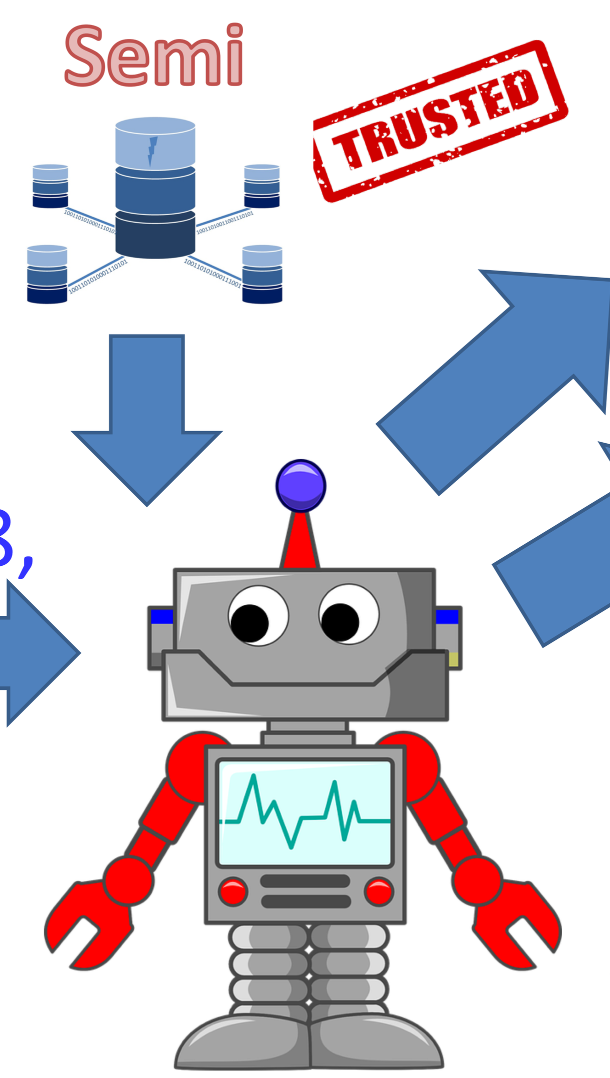
CPS: Small: Self-Improving Cyber-Physical Systems

Susmit Jha, SRI International
Github: https://github.com/SRI-CSL/Trinity

Challenge: Designing safe, data-driven, and model-based adaptive cyber-physical systems

Specification Mining
RV17, NeurIPS'18



Uncertainty-aware Synthesis FORMATS'18, JAR'18, ACC'19

Verification: ML model + closed loop
NASA FM'18, ADHS'18, HSCC'19, VNN/AAAI'19, CoRL'20

Characterize uncertainty of ML models
MILCOM'18, NeurIPS'19, DAC'20, ICLR'20

Logic-guided And Robust Control
DISE/ICML'18, Allerton Control'18, SafeComp'20

Explanations
NASA FM'17, JAR'18, NeurIPS'18, IJCAI'21

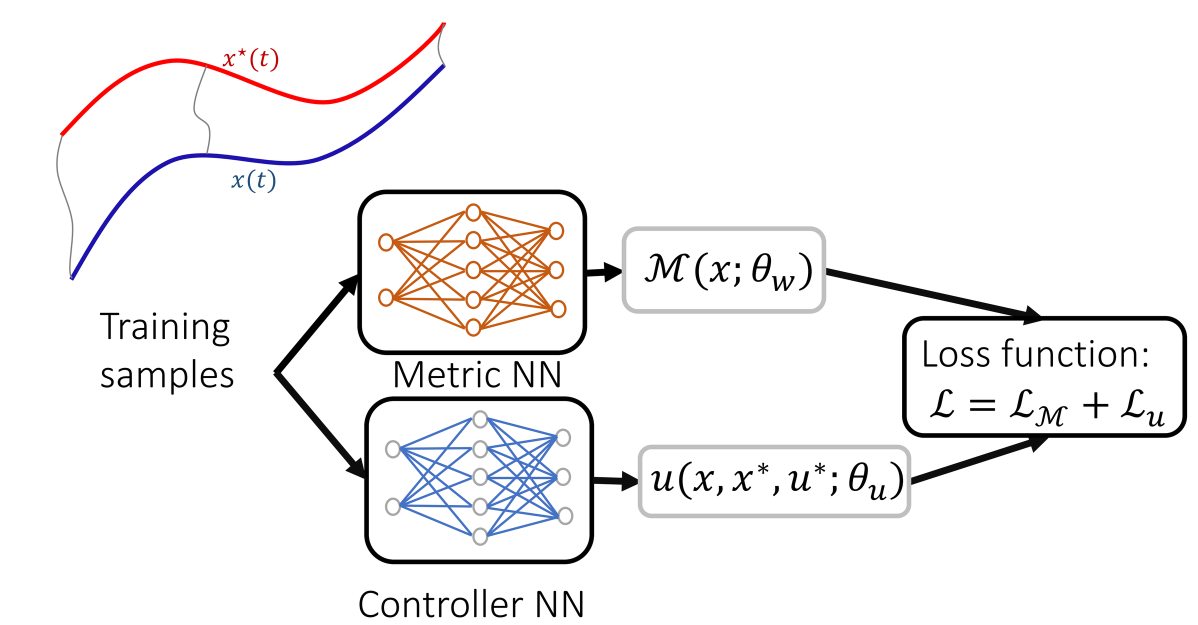
Co-learning of control policy and its correctness proof

Deep reinforcement learning and imitation learning techniques generate large and complex policy networks which cannot be formally verified.

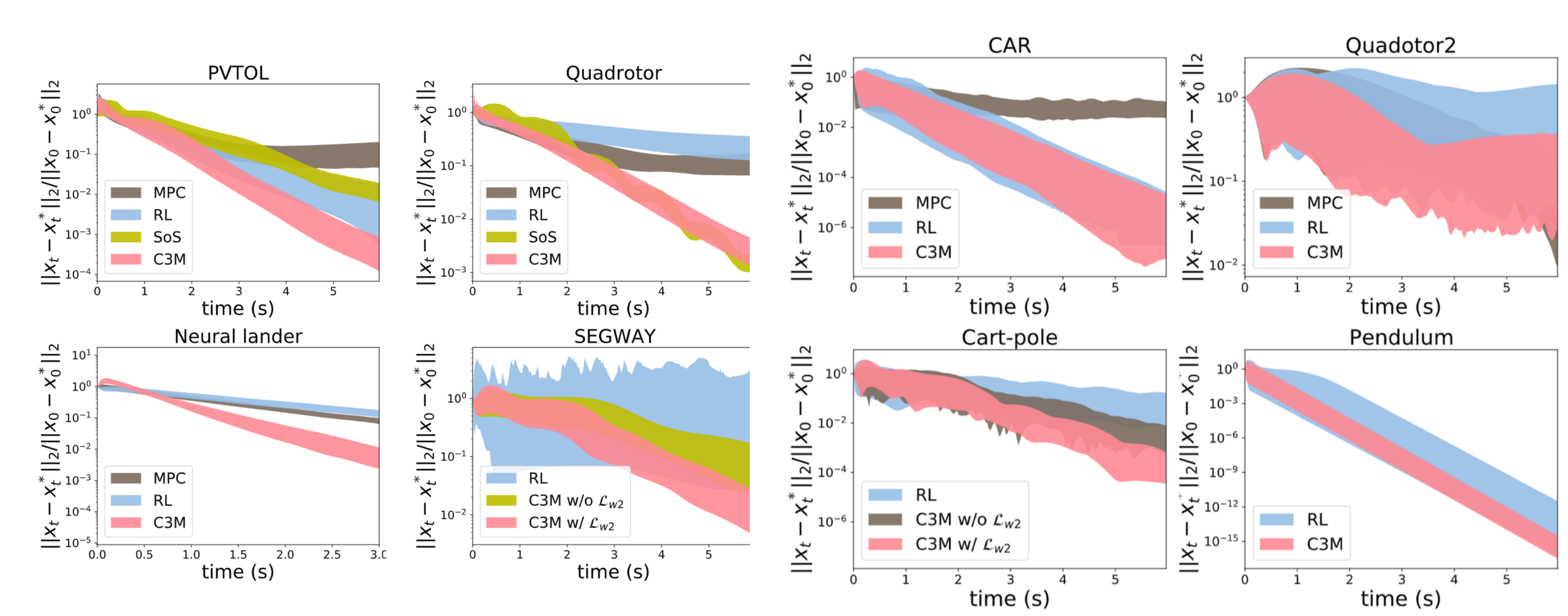
Learning policies without proof of correctness can lead to non-robust policies that can fail on rare scenarios.

We developed a co-learning techniques that can learn the control policy and its proof of correctness.

From control theory, a contraction metric gives a proof of converging to desired behaviors



Our approach outperforms other control synthesis methods including reinforcement learning, MPC and sum-of-squares which are unable to track target behavior when faces with novel conditions.



Learning certified control using contraction metric. Dawei Sun, Susmit Jha, and Chuchu Fan, Conference on Robot Learning, 2020

Broader Impact:

- Enabling design of assured autonomous systems. The PI has been concurrently working on DARPA Assured Autonomy to transition ideas from NSF project to higher TRL.
- Application to robust and resilient Internet of Things via Army Research Lab's Collaborative Research Alliance on Internet of Battlefield Things.
- 3 internships including 2 female students were supported last year.

Scientific Impact:

- Contributions to machine learning and control published in venues such as NeurIPS, ICLR, IJCAI and AAAI over last three years.
- Extension of the developed approach for finding safe and optimal policy for CPS being pursued for joint exploration of cyber and physical design in DARPA SDCPS where the PI leads one of the teams. The goal is to design novel CPS designs such as autonomous underwater vehicles and air taxis.