Research Interest

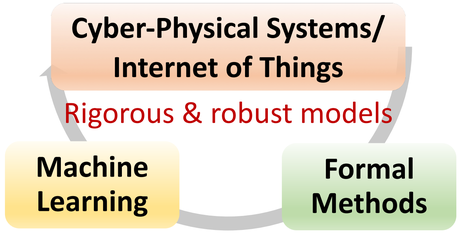


Figure 1

Motivation & Challenges

CPS/IoT are **complex systems** with **high uncertainty**, where decision making is challenging and **safety critical**

Gap

DNNs are NOT rigorous or robust for CPS/IoT

- No guarantee on the predicted sequences to follow model properties
- No well-calibrated uncertainty estimation for sequential prediction

Contribution

1. Data-driven studies on smart cities: city requirements, uncertainty, model properties
2. **Novel temporal logic-based learning frameworks** that
   - guide RNNs to satisfy model properties
   - measure and train uncertainty estimation schema for Bayesian RNN predictions
3. Apply to RNNs & Transformer models using large-scale real-world city data:
   - Significantly increases the satisfaction of model properties, uncertainty calibration and prediction accuracy
   - Improves city safety and performance

CityPM: Predictive Monitoring with Logic-Calibrated Uncertainty for Smart Cities [Sensys 20']

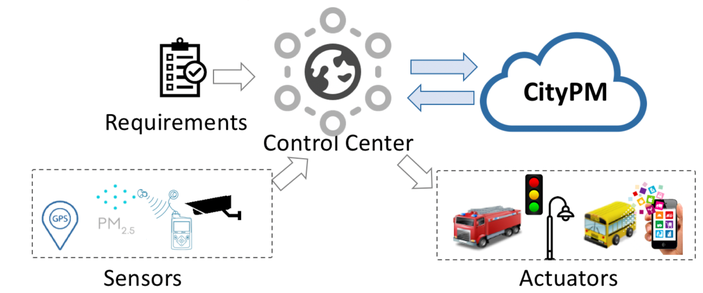


Figure 2

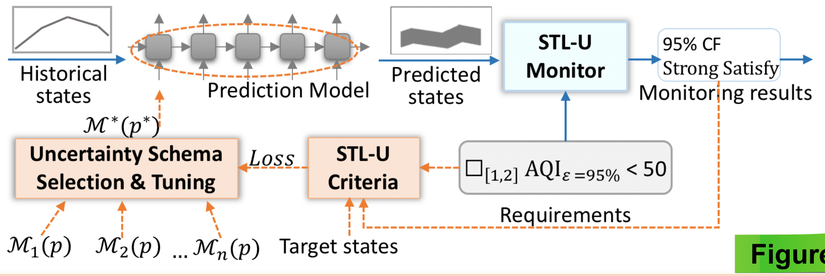
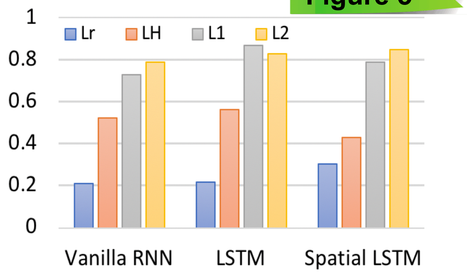


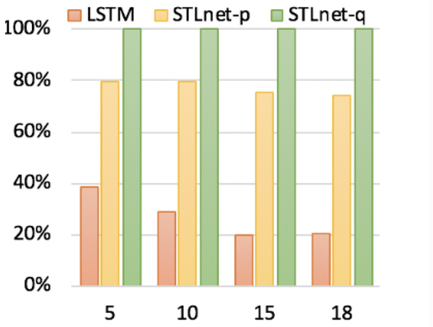
Figure 3

Results

Figure 5



F1-scores on the Uncertainty Estimation regarding to Requirement Satisfaction



Satisfaction Rate of Model Properties with different prediction lengths

	No Monitor	STL Monitor	CityPM
Number of Violation	undetected	267	**189**
Air Quality Index	67.91	57.22	**43.65**
Noise (db)	73.32	49.27	**48.21**
Emergency Waiting Time (s)	20.32	14.87	**10.65**
Vehicle Waiting Number	22	18	**15**
Pedestrian Waiting Time (s)	190.2	148.9	**121.1**
Vehicle Waiting Time (s)	112.12	89.77	**80.31**

Table 1. Comparison on the City Safety and Performance

STLnet: Signal Temporal Logic Enforced Multivariate Recurrent Neural Networks [NeurIPS 20']

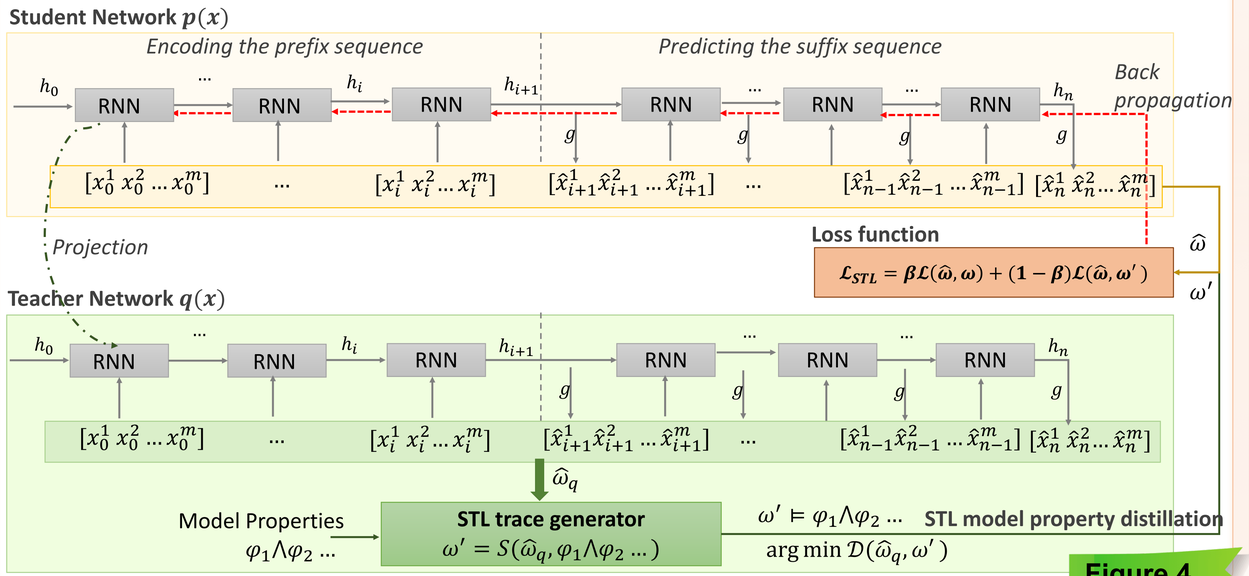


Figure 4

Insights & Future

1. Considering system properties and requirements is important for building learning models for complex systems.
2. Formal logic can be an effective way to enhance the robustness of the deep learning models.
3. Future: developing **rigorous and robust** models for safe and AI-powered CPS through **combining formal methods with machine learning**.

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