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IceCube-Upgrade Reconstructions using Recurrent Neural Networks

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Neutrinos offer a variety of insights into Standard Model physics that are not yet understood, including flavor oscillations and the neutrino mass ordering. One instrument being used to study neutrinos is the IceCube South Pole Neutrino Observatory, a cubic kilometer-scale Cherenkov detector over 1.5 km below the South Pole. An extension, the IceCube-Upgrade, is currently under development and is designed to enhance the detector's low-energy performance. The DOMs detect Cherenkov radiation from neutrino interactions within the ice. Using features of the recorded light, such as arrival time and intensity, we can reconstruct neutrino properties such as energy and direction. Reconstructing neutrino events in IceCube is difficult at lower energies (below 100 GeV) due to both the lower number of Cherenkov photons produced during interactions, as well as the large spacing between DOMs, which is optimized for higher-energy events. One way to reconstruct these events is with neural networks, specifically Recurrent Neural Networks (RNNs). RNNs excel at handling data with a sequential relationship such as time, which makes them a great candidate for reconstructing particle interactions. This study highlights the results of an RNN trained to reconstruct the energy and direction of low-energy neutrinos using IceCube-Upgrade simulation; we also provide a comparison to an existing likelihood-based reconstruction.

Are you are a member of the APS Division of Particles and Fields?

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