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Identification of Protohalos with Deep Learning

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The gravitational collapse of dark matter halos from small density perturbations in the early universe is a highly stochastic and non-linear process that is best approximated through N-body simulations. In this work, we test and compare the ability of fully-convolutional neural networks and transformer-based neural networks to predict the formation of dark matter halos from initial conditions, and classify the detected protohalos according to their final mass at redshift z = 0. We find that the transformer-based model outperforms the CNN-based model substantially, achieving < 1% error on the level of the whole simulation box, and < 10% error on the level of individual objects. We also test the possibility of getting some physical insights into the training process.

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