Machine Learning in High Energy Physics

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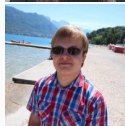
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Personnel

Efforts in HEP applications of ML started just a year ago in Helsinki Institute of Physics (HIP). Currently we have

- Henning Kirschenmann, postdoctoral researcher

- Joona Havukainen, doctoral student

- Ville Pyykkönen, master's student

Particle track reconstruction

Particle track reconstruction

- Tracks are reconstructed based on *hits* in the tracker subdetector in the heart of CMS.

- Large number of hits in any given collision event $\Rightarrow$ possibility of constructing *false tracks* that seem plausible but are not real.

- Machine learning used to decide whether track is real or fake, also quantifies how good quality the track is.
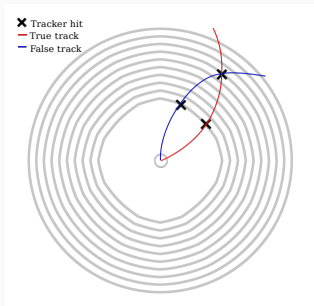

Figure 1: It is possible to reconstruct a false track that seems to fit the tracker hits. Machine learning is used to discard falsely reconstructed tracks.

Jet flavour tagging

Jet flavour tagging

- Accurate jet tagging is vital for many physics analyses, but a difficult task to accomplish
- The "DeepFlavour" effort uses deep learning methods to tag jets (Markus Stoye's presentation at the IML Workshop at CERN: `https://cds.cern.ch/record/2256692`)
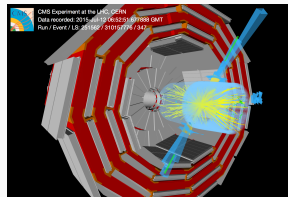- Deep learning shown to offer improved accuracy over methods used so far.

Figure 2: A highly energetic dijet event at the CMS. Image: Thomas McCauley and Tai Sakuma

Search for the
Charged Higgs boson

- Separating events containing new physics from background using ML techniques.
- So far the analysis has been cut-based (https://arxiv.org/pdf/1508.07774.pdf), adding ML selection should offer improved sensitivity through better separation of signal and background events.
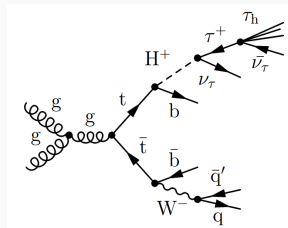

Figure 3: A possible production mechanism for a Charged Higgs boson. Machine learning is used to select events that are deemed plausible to contain new particles.

Summary

Currently working on three machine learning applications:

- Track reconstruction classification
- Jet flavour tagging
- Search for a new particle

These projects support the already strong participation in track reconstruction, jet physics and the Charged Higgs boson search in HIP. We are looking into expanding our currently small group of people working on ML in HEP.