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Using C++ From Numba, Fast and Automatic

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The scientific community using Python has developed several ways to accelerate Python codes. One popular technology is Numba, a Just-in-time (JIT) compiler that translates a subset of Python and NumPy code into fast machine code using LLVM. We have extended Numba's integration with LLVM's intermediate representation (IR) to enable the use of C++ kernels and connect them to Numba accelerated codes. Such a multilanguage setup is also commonly used to achieve performance or to interface with external bare-metal libraries. In addition, Numba users will be able to write the performance-critical codes in C++ and use them easily at native speed.

This work relies on high-performance, dynamic, bindings between Python and C++. Cppyy, which is the basis of PyROOT's interfaces to C++ libraries. Cppyy uses Cling, an incremental C++ interpreter, to generate on-demand bindings of required entities and connect them with the Python interpreter. This environment is uniquely positioned to enable the use of C++ from Numba in a fast and automatic way.

In this talk, we demonstrate using C++ from Numba through Cppyy. We show our approach which extends Cppyy to match the object typing and lowering models of Numba and the necessary additions to the reflection layers to generate IR from Python objects. The uniform LLVM runtime allows optimizations such as inlining which can in the future remove the C++ function call overhead. We discuss other optimizations such as lazily instantiated C++ templates based on input data. The talk also briefly outlines the non-negligible, Numba-introduced JIT overhead and possible ways to optimize it. Since this is built as a Cppyy extension Numba supports all bindings automatically without any user intervention.

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