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# How can Bayesian networks be used for uncertainty quantification in particle physics?

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Uncertainty quantification is crucial for data analysis and hypothesis testing. Many machine learning algorithms were not designed to provide information about the reliability of their predictions, and the methods for estimating uncertainties from these algorithms can lack transparency. In this talk we demonstrate the Bayesian network framework, which was developed using a rigorous formalism for probabilistic reasoning including both representation and inference (Pearl 1988). This framework uses a graph-based representation of the joint probability distribution as the basis for compactly encoding a high-dimensional distribution, resulting in a simple, interpretable model that is designed for uncertainty quantification. Bayesian networks are well suited to problems where uncertainty quantification is paramount, the scientist would like to constrain the model based on domain knowledge, and the set of variables is small. We constructed a Bayesian network for reconstruction of interaction position in dark matter direct-detection experiments and found that it yielded highly informative per-interaction uncertainties, while also demonstrating precision on reconstructed positions comparable to existing methodologies. This framework can be applied similarly to other inverse problems in particle physics, such as jet classification.

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