IRIS-HEP Fellowship Proposal

Name: Varun Sreenivasan

Home Institution: University of Wisconsin-Madison

Project: Graph Methods for Particle tracking

Mentors: Savannah Thais and Daniel Murnane

FTE Period: I propose to work full-time over the summer (3 months) on this project.

Conflicting Commitments: None

Project Outline

The HL-LHC is in need of efficient and fast particle track reconstruction as algorithms in use are unable to scale to current requirements. Graph Neural Network Methods seem to be a promising solution to this problem.

A critical aspect of this solution revolves around the construction of the graph that can be used for particle tracking and I intend to work in this space.

I want to explore Bucketing/hashing/approximate nearest neighbor algorithms for graph construction with Prof. Daniel Murnane's Berkeley lab.

Approximate Nearest Neighbor Algorithms is a fundamental problem in many areas of Machine Learning. The goal of this class of algorithms is to return the most accurate nearest neighbors in the shortest time.

Background

I have excelled in my previous Machine Learning endeavors and I believe this coveted fellowship provides me a platform to showcase my skills and help me further bolster my knowledge of this field.

Anticipated timeline with deliverables

1) Week 1
    - Understand current approximate Nearest Neighbor Algorithms (ANNs)
    - Understand approaches to hashing and bucket indexes

2) Week 2-3
    - Build a library specific to particle physics requirements of KNN/ANNs
3) Week 4-5
    - Testing and Benchmarking the various techniques on the problem
4) Week 6-7
    - Trying novel deep learning approaches to nearest neighbors in learned metric space (e.g the concept of seediness – learning which points to make good seeds)
5) Week 8-9
    - Trying Non-Euclidean ideas for this learned space (e.g. hyperbolic metric learning is an emerging field that may capture some of the hierarchical properties of the physical problem)
6) Week 10-12
    - Implementing GPU-specific versions of some of these ideas into the library

References

1) Cai, Deng. "A Revisit of Hashing Algorithms for Approximate Nearest Neighbor Search." *IEEE Transactions on Knowledge and Data Engineering*, 2019, pp. 1–1., doi:10.1109/tkde.2019.2953897.