Contribution ID: **42** Type: **not specified**

Differentiable Programming for High-Energy Physics

Wednesday 15 June 2022 11:15 (15 minutes)

Abstract: Machine learning methods are now ubiquitous in physics, but often target objectives that are one or two steps removed from our physics goals. A prominent example of this is the discrimination between signal and background processes, which doesn't account for the presence of systematic uncertainties —something crucial for the calculation of quantities such as the discovery significance and upper limits.

To combat this, we show that physics analysis workflows can be optimised in an end-to-end fashion, including the treatment of nuisance parameters that model systematic uncertainties, provided that the workflow is differentiable. By leveraging automatic differentiation and surrogates for non-differentiable operations, we've made this possible for the first time, and demonstrate its use in a proof-of-concept scenario.

This talk will motivate the use of end-to-end optimisation as described above, cover the techniques that make it possible, and show recent developments in a high-energy physics context. Future directions that aim to scale and apply these methods will also be highlighted.

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Session Classification: Sektionen för elementarpartikel och astropartikelfysik

Track Classification: Parallel session: partikelsektionen