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Transformer for seed reconstruction in ACTS

Reconstructing particle trajectories is a significant challenge in most particle physics experiments and a major consumer of CPU resources. It can typically be divided into three steps: seeding, track finding, and track fitting. Seeding involves identifying potential trajectory candidates, while track finding entails associating detected hits with the corresponding particle. Finally, track fitting focuses on reconstructing the parameters of the trajectory.
Many deep learning-based methods for tracking aim to combine the first two steps into a single process, using a neural network to identify particle trajectories from detector hits. This approach has achieved promising results, nearing the performance of traditional algorithms. However, it still requires a substantial amount of computing power. In classical tracking, most of the intensive computational workload stems from the seed identification process, while the track finding is well understood. Therefore, fully emulating the track-finding process typically performed by a Kalman filter may not be efficient in terms of resources and physics performance.
Instead, we propose utilising a transformer-based network for the seeding step, focusing exclusively on the hits at the centre of the detector. This network will be used to project the hits onto the track parameter space; then a clustering algorithm is used to identify preferred trajectory directions within this space. These preferred directions can then be transformed into seeds for tracking. This process can be completed much faster than conventional seeding, resulting in fewer extraneous seeds and, consequently, a quicker track-finding process. Afterwards, the seeds are passed to a standard tracking algorithm that can run on either a CPU or GPU to complete the reconstruction process. Our goal with this approach is to combine the speed of deep learning with the reliability of classical tracking techniques. This method will be implemented within the A Common Tracking Software framework and tested on the Open Data Detector to ensure a realistic testing environment.

Significance

Most deep learning methods for tracking rely on neural networks to identify particle trajectories from detector hits, imitating the track-finding process traditionally conducted by Kalman filters, which are well understood and calibrated. In contrast, we propose using a transformer solely for the seeding step, while the remainder of the trajectory reconstruction will be carried out using classical, well-established algorithms.

References

Experiment context, if any

ACTS, Open Data Detector

Author: ALLAIRE, Corentin (IJCLab, Université Paris-Saclay, CNRS/IN2P3)

Co-authors: ROUSSEAU, David (IJCLab-Orsay); BOUVET, Françoise; GRASLAND, Hadrien (IJCLab)

Presenter: ALLAIRE, Corentin (IJCLab, Université Paris-Saclay, CNRS/IN2P3)

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