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Re-simulation-based self-supervised learning

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Self-Supervised Learning (SSL) is at the core of training modern large machine learning models, providing a scheme for learning powerful representations that can be used in a variety of downstream tasks. We propose RS3L ("Re-simulation-based self-supervised representation learning"), a novel simulation-based SSL strategy that employs a method of re-simulation to drive data augmentation for contrastive learning in the physical sciences, particularly, in fields that rely on stochastic simulators. By intervening in the middle of the simulation process and re-running simulation components downstream of the intervention, we generate multiple realizations of an event, thus producing a set of augmentations covering all physics-driven variations available in the simulator. Using experiments from high-energy physics, we explore how this strategy may enable the development of a foundation model; we show how RS3L pre-training enables powerful performance in downstream tasks such as discrimination of a variety of objects and uncertainty mitigation.

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