Worskhop on Verification of Autonomous Systems

Techniques for Practical Verification

Jana Tumova

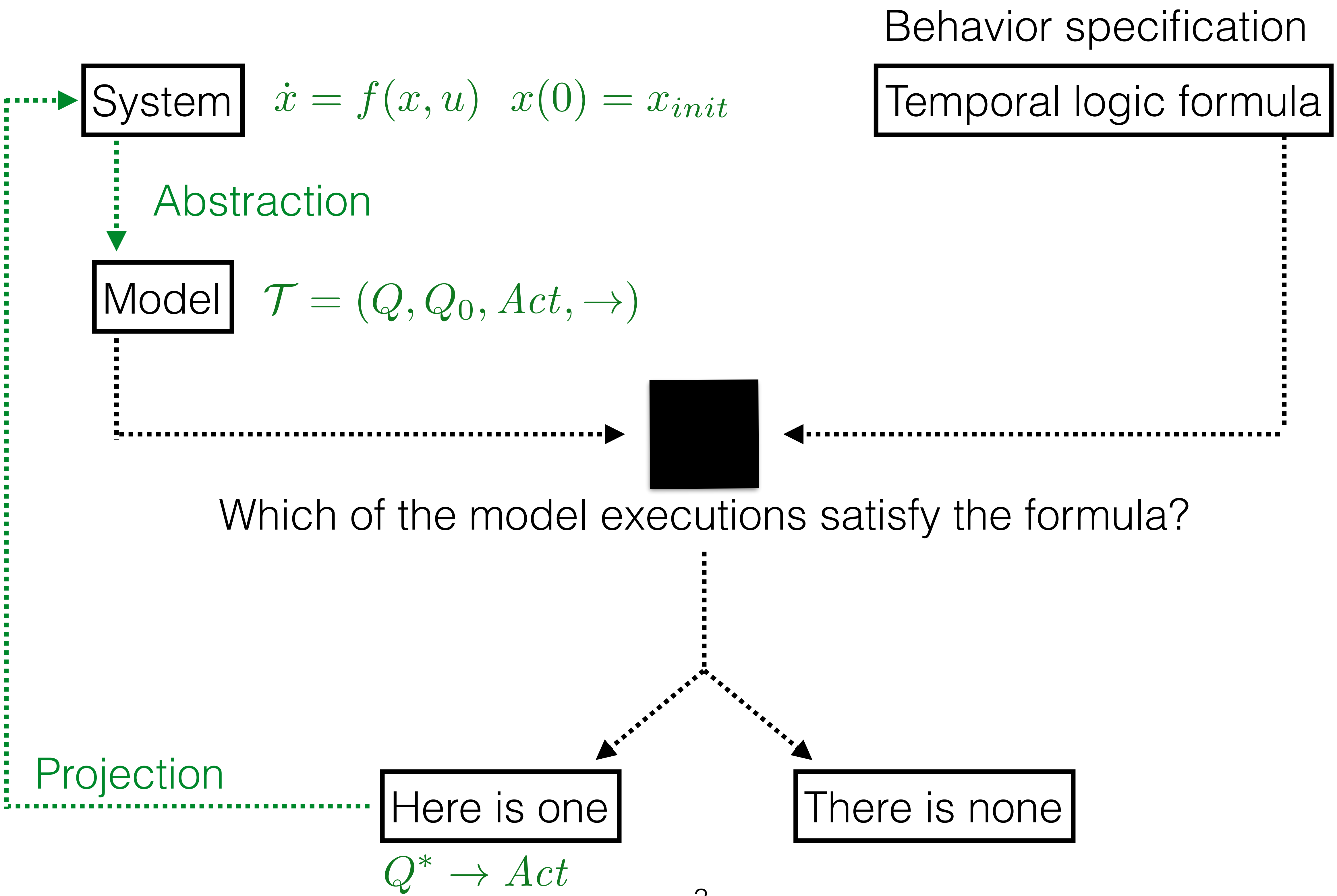
KTH
VETENSKAP
OCH KONST

Research interests

- Past
  - Parallel and distributed probabilistic model checking
  - Quantitative model checking of systems with degradation
  - Temporal logic analysis and control of piecewise affine systems

- Ongoing
  - Model checking-based robot motion and action planning
  - Model checking-based multi-agent control

Model checking-based planning



Behavior specification

System $\dot{x} = f(x, u) \quad x(0) = x_{init}$

Temporal logic formula

Abstraction

Model $\mathcal{T} = (Q, Q_0, Act, \rightarrow)$

Which of the model executions satisfy the formula?

Projection

Here is one

$Q^* \rightarrow Act$

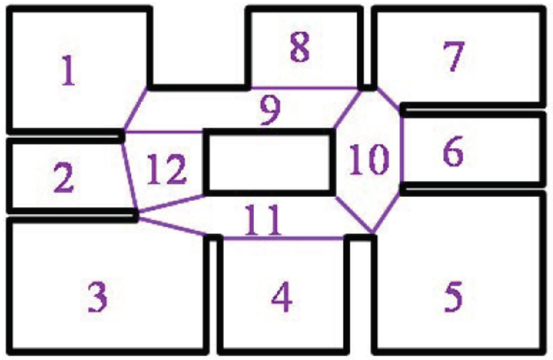
There is none

Model checking-based robot mission and motion planning

System

$\dot{p}(t) = u(t) \quad p(t) \in P \subseteq \mathbb{R}^2 \quad u(t) \in U \subseteq \mathbb{R}^2$

$p(0) = P_1$



Behavior specification

Periodically visit P_1, P_4, P_8

and never enter P_{10}

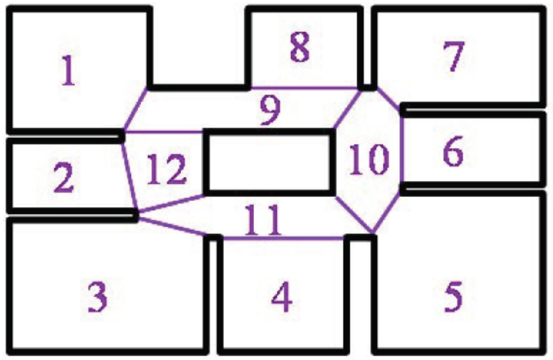
[KFP09] Kress-Gazit, Fainekos, Pappas, “Temporal-Logic-Based Reactive Mission and Motion Planning,” *TRO,* 2009.

Model checking-based robot mission and motion planning

System

$\dot{p}(t) = u(t) \quad p(t) \in P \subseteq \mathbb{R}^2 \quad u(t) \in U \subseteq \mathbb{R}^2$

$p(0) = P_1$

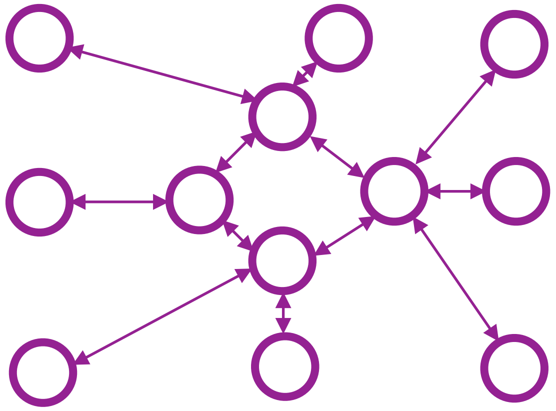


Behavior specification

Periodically visit P_1, P_4, P_8

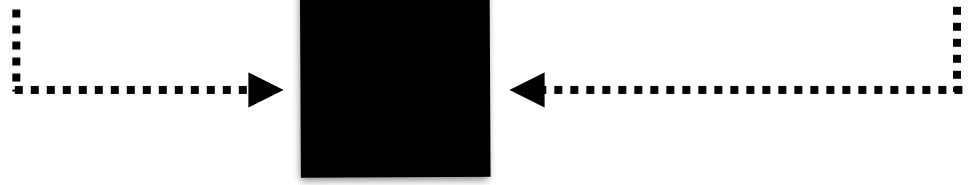
and never enter P_{10}

Model



Linear Temporal Logic (LTL) formula

$\mathcal{GF}\,P_1 \;\wedge\; \mathcal{GF}\,P_4 \;\wedge\; \mathcal{GF}\,P_8 \;\wedge\; \mathcal{G}\,\neg P_{10}$



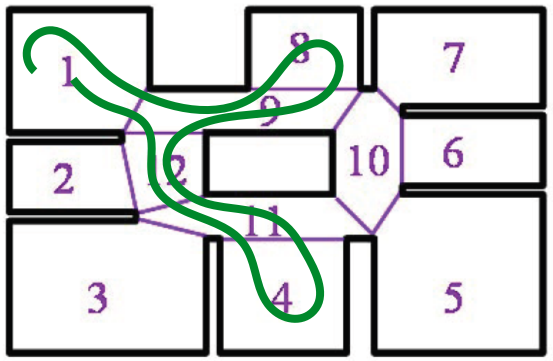
[KFP09] Kress-Gazit, Fainekos, Pappas, "Temporal-Logic-Based Reactive Mission and Motion Planning," *TRO,* 2009.

Model checking-based robot mission and motion planning

System

$\dot{p}(t) = u(t) \quad p(t) \in P \subseteq \mathbb{R}^2 \quad u(t) \in U \subseteq \mathbb{R}^2$

$p(0) = P_1$

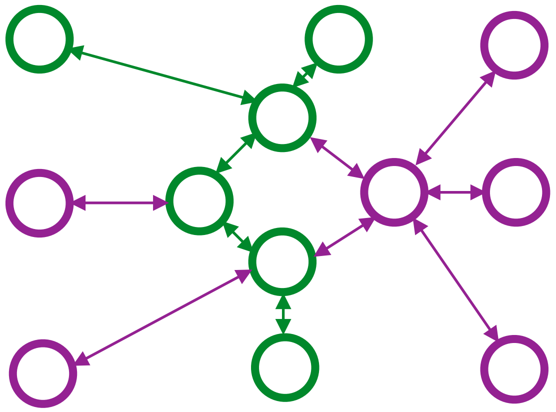


Behavior specification

Periodically visit P_1, P_4, P_8

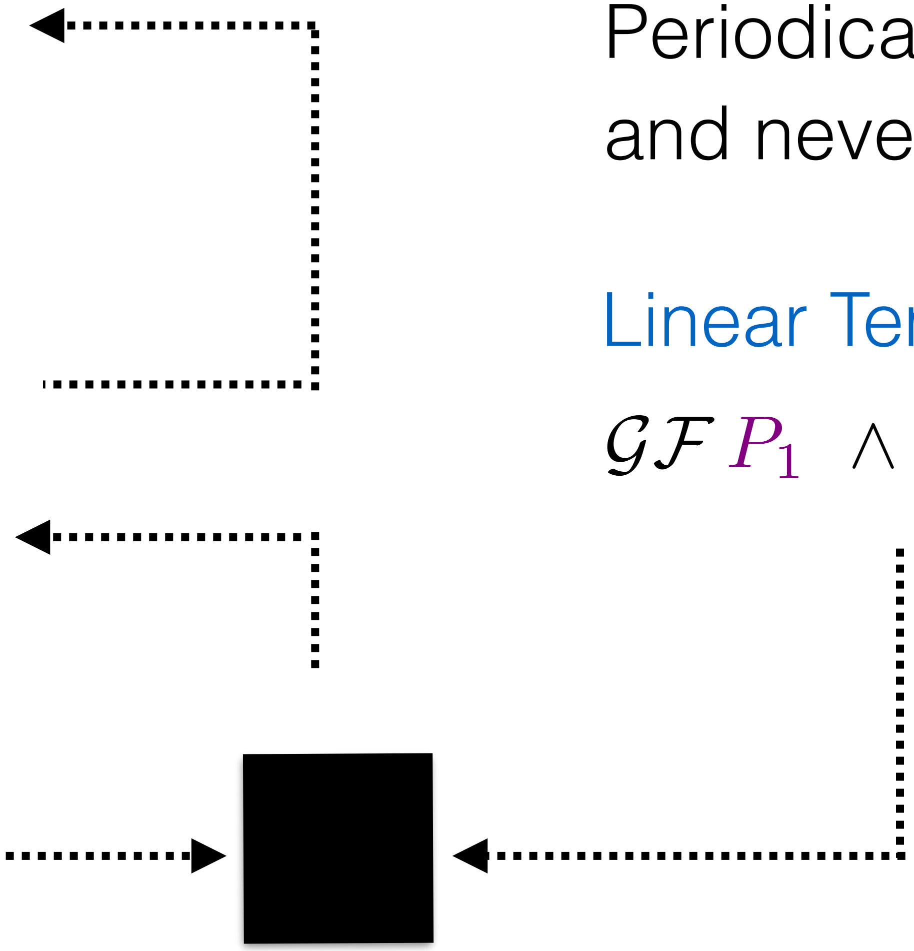
and never enter P_{10}

Model



Linear Temporal Logic (LTL) formula

$\mathcal{G}\mathcal{F}\, P_1 \;\wedge\; \mathcal{G}\mathcal{F}\, P_4 \;\wedge\; \mathcal{G}\mathcal{F}\, P_8 \;\wedge\; \mathcal{G}\,\neg P_{10}$

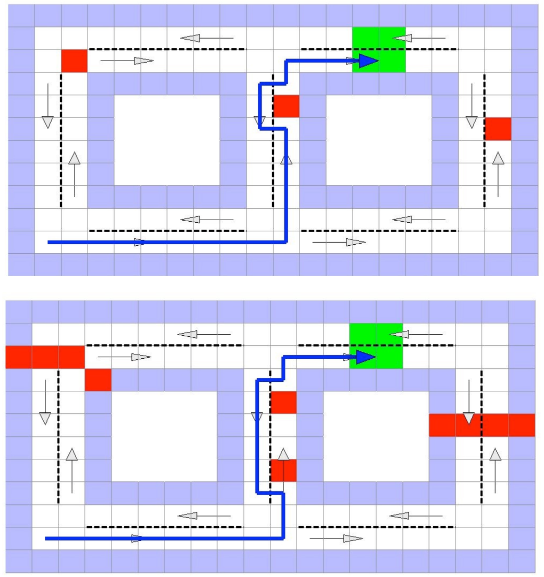


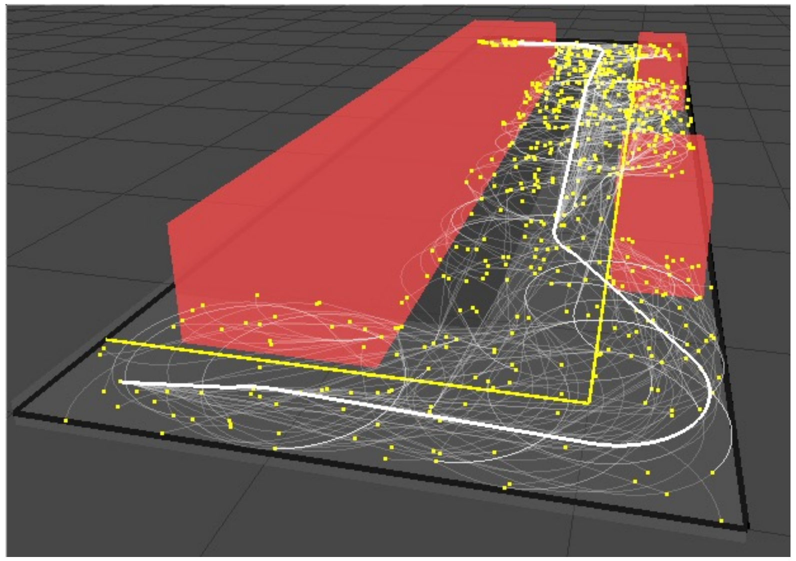
[KFP09] Kress-Gazit, Fainekos, Pappas, “Temporal-Logic-Based Reactive Mission and Motion Planning,” *TRO,* 2009.

Research challenges

- Input user-friendliness
    - structured English, graphical representation
- Computational complexity and scalability
    - receding horizon, fragments of logics
- Dynamic environments and imprecisions of sensors and actuators
    - nondeterministic, probabilistic, partial observable models
    - reactive re-planning
- Multi-agent systems
    - task decomposition, decentralized planning
- Optimality
    - weighted models
- Specification infeasibility
    - least-violating planning, model repair, analysis of reasons

1 Highlight: Least violating sampling-based motion planning algorithm





Least-violating Control Strategy Synthesis with Safety Rules
in HSCC 2013, with Gavin Hall, Sertac Karaman, Emilio Frazzoli, Daniela Rus

Incremental Sampling-based Algorithm for Minimum-violation Motion Planning
in CDC 2013, with Luis Reyes-Castro, Pratik Chaudhari, Sertac Karaman, Emilio Frazzoli, Daniela Rus