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Semantic Segmentation Of Pileup Particle Identification In The ATLAS Detector using Graph Neural Networks

Simulating pileup at the Large Hadron Collider (LHC) involves the simulation of multiple proton interactions via soft QCD Monte Carlo models that are then overlaid onto a single primary interaction (or hard scatter event). This poses a significant challenge moving into the high luminosity era due to the increased average number of interactions per bunch crossing, and the growing complexity of the detector. In tandem these two factors lead to a rapid growth in the computational resources required to generate simulated datasets. To combat this problem, generative machine learning models are currently in development that aim to replace parts of the detector simulation with fast and efficient algorithms in order to reduce the CPU required to generate a single event.

One of these projects is the simulation of the ATLAS calorimeter using a generative machine learning model trained on LHC zero-bias data in order to more accurately replicate multi-proton pileup. Whilst such models can be trained to emulate calorimeter layer images on average, localised calorimeter cell activity driven by charged and neutral particles is potentially lost. The proposed project is to develop particle identification algorithms (e.g. Pileup Per-Particle Identification [1]) to associate localised cell activity in zero-bias data to charged/neutral particles originating from proton collisions. With this identification information, graph neural network architectures can then be developed to augment the generative models by encoding layer-to-layer cell correlations arising due to particle flight paths.

In summary the project aims to improve the emulation of calorimeter layer images generated via generative machine learning models by encoding particle flight information between layers using graph neural networks, which requires particle identification algorithms in zero-bias data to be developed.

FTE applied to topics:
Physics: 40%
Statistical/Machine Learning: 40%
Computing: 20%

Field

B1: Particle physics analysis (software-oriented)

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