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Speaker: Rüdiger Ehlers

20th August 2013
Overview

Goal
High-level programming of robots by end-users

Challenges
- Physical systems
- Non-linear dynamics
- Open worlds
- Optimality of control

Work by Roberto Villalba, photo by R. Ehlers
Overview

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Work by Roberto Villalba, photo by R. Ehlers
A Challenge Problem

This challenge problem is:
- simple to understand, yet challenging,
- scalable,
- reactive, and
- has mission planning and hybrid control aspects.

Speaker: Rüdiger Ehlers (UCB/Cornell)
Challenge problem video

Speaker: Rüdiger Ehlers (UCB/Cornell)
What to do if input/output spaces are infinite?
→ Synthesis with Identifiers (UC Berkeley, Cornell)

What if our sensors and actuators are imprecise?
→ Robust Synthesis (UCLA, Cornell)

What if the robot’s task is not 100% achievable?
→ Iterative Motion Planning for Hybrid Systems (Rice, Cornell)

What if we are interested in efficient solutions?
→ Cost-optimal Synthesis (Cornell)

What if the environment behaves faulty?
→ Error-resilient Synthesis (Cornell)
### Main idea

- Allow checking the realizability of many specifications that cannot be implemented in a finite-state fashion
- Synthesize a memory-conservative implementation in case of realizability
Robust Synthesis

High-level controller

q₀ \rightarrow q₁
true/m₁
i/m₂

q₀ \rightarrow q₂
true/m₂

q₁ \rightarrow q₂
¬i/m₃

Motion layer

Challenges

- Uncertainty in measurement
- Imprecision in motion

Figure by Matthias Rungger

Speaker: Rüdiger Ehlers (UCB/Cornell)
Iterative Motion Planning for Hybrid Systems

Temporal Logic Specification

Hybrid System with Dynamics

abstraction

High Level Planner

Synergy Layer

Sampling-based Motion Planner

obstacle discovered

Braking and Re-abstraction

Continuous Solution Trajectory

**Novelty:** Use a two-dimensional cost notion to track *waiting cost* and *transition cost* in adversarial environments.

Aim
Let the robot behave **reasonably** in cases of environment assumption violations.

Solution
Modify the *strategy extraction* part of the synthesis algorithm – let it tolerate moving away from the goal whenever there is no alternative.
Error-resilient Synthesis

Door1 closed
Door2 stays open
Door1/Door2 status is ignored
Summary

General goal
Enable synthesis of reasonable robot controllers for reactive scenarios with correct-by-construction hybrid control by end users, e.g. a robot waiter.

Approaches to push the frontier presented in this talk
1. Synthesis with Identifiers
2. Robust Synthesis
3. Iterative Motion Planning for Hybrid Systems
4. Cost-optimal Synthesis
5. Error-resilient Synthesis