Synthetic Experience Replay

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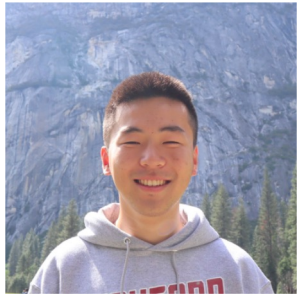
RRL Workshop



Motivation

- RL agents are typically bottlenecked by useful data which they need to gather themselves
- Recent advances in diffusion generative modelling have shown that it's a powerful method to **generate synthetic data** to boost downstream performance, e.g. in image classification or robotics [1, 2]
- Proposed solution: **upsample** agent replay data using a diffusion model!

[1] Synthetic Data from Diffusion Models Improves ImageNet Classification. Shekoofeh Azizi, Simon Kornblith, Chitwan Saharia, Mohammad Norouzi, David J. Fleet. 2023
[2] GenAug: Retargeting behaviors to unseen situations via Generative Augmentation. Zoey Chen, Sho Kiami, Abhishek Gupta, Vikash Kumar. 2023

Background and Notation

- Reinforcement Learning
  - We model the environment as a MDP $\boldsymbol{M = (S, A, P, R, \gamma)}$
  - Agents train on $\boldsymbol{\mathcal{D}=\{(s_i, a_i, r_i, s_i')\}}$ in order to learn a policy $\boldsymbol{\pi(a|s)}$ to maximize expected return in the environment $\boldsymbol{M}$

- Diffusion Generative Models
  - A class of models that learn to model a data distribution ***p(x)***
  - Learns to iteratively reverse a forward noising process and generate samples starting from pure noise

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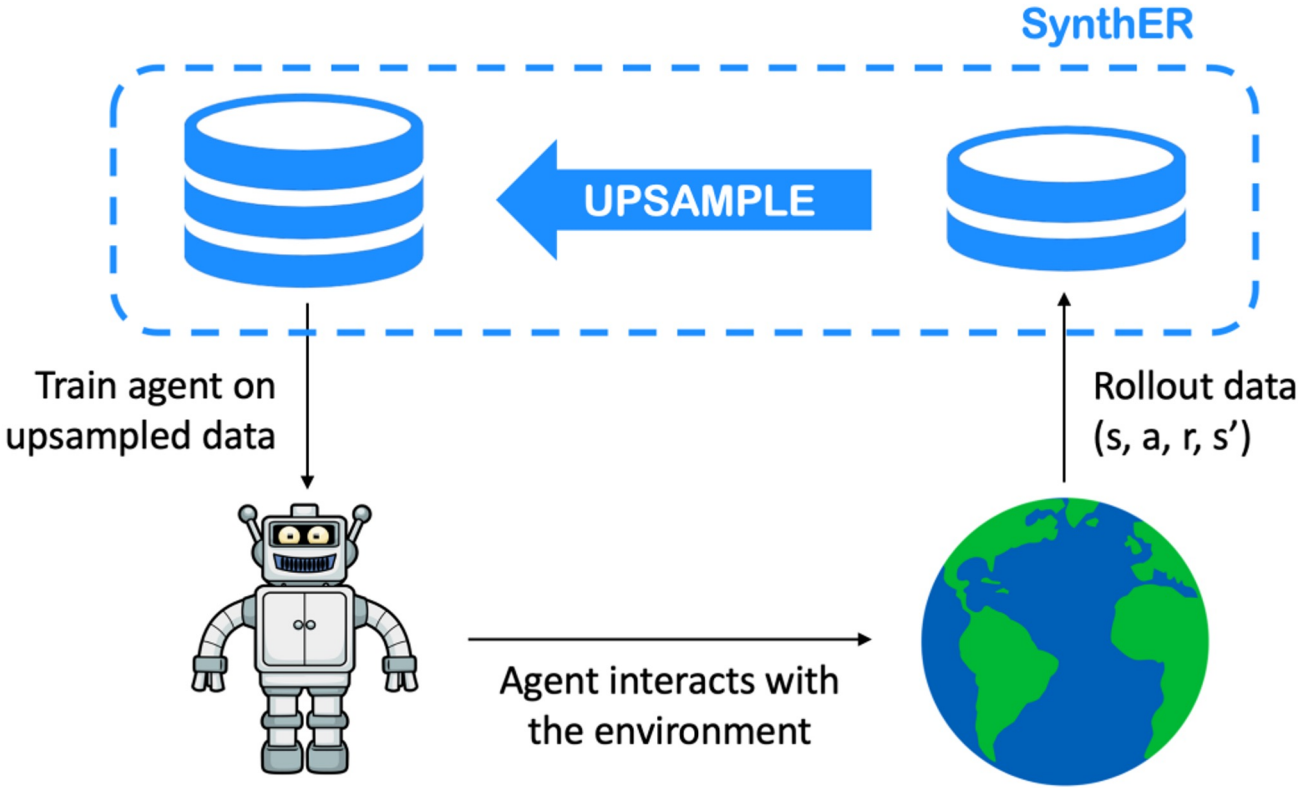
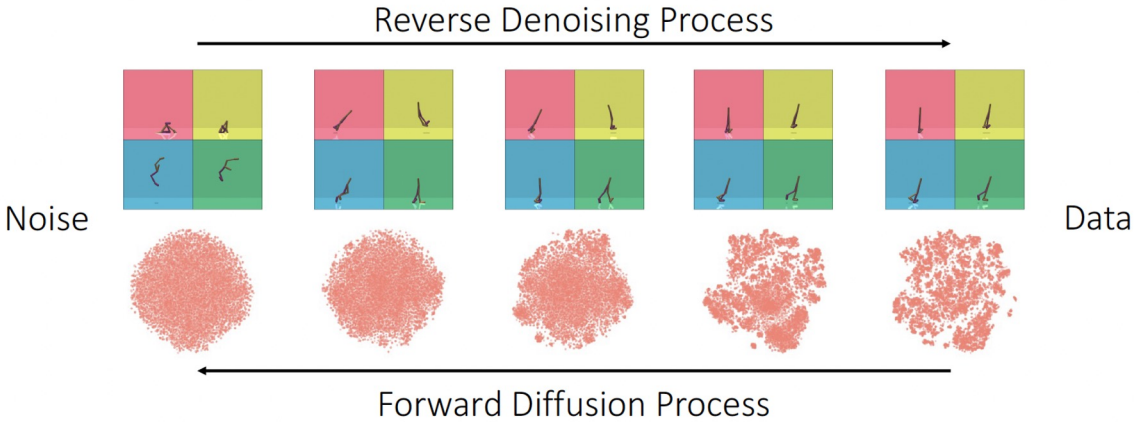
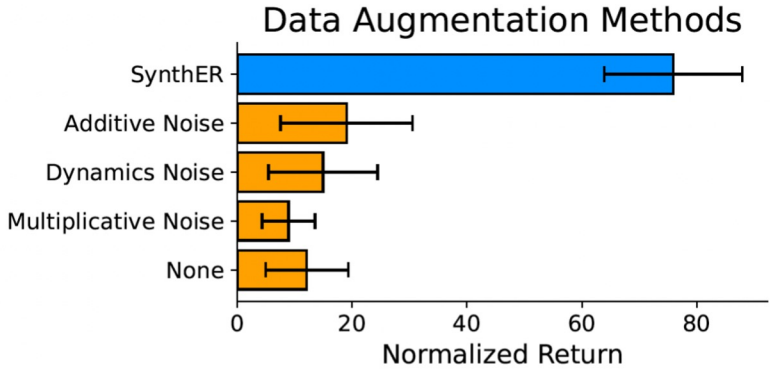


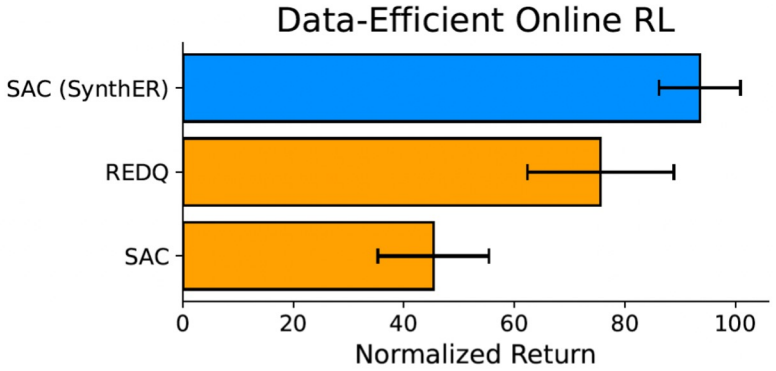
Visualization of the Data Generation Process



Summary of Results

Upsampling data using SynthER greatly outperforms explicit data augmentation schemes for small offline datasets and data-efficient algorithms in online RL **without any algorithmic changes.**





(a) IQL (Kostrikov et al., 2022) on a reduced 15% subset of walker2d medium-replay (Fu et al., 2020).

(b) SAC (Haarnoja et al., 2018) on 6 DeepMind Control Suite and OpenAI Gym environments.

Comparison To Traditional Data Augmentation

SynthER generates samples that both **more faithful** to the true dynamics and **more diverse** than traditional data augmentations

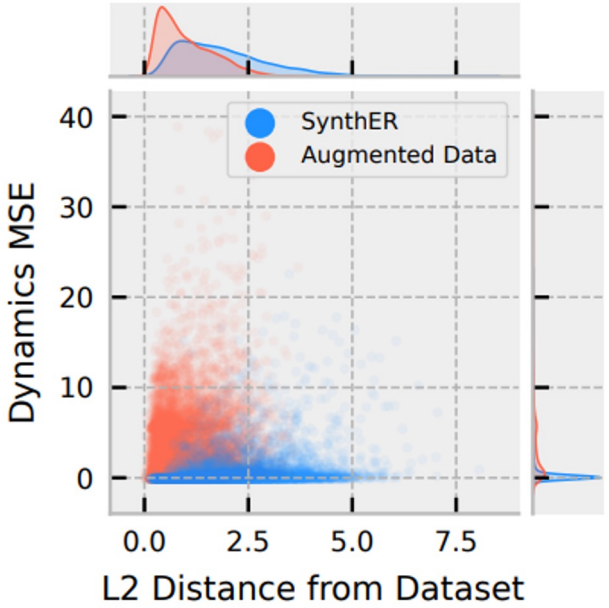


Figure 5: Comparing L2 distance from training data and dynamics accuracy under SYNTHER and augmentations.

Please get in touch with any questions!