**Unveiling the Hidden Galaxy-Halo Connection**

FINESST Proposal

Galaxies are complex structures with a great diversity of properties. An essential objective in the field of galaxy formation and evolution is to identify the physical processes that determine these properties and their evolution with time. Over the past several decades, there has been a growing understanding that these physical processes are regulated by the galaxy’s host dark matter halo and, in turn, the larger-scale environment. Simulations suggest correlations between environment and halo properties, including masses, density distributions, angular momenta, accretion rates, and merger histories. However, dark matter halo properties beyond mass are not directly observable, making the connection between a galaxy, its dark matter halo, and the larger-scale environment uncertain. **We propose to create the Nearest-Neighbors Neural Network (NN2), a neural network that extracts observable information embedded in a galaxy’s environment (e.g., the locations and stellar masses of a galaxy’s nearest neighbors) to predict the properties of its host halo.** NN2will be trained on a mock universe from the Bolshoi-Cosmological Simulation, populated by galaxies using UniverseMachine. The network’s ability to recover the properties of dark matter halos from the simulation can be tested against the simulation with verifiable accuracies. NN2 will: 1) reveal new connections between galaxy, halo, and environment; and 2) serve as a powerful tool for placing galaxies into halos in future cosmological simulations and for inferring the properties of real halos from next-generation survey data.