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Machine learning at the Cosmic Frontier

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Within the field of dark matter direct detection, there has been very little penetration of machine learning. This is primarily due to the difficulty of modeling such low-energy detectors for training sets (the keV energies are 10^{-10} smaller than LHC). Xenon detectors have been leading the field of dark matter direct detection for the last decade. The current front runner is XENON1T, which has invested heavily into full-chain simulations and a flexible Python-stack reconstruction chain. Accordingly, we have been able to explore what opportunities there exist at the Cosmic Frontier with machine learning. I will report on three things. First, a new type of energy and spatial reconstruction algorithm that may enable this technology to reduce a major source of background while opening up double-beta-decay measurements in later such TPCs. This regression is achieved using deep convolutional neural networks. Second, how machine learning has been used to reduce certain nonphysical backgrounds that we have encountered, primarily using random forests. Third, how machine learning can be used in signal processing for classifying the two signal types that we observe. These three machine-learining R&D topics are applicable to all such detectors in our field and this work constitutes the first known robust exploration of such opportunities for dark matter experiments.

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