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Improved estimate of systematic uncertainty of distributions with finite samples

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In a high energy physics experiment, a straightforward approach to estimating the dependency of a distribution of events on a nuisance parameter is to take the difference of histograms of the distribution coming out of a simulation before and after perturbing the value of the nuisance parameter. This is often done by perturbing one already simulated event at a time by a small post-simulation correction, due to e.g. a change of energy scale or energy resolution. This leads, unfortunately, to uncomfortably large statistical fluctuations, as the perturbed events move discontinuously from one histogram bin to the next. These fluctuations are frequently dealt with by a smoothing technique, which is pain-staking to validate. In this work we focus on the first and second moments of the small movements of the events to more directly estimate the shape dependence on the nuisance parameter. A fundamental assumption, and limitation, of this approach is that there is no hidden dependence one the acceptance on the nuisance parameter, i.e., events may move around in the distribution but events do not leave or enter the analysis acceptance except at the edges of the histogram. The approach could, however, prove useful for precision shape-dependent measurements of, for example, the mass of the W boson. Toy studies illustrate the potential of the approach.

Author: READ, Alexander Lincoln (University of Oslo (NO))

Presenter: READ, Alexander Lincoln (University of Oslo (NO))

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