

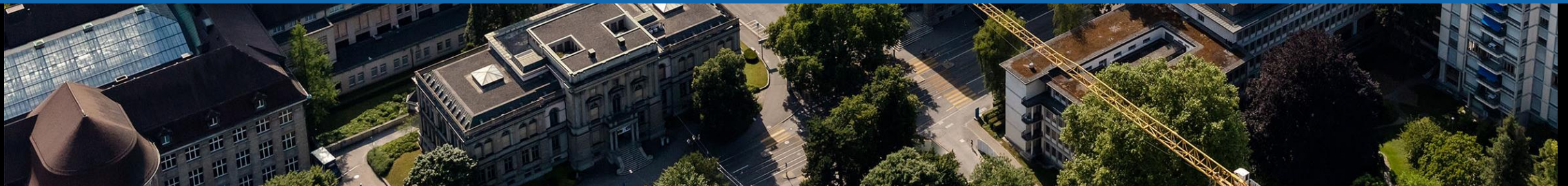


DeSKO: Stability-Assured Robust Control of Nonlinear Systems with a Deep Stochastic Koopman Operator

Minghao Han^{1,2}, Jacob Euler-Rolle¹, Robert K. Katzschmann¹

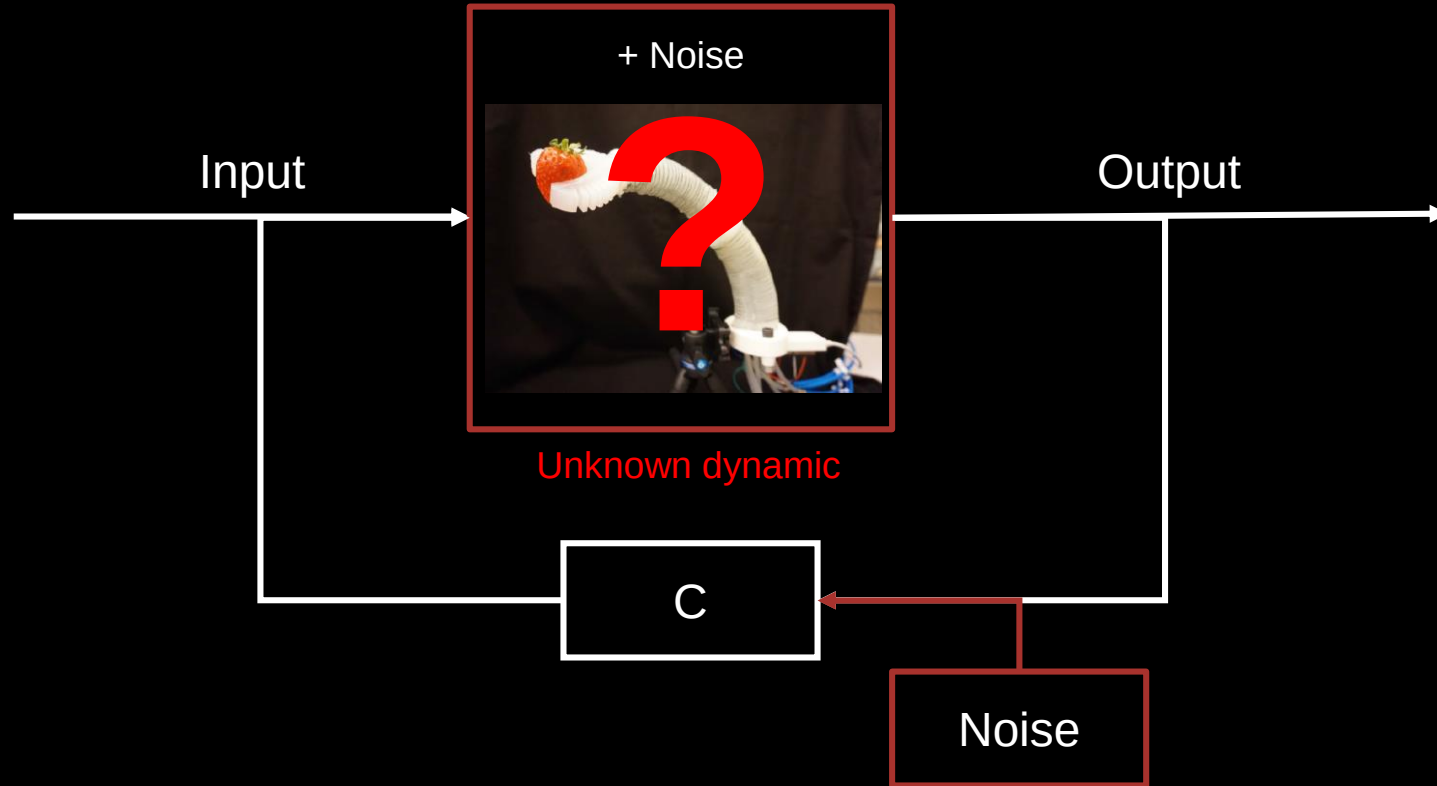
¹ ETH Zurich

² Harbin Institute of Technology



DeSKO: Deep Stochastic Koopman Operator

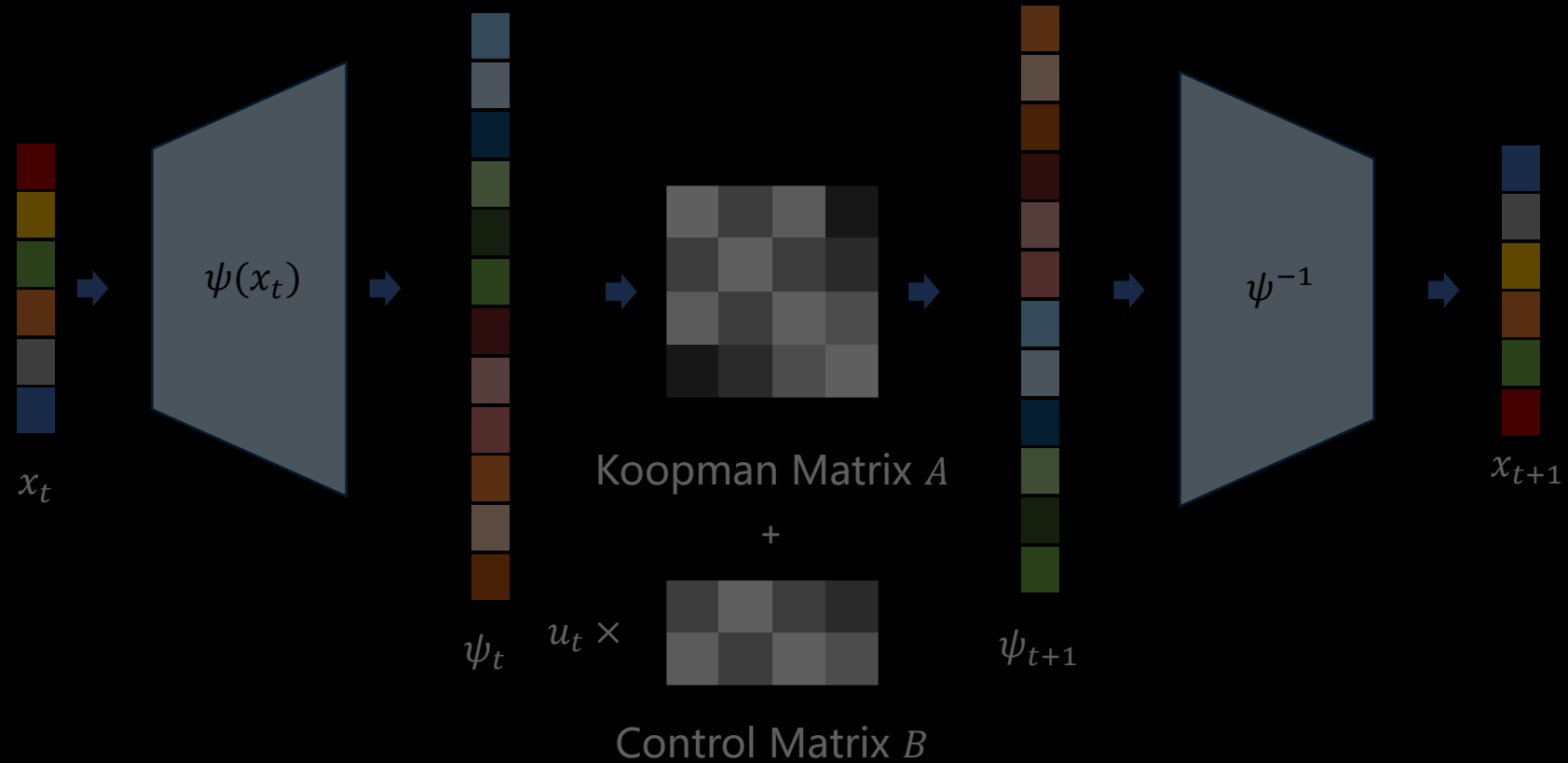
Preliminary | Modeling | Control | Results | Conclusion



Motivation: Learning an accurate and concise model

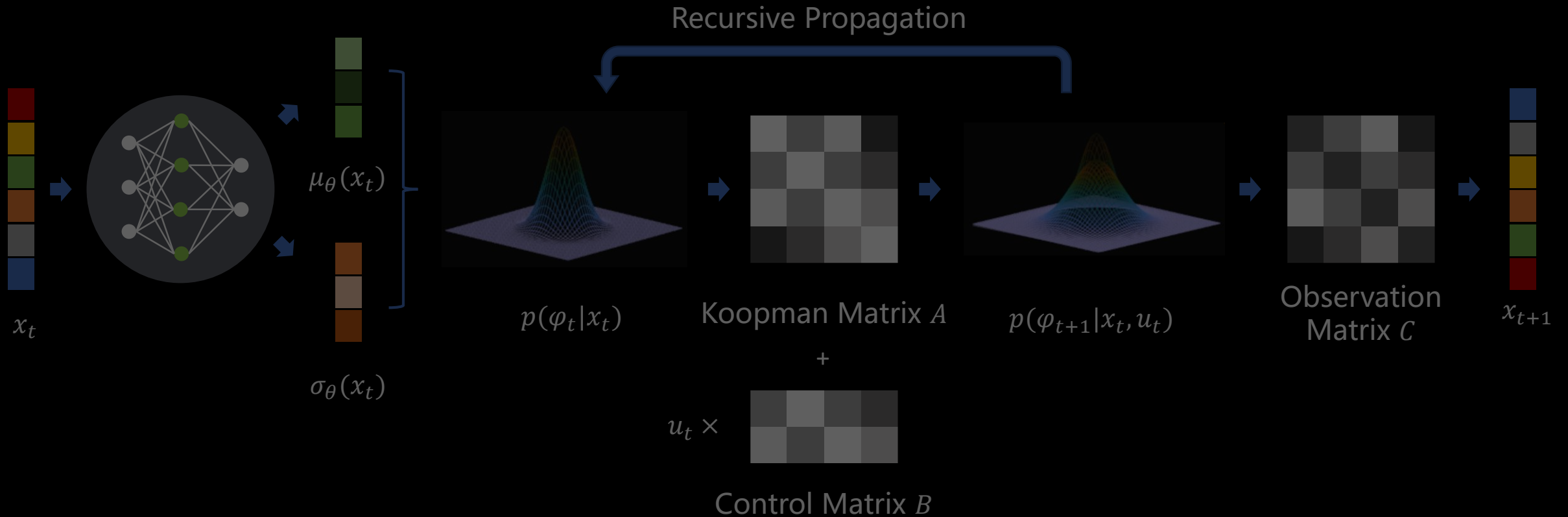
DeSKO: Deep Stochastic Koopman Operator

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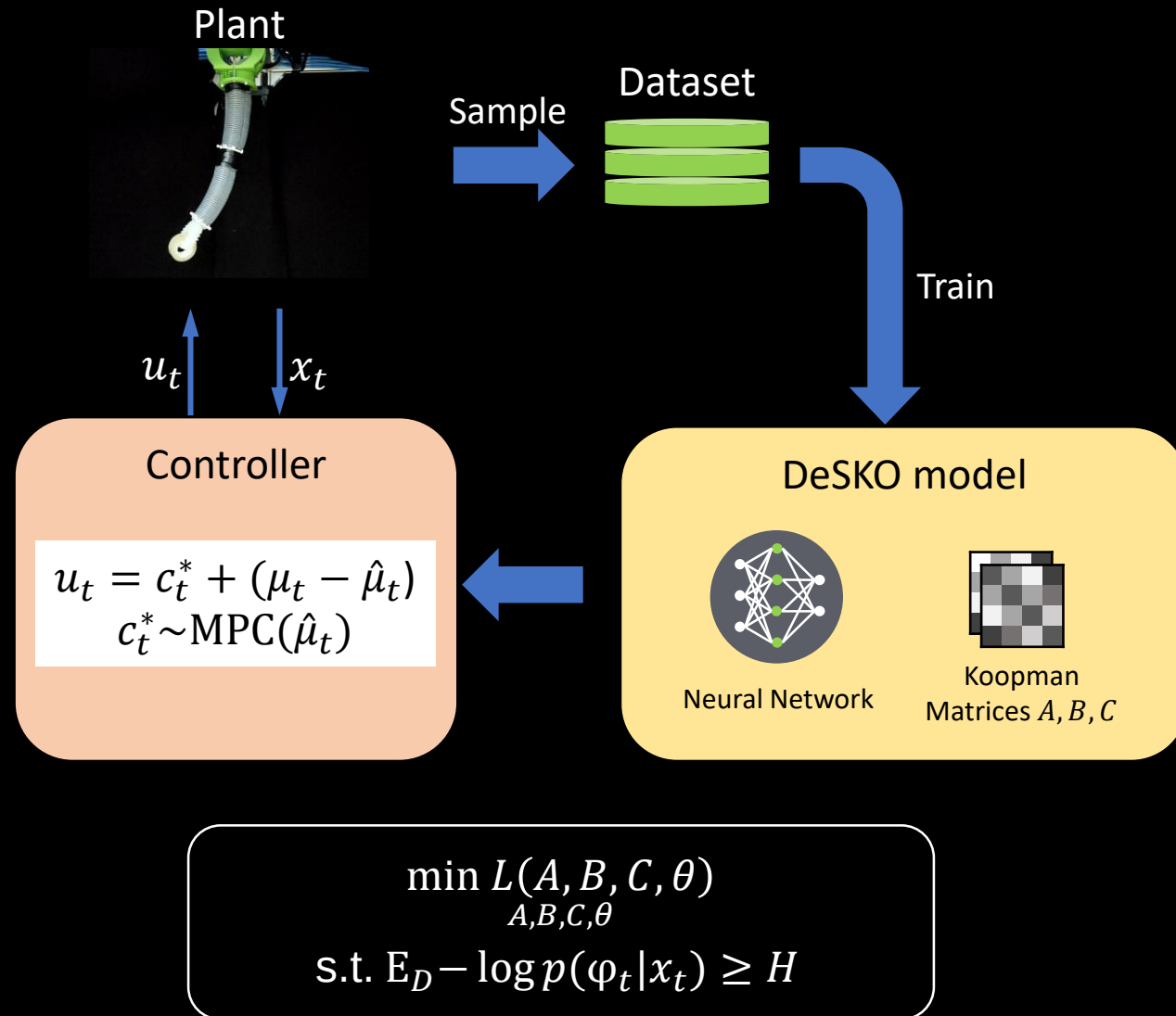
Encoding of states into
parameters of the
distribution of observables

Propagation of the distribution with
Koopman operator

Mapping of observables back to
state space

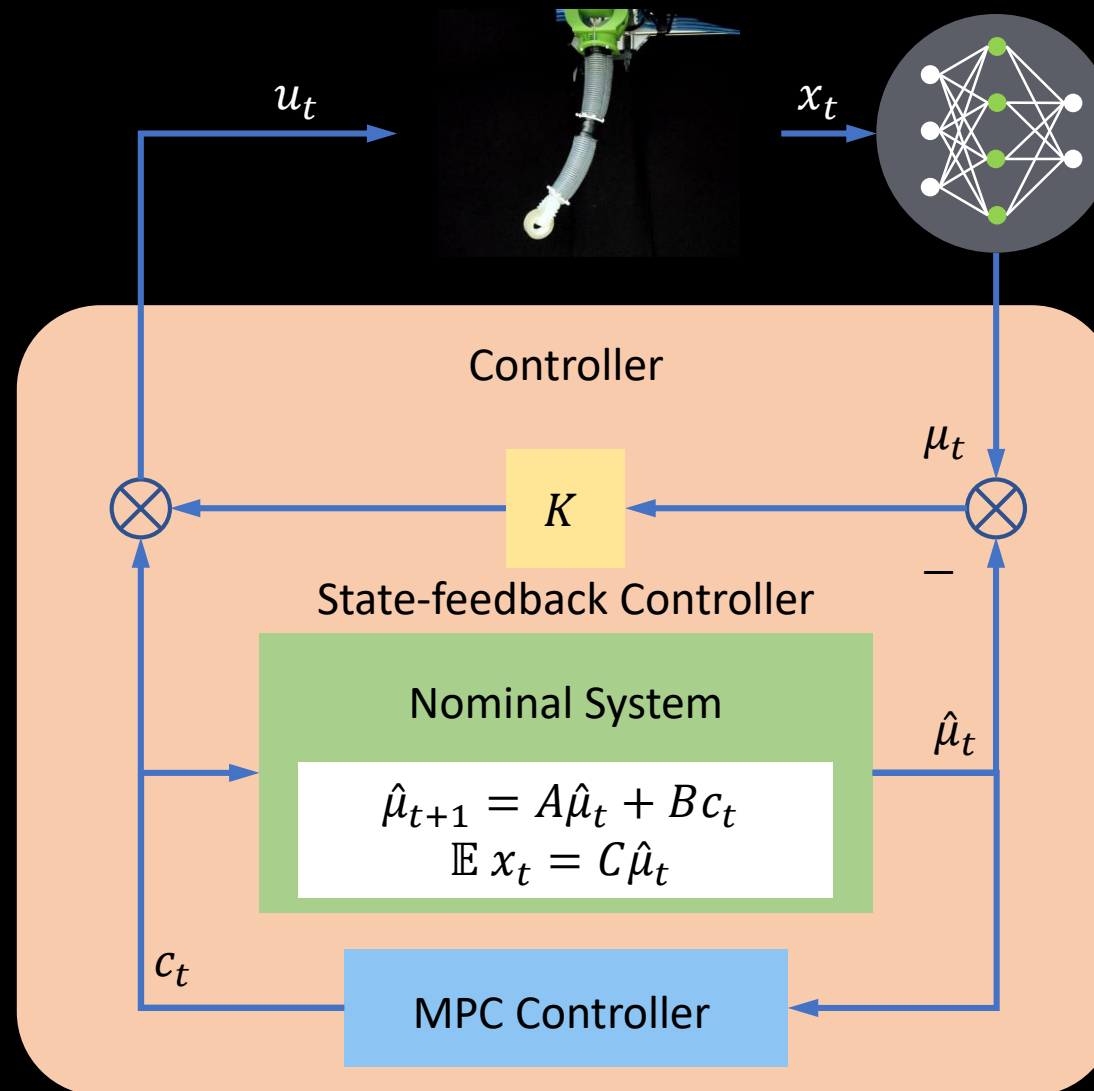
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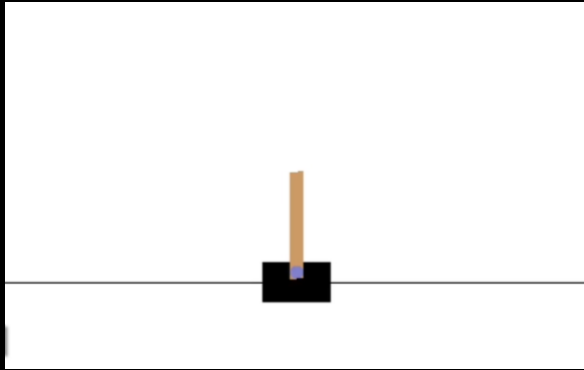
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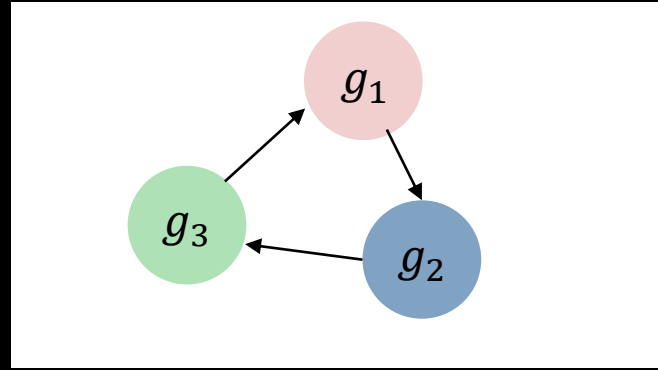


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CartPole

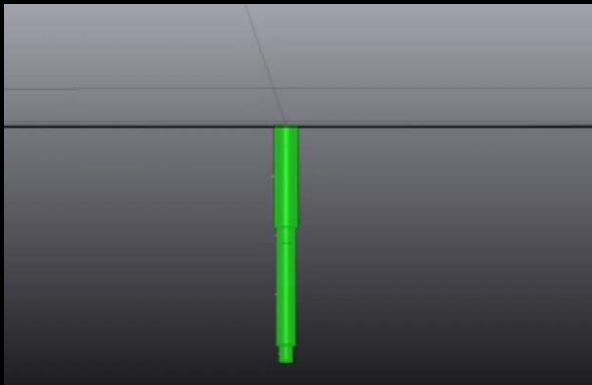


Gene Regulatory Network

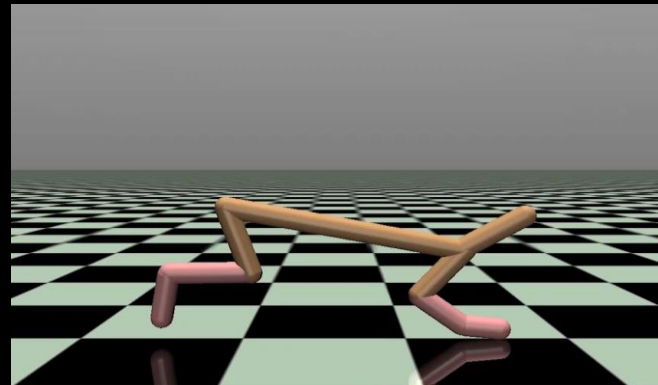
Nominal

Observation Noise

Process Noise



Soft Robot Arm



HalfCheetah

Nominal

Observation Noise

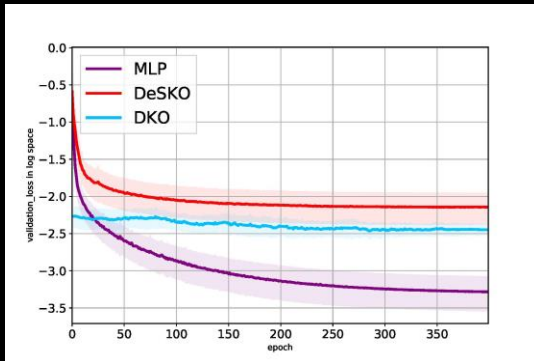
10 systems in total

DeSKO: Deep Stochastic Koopman Operator

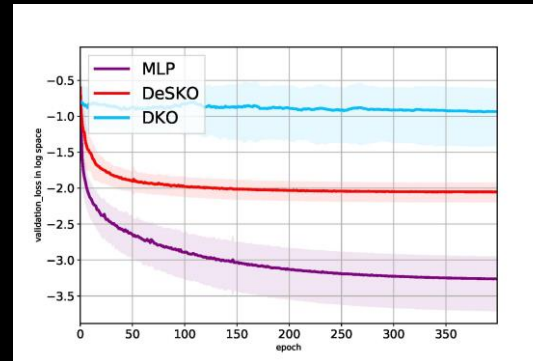
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Prediction Error

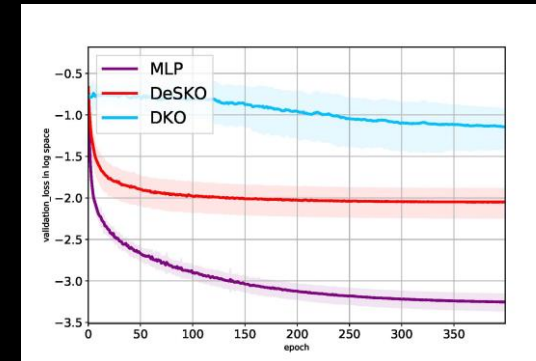
Nominal



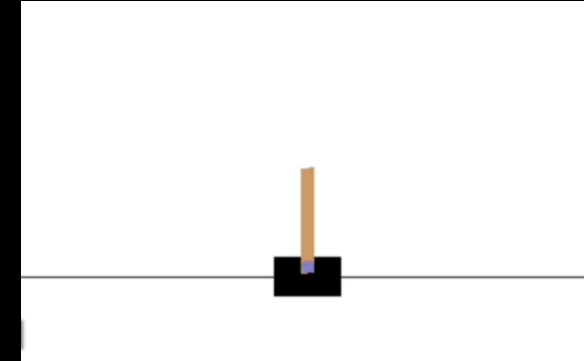
Observation noise



Process noise



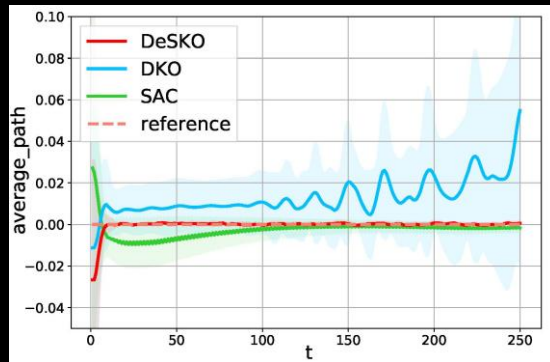
Epochs



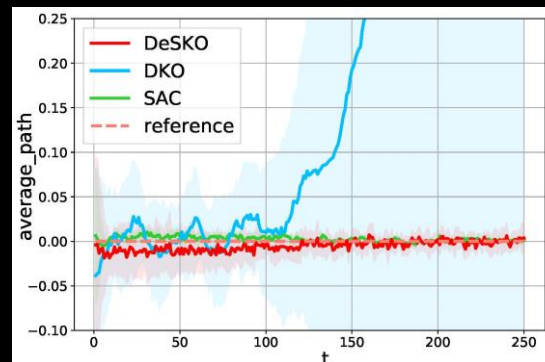
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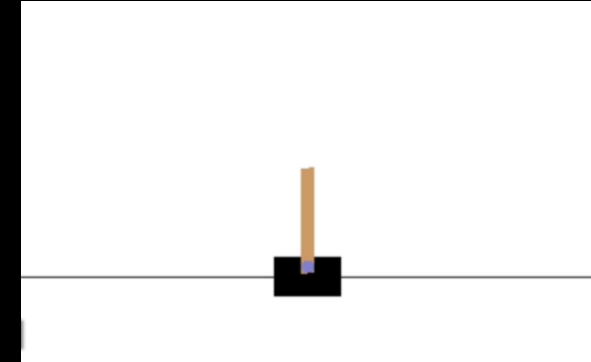
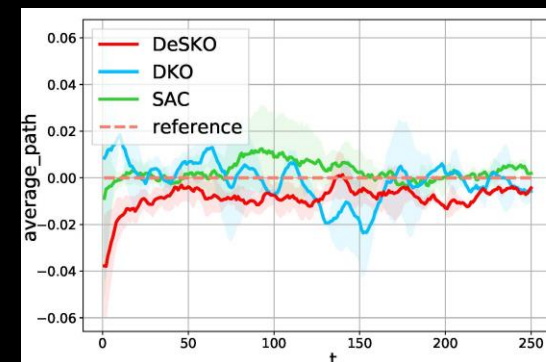
Nominal



Observation noise



Process noise



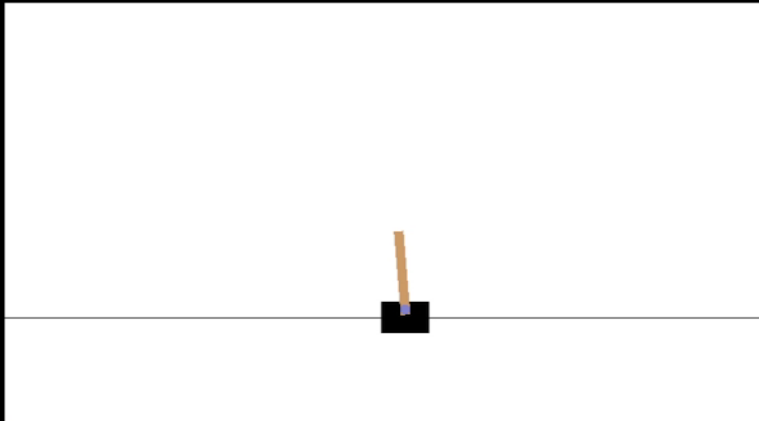
Time

DeSKO: Deep Stochastic Koopman Operator

Preliminary | Modeling | Control | Results | Conclusion

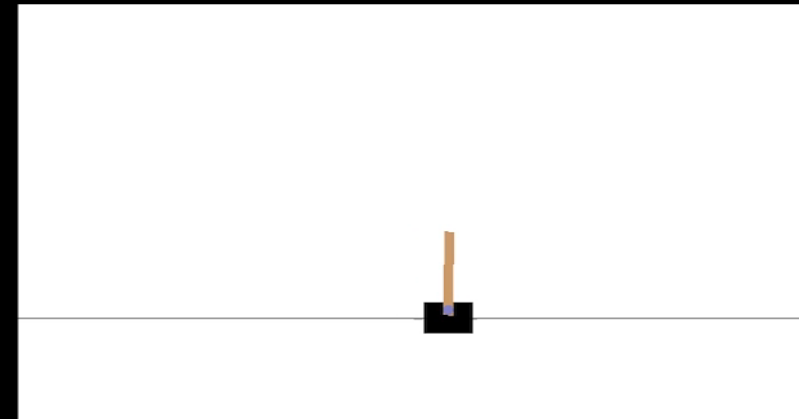
Impulsive disturbances of 80N
(maximum control input 20N)

DeSKO



Ours

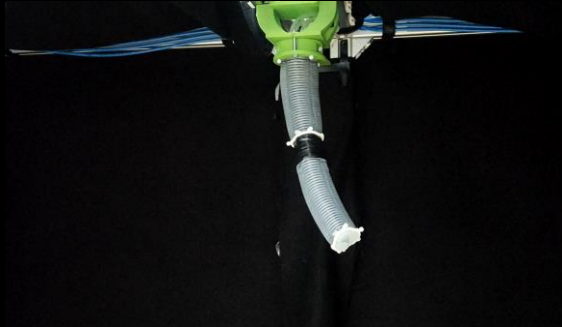
SAC



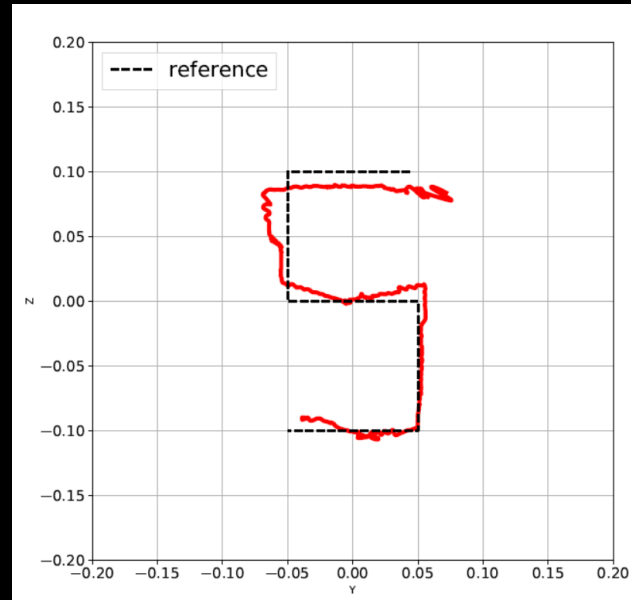
Haarnoja T, Zhou A, Abbeel P, et al. Soft actor-critic: Off-policy maximum entropy deep reinforcement learning with a stochastic actor[C] International Conference on Machine Learning. PMLR, 2018: 1861-1870.

DeSKO: Deep Stochastic Koopman Operator

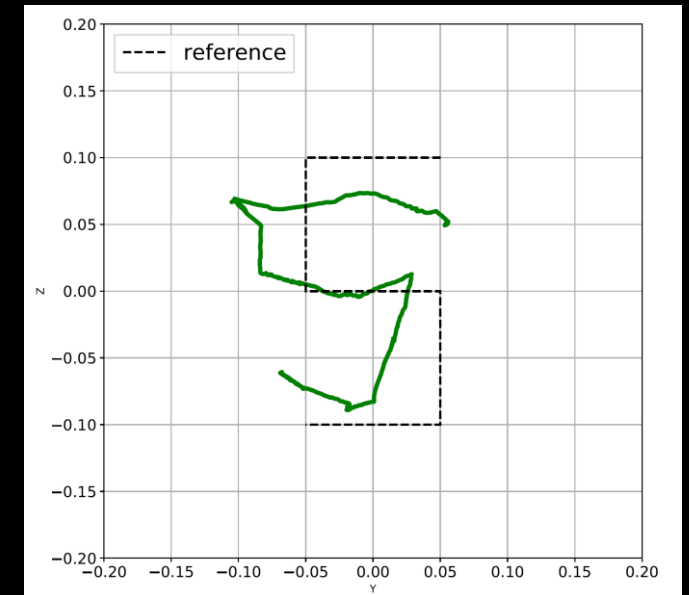
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DeSKO

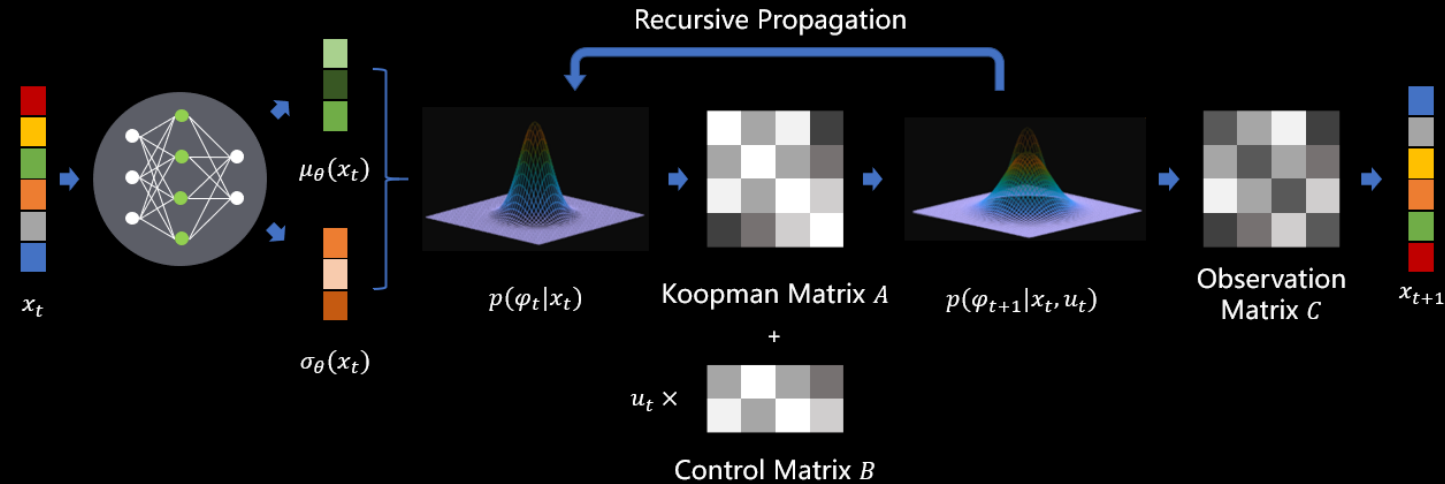


DKO



DeSKO: An efficient framework for learning and control of uncertain nonlinear systems

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Future Works:

- ❑ Koopman representation that allows nonlinear control input
- ❑ Convergence proof for Koopman operators with deep neural structure
- ❑ Would Koopman operator be able to model visual sequences?



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