MACHINE LEARNING FOR ASTROPHYSICS

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Interpreting the largest cosmological simulations using Representation Learning

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Numerical simulations are the best approximation to experimental laboratories in astrophysics and cosmology. However, the complexity and richness of their outputs severely limit the interpretability of their predictions. We describe a new assumption-free approach to obtaining scientific insights from cosmological simulations. The method can be applied to today's largest simulations and will be essential to solve the extreme data access, exploration, and analysis challenges posed by the Exascale computing era. Our tool automatically learns compact representations of simulated galaxies in a low-dimensional space that naturally describes their intrinsic features. The data is seamlessly projected onto this latent space for interactive inspection, visual interpretation, sample selection, and local analysis. We present a working prototype using a Hyperspherical Variational Convolutional Autoencoder trained on the entire sample of simulated galaxies from the IllustrisTNG project. The tool produces an interactive visualization of a "Hubble tuning fork"-style similarity space of simulated galaxies on the surface of a sphere. The hierarchical spherical projection of the data can be extended to arbitrarily large simulations with millions of galaxies.

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