Contribution ID: **178**   Type: **Poster**

Differentiating through Awkward Arrays using JAX and a new CUDA backend for Awkward Arrays

Wednesday, 26 October 2022 11:00 (30 minutes)

Awkward Array is a library for nested, variable-sized data, including arbitrary-length lists, records, mixed types, and missing data, using NumPy-like idioms. Auto-differentiation (also known as "autograd" and "autodiff") is a technique for computing the derivative of a function defined by an algorithm, which requires the derivative of all operations used in that algorithm to be known.

The grad-hep group is primarily focused on end-to-end analysis, and they use JAX as their primary library for auto-differentiation. As part of such an effort, we developed an interoperability layer between JAX and Awkward Arrays using JAX's pytrees API. JAX now differentiates most of the Awkward Array functions including reducers algorithms. This allows investigators to differentiate through their functions if they are using Uproot with Awkward Arrays. However, extending JAX's vectorized mapping APIs is not possible currently, because of the fundamental differences between the two libraries.

Future work on this might involve testing for a large subset of most commonly used differentiable cases. Currently, testing is carried out on a relatively small number of cases which were developed to catch edge cases.

We also developed a GPU backend for Awkward Arrays by leveraging CuPy's CUDA capabilities. Awkward Arrays now has the entire infrastructure to support operations on a GPU. However, many low-level "C" Kernels (115/204) are yet to be translated to CUDA. After implementing this, Awkward Arrays will have full GPU support and this would indirectly help in making auto-differentiation fully deployable on the GPUs too.

Significance

References

Experiment context, if any

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Session Classification: Poster session with coffee break