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Deep(er)RICH: Reconstruction of Imaging CherenkovDetectors with Swin Transformers and Normalizing Flow Models

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The Deep(er)RICH architecture integrates Swin Transformers and normalizing flows, and demonstrates significant advancements in particle identification (PID) and fast simulation. Building on the earlier DeepRICH model, Deep(er)RICH extends its capabilities across the entire kinematic region covered by the DIRC detector in the \textsc{GlueX} experiment. It learns particle identification (PID) tasks as a continuous function of the charged particle's momentum, direction, and point of impact on the DIRC plane, showing superior performance over traditional geometric reconstruction methods for PID. Leveraging GPU deployment, we have achieved state-of-the-art time performance, with an effective inference time for identifying a charged particle of $\leq \mathcal{O}(10)\ \mu s$, comparable to the first version of DeepRICH, and an effective simulation time of $< 1\ \mu s$ per hit. This ideally enables near real-time applications, which are of particular interest for future high-luminosity experiments aiming to implement deep learning architectures in high-level triggers or more sophisticated streaming readout schemes like those under development at the EIC.

The high quality of reconstruction and the fast computing time are two compelling features of the Deep(er)RICH architecture. The possibility of combining enhanced PID and fast simulations also enables handling complicated topologies arising from overlapping hit patterns detected in the same optical box and generated by simultaneously detected tracks, a problem that traditional methods currently cannot cope with. Consequently, Deep(er)RICH could contribute to important physics channels at both JLab and EIC. Deep(er)RICH is extremely portable; it is agnostic to the data injected, photon-yield, and detector geometry, and can therefore be adapted to other experiments and imaging Cherenkov detectors beyond the DIRC at \textsc{GlueX}, such as the hpDIRC at ePIC.

Focus areas

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