AI-Augmented Test Automation for Cyber-physical Systems

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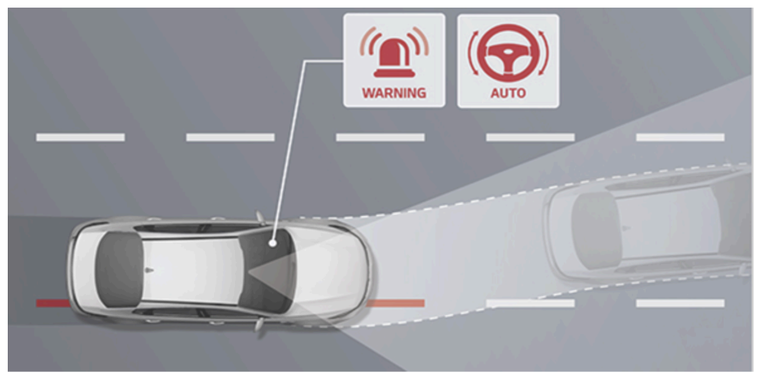
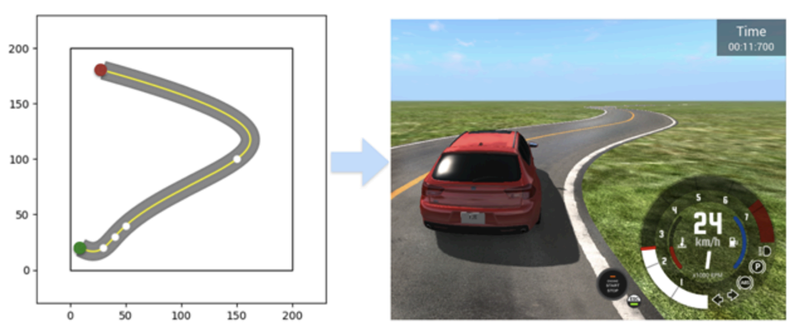
Motivation

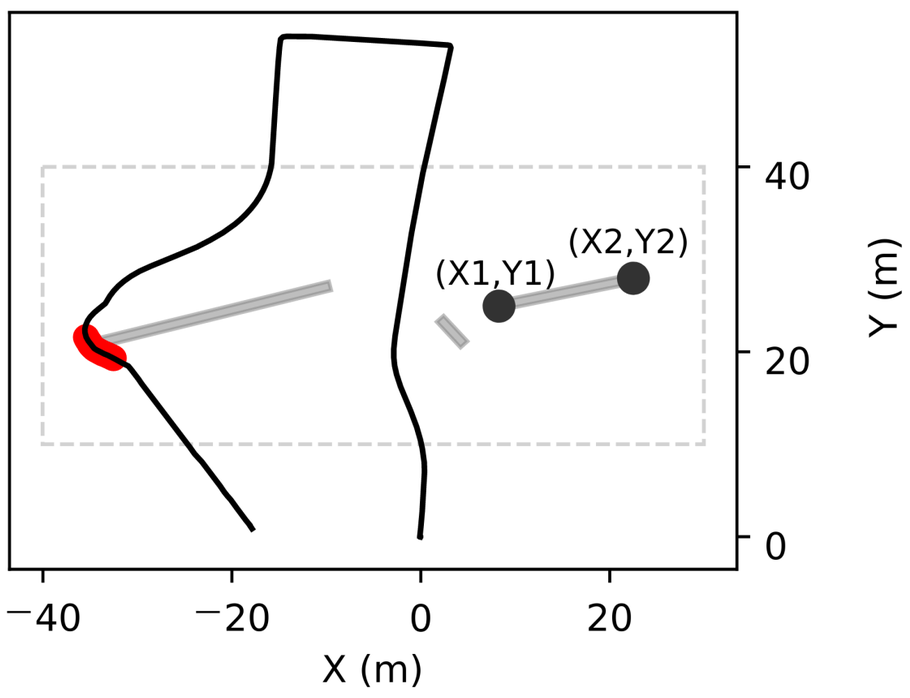
Cyber-physical systems, such as self-driving cars, autonomous robots, and UAVs, integrate hardware and software for real-time interaction with the physical environment. These safety-critical systems require testing to prevent malfunctions that could cause significant harm. Due to their complexity, testing CPS can be difficult and expensive. Search-based testing within simulators offers a cost-effective method to identify design flaws and evaluate various conditions that would otherwise be to complicated or expensive to replicate physically.

WOGAN at the SBFT 2023 CPS Tool Competition - Cyber-Physical Systems Track

- Wasserstein Online Generative Advarsarial Network
- Lane-keep assist system validation in BeamNG
  - Generate failure-inducing roads
  - BeamNG.AI and DAVE-2 driving agents
- Combined fitness function (body out of lane percentage + the distance from the lane)





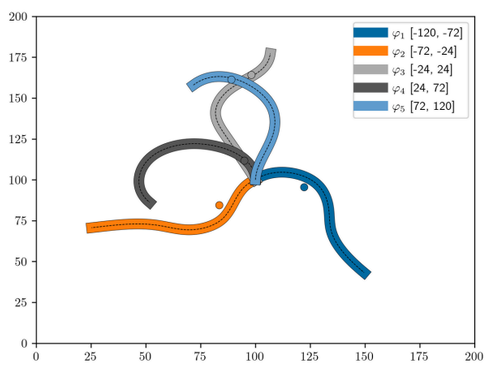


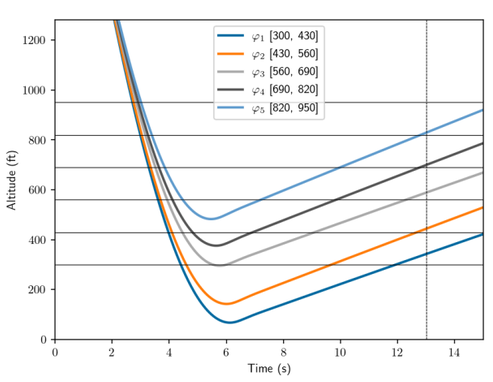
Adaptive Test Generation for Unmanned Eerial Vehicles using WOGAN-UAV

- Wasserstein Online Generative Advarsarial Network
- UAV obstacle avoidance in Aerialist
  - Generate failure inducing obstacles
  - Crash into obstacle or cause the drone to fly within a minimum-safety distance (1.5m)
- First place award

Testing Cyber-physical Systems with Explicit Output Coverage

- Efficient Output Coverage (EOC)
- Generate tests that satisfy a set of requirements
  - Explicit output coverage based on STL formulas
  - BeamNG, F16 and AmbieGen as test systems
- Best paper award





Future Research

CROC: Reinforcement Learning with Composite Rewards for Output Coverage

Use Reinforcement Learning to find many diverse output requirements within a system under test, either from a wide range of requirements or from a set of hard to find hand-picked requirements.

Where to find my research

Research Profile Orcid

References

- **J. Winsten and I. Porres, "WOGAN at the SBFT 2023 CPS tool competition - Cyber-physical systems track," in 16th IEEE/ACM International Workshop on Search-Based and Fuzz Testing. SBFT 2023, 2023, pp. 43–44.**
- **J. Winsten, V. Soloviev, J. Peltomäki, and I. Porres. 2024. Adaptive test generation for unmanned aerial vehicles using WOGAN-UAV. In IEEE/ACM International Workshop on Search-Based and Fuzz Testing, SBFT@ICSE 2024.**
- **J. Peltomäki, J. Winsten, M. Methais and I. Porres 2024. Testing cyber-physical systems with explicit output coverage. The 8th International Workshop on Testing Extra-Functional Properties and Quality Characteristics of Software Systems, ITEQS at ICST 2024.**