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PELICAN Update: Equivariance, Explainability, and Robustness in Jet ML

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While the plethora of recent machine learning solutions to particle physics tasks have improved statistical power over hand-crafted methods, they often discount the importance and impact of explainability and the theoretical foundations the problems which they are used to address. This talk will present a comprehensive description of the latest version of the PELICAN network, a permutation and Lorentz-equivariant network architecture for particle physics. We demonstrate significant improvements in particle classification and four-vector regression tasks while maintaining a lightweight and uniquely explainable architecture that allows for new approaches to interpreting the network performance and results. PELICAN operates on lists of four-momenta and allows for both scalar and four-momentum outputs while respecting permutation and Lorentz symmetries. We showcase PELICAN's classification performance in the context of various hadronic final state problems: discriminating between top-quark vs. QCD backgrounds; discriminating gluon vs. light quark-induced jets; and multi-classification of gluon, light quark, W boson, Z boson, and top-quark jets. Further, we investigate the model dependence of the network performance and characterize PELICAN's full classification to four-vector regression pipeline behavior in the context of W boson reconstruction in fully hadronic top-quark decays with QCD background including infrared and collinear-safe instances of the network.

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