Contribution ID: **479** Type: **Oral**

Excursion Set Estimation using Sequential Entropy Reduction for Efficient Searches for New Physics at the LHC

Wednesday 13 March 2019 18:40 (20 minutes)

A common goal in the search for new physics is the determination of sets of New Physics models, typically parametrized by a number of parameters such as masses or couplings, that are either compatible with the observed data or excluded by it, where the determination into which category a given model belong requires expensive computation of the expected signal. This problem may be abstracted into the generalized problem of finding excursion sets (or, equivalently, iso-surfaces) of scalar, multivariate functions in n dimensions.

We present an iterative algorithm for choosing points within the problem domain for which the functions are evaluated in order to estimate such sets at a significantly lower computational cost. The algorithm implements a Bayesian Optimization procedure, in which a information-based acquisition function seeks to maximally reduce the uncertainty on a excursion set. Further extension of the basic algorithm to the simultaneous estimation of excursion sets of multiple functions as well as batched selection of multiple points is presented.

Finally, a python package, excursion[1], is presented, which implements the algorithm and performance benchmarks are presented comparing this active-learning approach to other strategies commonly used in the high energy physics context, such as random sampling and grid searches.

[1] https://github.com/diana-hep/excursion

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Session Classification: Track 2: Data Analysis - Algorithms and Tools

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