Processing of Large Quantities of Physics Data Using Machine Learning

In order to collect a large set of data for subsequent processing, modern particle physics experiments usually rely on performing measurements with high frequency. These measurements may however be conducted with rates that make storing and processing of every physics event technically unfeasible with presently available technology. As a result, only the events that exhibit interesting properties must be selected during the data acquisition process.

To achieve such reduction of frequency of data taking, the operation of particle physics experiments is usually governed by a trigger system. These systems evaluate physics events based on predetermined set of criteria in order to determine the probability that the event carries relevant data. Depending on the evaluation done in a trigger system, the event is then either processed or discarded.

Trigger systems are usually implemented on the hardware level of the measuring apparatus. In addition, high-level, software-based trigger may be implemented, which conducts preliminary analysis of events and acts as an additional event acceptance test. High-level triggers have the advantage of being able to perform more complex decisions at the cost of calculation speed, therefore, hardware trigger is still required to reduce the amount of data sent to high-level trigger.

However, increasing computational power of hardware enables to investigate entirely new approach to data acquisition, which would result in construction of “triggerless” data acquisition systems. “Triggerless” data acquisition system in this context is a system which possesses no hardware trigger, or a hardware trigger with particularly benevolent set of event acceptance criteria. As a result, the filtering task is transferred to the software-based high-level trigger. The Ph.D. candidate will be tasked with designing algorithms that will achieve filtering of physics events in such high-level trigger that is part of a “triggerless” data acquisition system.

The algorithms that the Ph.D candidate will design must therefore be able to process data events at a rate high enough to process all events produced by measuring apparatus of a particle physics experiments. Additionally the algorithms must be able to filter sufficient amount of events so that the output of the data acquisition system is manageable by available data storage solutions.

Given the parameters of this task, the Ph.D. candidate should consider to utilize methods belonging to the field of machine learning. The candidate shall explore the possibility of employing existing methods, as well as introduce new principles of physics events filtering.

After designing suitable filtering techniques that satisfy the above criteria, the Ph.D. candidate will additionally be tasked with an implementation of the designed algorithms, with the intent of deploying them for usage on a specific scientific experiment.

Recommended literature

Stuart Russel and Peter Norvig. *Artificial Intelligence. A Modern Approach.* 3rd edition. London, United Kingdom: Pearson, 2009. ISBN: 978-0-13-604259-4.

Ian Goodfellow, Yoshua Bengio, and Aaron Courville. *Deep Learning.* Cambridge, MA, USA: MIT Press, 2016. ISBN: 978-0-262-03561-3.

Tom M. Mitchell. *Machine Learning.* New York, NY, USA: McGraw-Hill Education, 1997. ISBN: 978-0-07-042807-2.

Amit Konar. *Artificial Intelligence and Soft Computing. Behavioral and Cognitive Modeling of the Human Brain.* Boca Rayton, FL, USA: CRC Press, 1999. ISBN: 978-0-8493-1385-1.