

GANISP: a GAN-assisted Importance Splitting Probability Estimator

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<https://github.com/NREL/GANISP>

Motivation

$$\frac{d\xi}{dt} = F(\xi)$$

$$P = \text{Prob}(q(\xi(T)) > a \mid \xi(0) \sim \mathcal{P})$$

Rare event probability estimation

- Risk analysis
- Cyclic fatigue

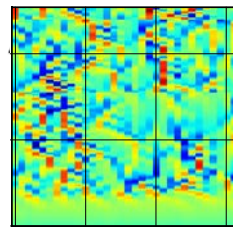
Genealogical adaptive multilevel splitting (Wouters et al.)

- Replicate realizations headed to rare events
- Deterministic systems require perturbations
- Random cloning $\xi_{offspring} = \xi_{parent} + \eta$

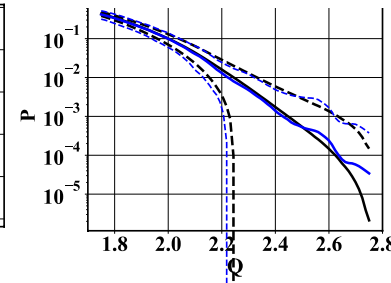
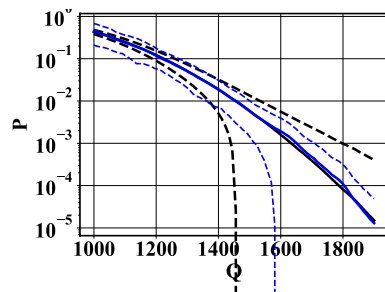
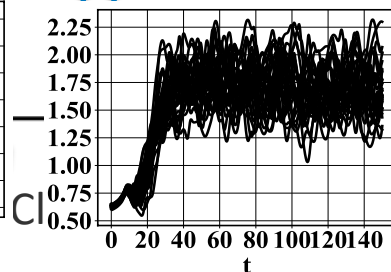
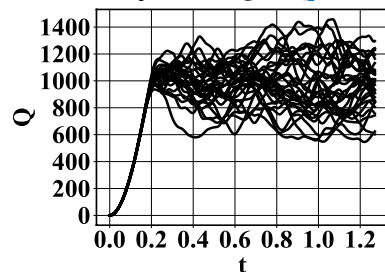
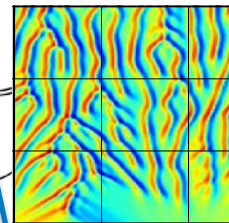
Spatially coherent systems

- Random cloning efficient for Hamiltonian type systems
- Fails for spatially coherent cases (Lestang et al.)
- Harmonic perturbations preferred (Ragone et al.)

Lorenz 96



KSE



Perturbations introduced when cloning should be consistent with the systems' attractor

Hypothesis

Improved cloning procedure

Method

- cGAN conditioned on QoI + avoid mode collapse

$$\mathcal{L}_{div} = \| E(\xi|Q) - E_{a\ priori}(\xi|Q) \|^2$$

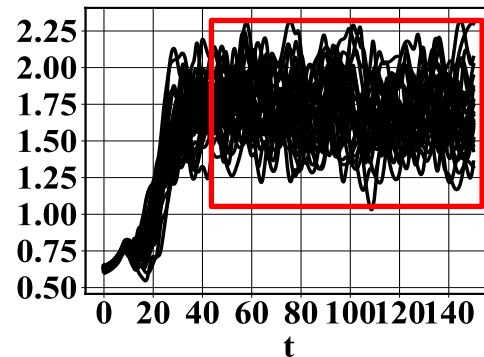
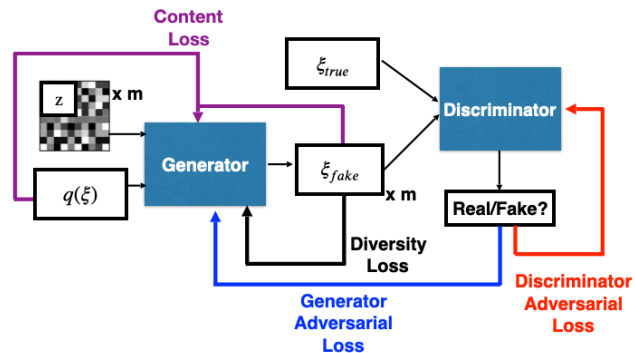
$$+ \sum_{j=1}^N E(\xi_j^2|Q) + E_{a\ priori}(\xi_j^2|Q) - 2\sqrt{E(\xi_j^2|Q)E_{a\ priori}(\xi_j^2|Q)}$$

- Filter generated clones: select close offspring

$$z_{clone} = \min \| G(Q, z) - \xi_{parent} \|_2$$

Data

- Use snapshots selected from the statistically stationary part of the simulations



Results

About GANISP

- Improves the variance reduction in the probability estimate
- Bridge the performance gap between spatially coherent and incoherent systems

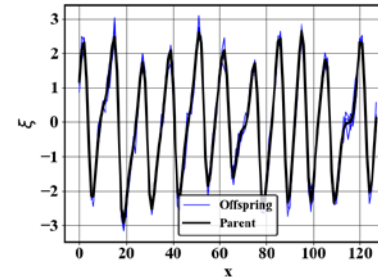
About GAMS

- Cloning method matters
- Realistic perturbations are useful

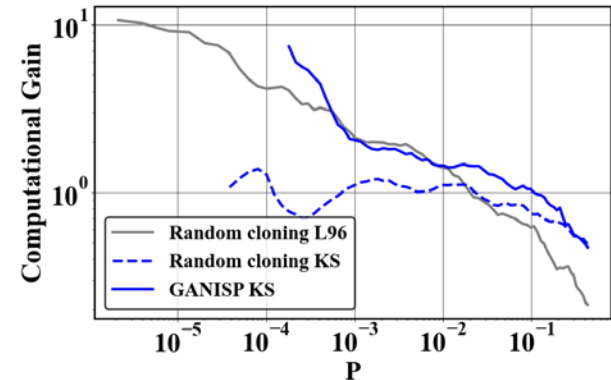
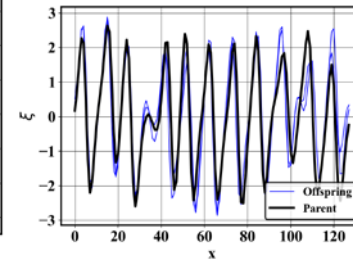
Future work

- Control the magnitude of perturbations introduced
- Identify systems that can benefit from GANISP

Random cloning



GAN cloning



Thank you

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