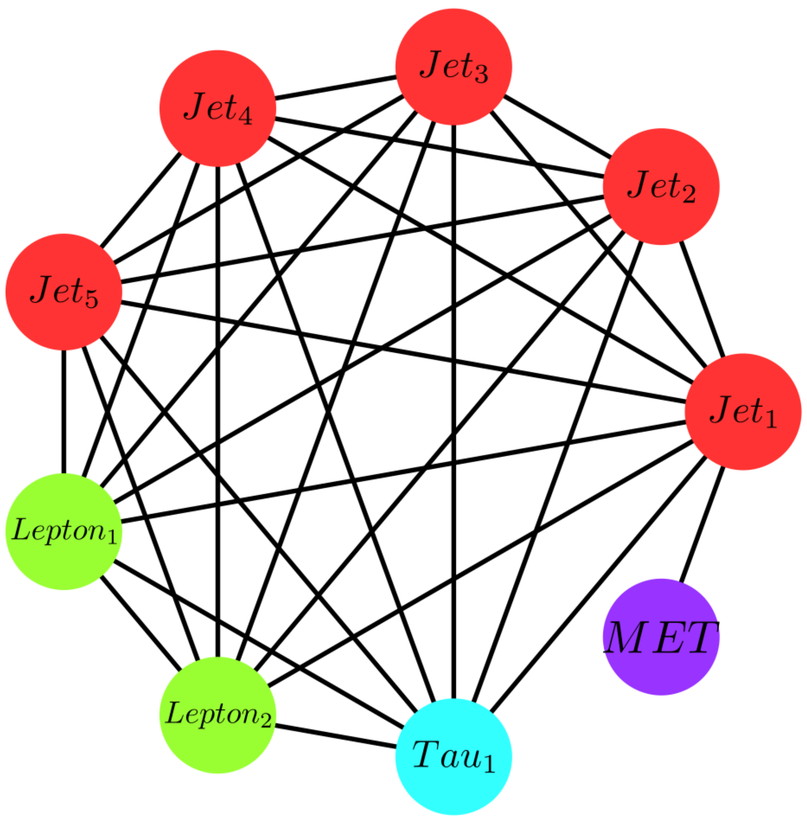
Paramott Bunnjaweht[1] and Nello Bruscino[2]

[1]Chulalongkorn University
[2]Sapienza Università & INFN Roma

Introduction

In this work, we attempt to distinguish signal events from background events, specifically $t\bar{t}H$ events from $t\bar{t}W$ and $t\bar{t}Z$ events in $2L(SS) + 1\tau_{had}$ channel which are simulated by Monte Carlo simulations, using **Graph Neural Networks (GNN)**. Similar works have been done using **Boosted Decision Trees (BDT)**. We want to design GNN models that can outperform BDTs by exploiting the underlying graph structure between objects and event variables. We use the model training framework called mva-trainer[1]. The performance of GNNs are then compared with that of the BDTs trained with the same set of variables.

Graph Structures



Nodes: 5 jets, 2 leptons, 1 tau and missing transverse energy (MET)
Node Features: Jet, Lepton, and Tau nodes contain 4-momentum information. In addition to them,

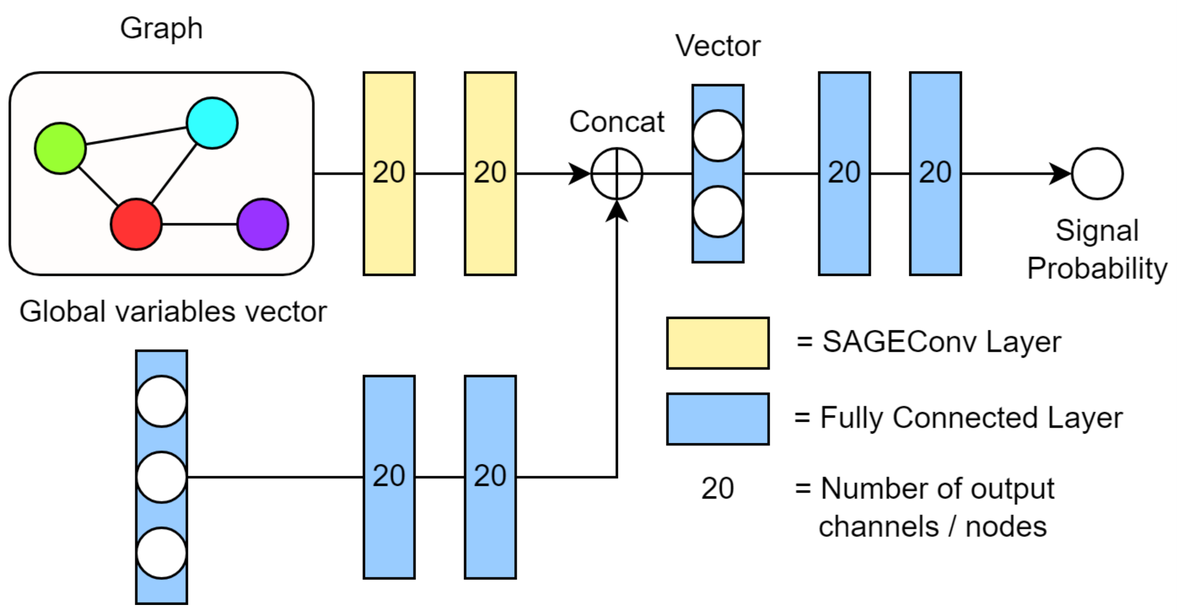
- Jets also contain the b-tagging score.
- Leptons also contain Lepton type, charge and Jet - Lepton minimum distance
- Taus also contain Charge
- While MET contains only the Event's Missing Energy in the transverse plane and its Transverse Plane Angle

Edges: Most nodes are connected by the distance between objects.
Global Features: Event-wide variables such as the number of jets and maximum pseudorapidity.

Results

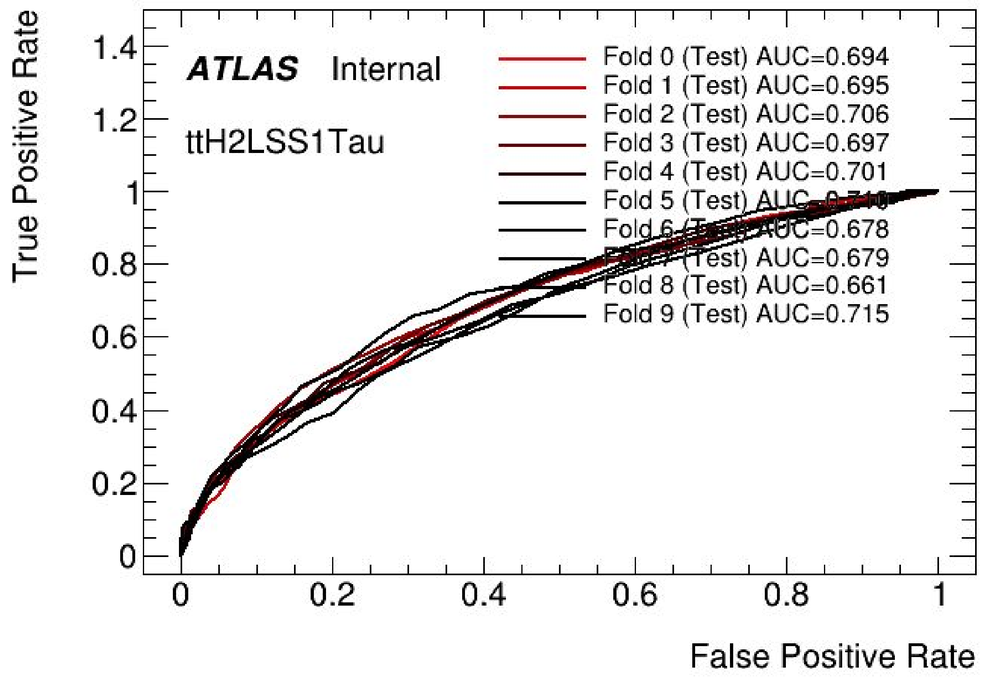
The performance of the GNN model does not exceed BDT's performance significantly while the training and evaluation time for GNNs are much longer than the BDTs.
This is still a work in progress, and we continue to study the structure of the variables to build better graphs for GNN model to classify more efficiently.

Model Architecture



Model Performance

The performance of GNN and BDT models are evaluated using the Area Under Curve (AUC) of their Receiver Operating Characteristic curve (ROC). Models are trained and evaluated 10 times with the available train/test dataset divided by the k-Fold cross-validation technique.



Test Performance (10 folds)	BDT	GNN
Average AUC	0.691	0.696
Standard Deviation	0.020	0.017

References

[1] Korn, Steffen. *Documentation for Mva-Trainer*, mva-trainer-docs-site.docs.cern.ch. Accessed 20 July 2023.