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Composition Analysis of cosmic-rays at IceCube Observatory, using Graph Neural Networks

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The IceCube Neutrino Observatory, located at the South Pole, is a multi-component detector that detects high-energy particles from astrophysical sources. Cosmic Rays (CRs) are charged particles from these astrophysical accelerators. CRs and CR-induced air-showers furnish us with the possibility to discern the fundamental properties and behavior of such sources. When coupled to the IceTop surface array, IceCube affords unique three-dimensional detection and cosmic-ray analysis in the transition region from galactic to extragalactic sources. This work tries to improve the estimation of CR primary mass on a per-event basis in the mentioned energy range. The work benefits from using the full in-ice shower footprint and additional composition-sensitive air-shower parameters, in addition to global shower-footprint parameters already used in an earlier work. A Graph Neural Network (GNN) based implementation uses the full in-ice shower footprint. Described using nodes and edges, graphs allow us to efficiently represent relational data and learn hidden representations of input data to obtain better model accuracy. Mapping in-ice IceCube detectors, DOMs(Digital Optical Module), as a graph emerges as a natural solution. Using GNNs for cosmic-ray analysis at IceCube also has the added benefit of allowing an easier re-implementation to the planned next-generation upgraded instrument, called IceCube-Gen2.

Type of Contribution

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