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Domain Adaptive Graph Neural Networks for Constraining Cosmological Parameters Across Multiple Data Sets

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State of the art astronomical simulations have provided datasets which enabled the training of novel deep learning techniques for constraining cosmological parameters. However, differences in subgrid physics implementation and numerical approximations among simulation suites lead to differences in simulated datasets, which pose a hard challenge when trying to generalize across diverse data domains and ultimately when applying models to observational data.
Recent work reveals deep learning algorithms are able to extract more information from complex cosmological simulations than summary statistics like power spectra. We introduce Domain Adaptive Graph Neural Networks (DA-GNNs), trained on CAMELS data, inspired by CosmoGraphNet (Villanueva-Domingo et al 2023). By utilizing GNNs, we can capitalize on their capacity to capture both astrophysical and topological features of galaxy distributions. Mixing these capabilities with domain adaptation techniques such as Maximum Mean Discrepancy (MMD), which enable extraction of domain-invariant features, our framework demonstrates enhanced accuracy and robustness. We present experimental results, including the alignment of distributions across domains through data visualization.
These findings suggest that DA-GNNs are an efficient way of extracting domain independent cosmological information, a vital step toward robust deep learning for real cosmic survey data.

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