Louvain-la-Neuve, September 8, 2021

Differentiable Programming for Experimental Design

White Paper

Tommaso Dorigo

INFN, Sezione di Padova

White Paper on Differentiable Programming for Experimental Design

This is a MODE collaboration activity – we are hereby hijacking a piece of this morning session to discuss our business

→not by accident: you could be an author of this paper if you join MODE

In our mind, this will be a comprehensive look (review-style) of the ongoing efforts in this direction, and a plan of research activities

The document is already partly drafted, but we need significant additional effort and some commitment to finalize it.

Present status of the document

We have an overleaf shared document
which we have been drafting intermittently

We target the journal Reviews in Physics,
or similar (bonus of above: no fee)

Toward the End-to-End Optimization of Particle Physics Instruments with Differentiable Programming: a White Paper

MODE Collaboration
...

September 8, 2021

Abstract

Ideally each section should be at most 5 pages long. We want to target an agile 20–25 pages document.

The full optimization of the design and operation of instruments whose functioning relies on the interaction of radiation with matter is a super-human task, given the large dimensionality of the space of possible choices for geometry, detection technology, materials, and data-acquisition and information-extraction techniques, and the interdependence of the related parameters. On the other hand, enormous potential gains in performance over standard, "experience-driven" layouts are in principle at reach if an objective function fully aligned with the final goals of the instrument is maximized by a systematic search of the configuration space. The stochastic nature of the involved quantum processes make the modeling of these systems an intractable problem from a classical statistics point of view, yet the construction of a fully differentiable pipeline and the use of deep learning techniques may allow the simultaneous optimization of all design parameters.

In this document we lay down our plans for the design of a modular and versatile modeling tool for the end-to-end optimization of complex instruments for particle physics experiments as well as industrial and medical applications that share the detection of radiation as their basic ingredient, and consider a selected set of use cases to highlight the specific needs of different applications.

Present status of the document

Divided in 6 sections

Content list of section 4 is still tentative - we will populate it with applications we care to describe, and on which we foresee future activities

Contents

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We need an opt-in system to take care of the sections to be drafted

- Section 1: (intro) partly written, should be easy to finalize
- Section 2 (state of the art in CS): need volunteers to take on, break down in subsections, and do drafting / coordinate
- Section 3 (problem description and possible solutions): also need volunteers to coordinate revision and drafting of what is missing
- Section 4 (use cases): we have good text on Muography (thx Andrea), we need to focus on a couple of interesting exemplary other cases, and identify contributors
- Section 5 (hardware and architecture req's): also in need of a couple of volunteers

Not going to start polling the audience or twist arms, but I believe this should be seen as a great opportunity – the effort is small, as the length of the paper is constrained and we only need to produce summaries of ideas.