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RoboCalc : A Calculus for Software Engineering of Mobile and Autonomous Robots

Overview

Modelling and development of robotic and autonomous systems is based on standard state machines, without formal semantics, to specify the robot controller only. This guides the development of a simulation, but no rigorous connection is established. Moreover, implementation requires ad-hoc adjustments to cater for the reality gap between simulation and the robot hardware and the environment.

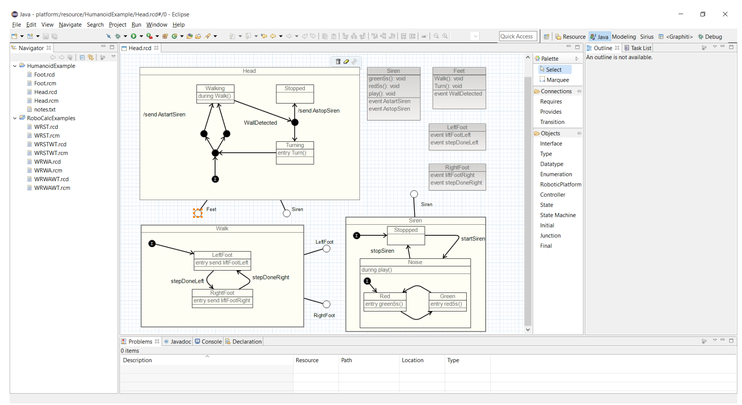
In this scenario, evidence of safety is scarce; full verification is beyond the state of the art.

In RoboCalc we are developing a framework for integrating the modelling, simulation, and programming. We are adopting notations akin to those already in use by the robotics community, but enriched with facilities to specify timed and probabilistic behaviours and the environment. For simulation we are developing a language that is tool independent. Our framework will ensure that models and simulations are consistent by using sound verification techniques.

Modelling

- Eclipse plug-in supporting both graphical and textual specification notation.
- State-machine based notation with facilities to specify reactive behaviour and data operations, as well as time properties and the environment.

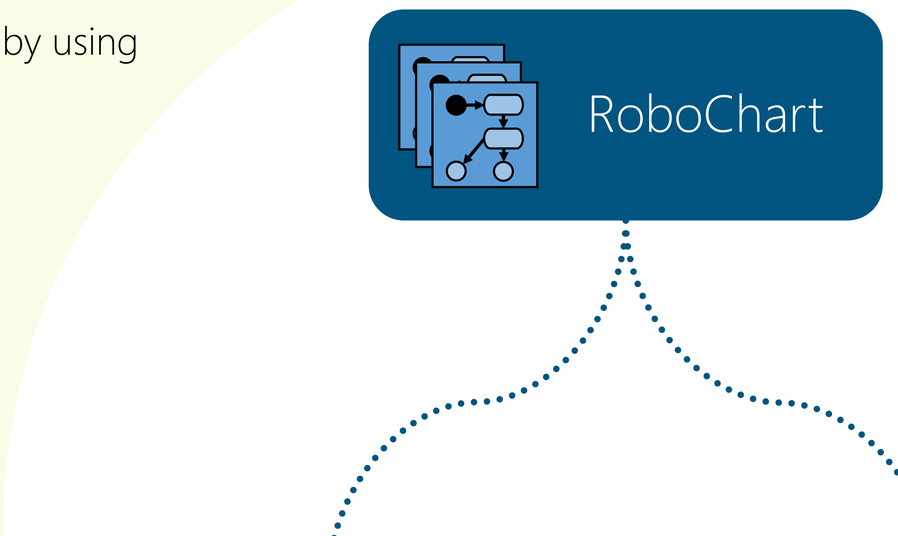
RoboTool



RoboTool graphical environment

Wheeled robot example

RoboChart



Simulation

- High-level domain specific language
- Platform independent
- Supports automatic code generation for simulation and deployment

RoboSim

```
robotic platform RP {
  provides IFace
}

interface IFace {
  event objectSeen
  event objectNotSeen
  moveTowardsObject(): void
  randomWalk(): void
}

configuration {
    RP is controlled by SM
}
```

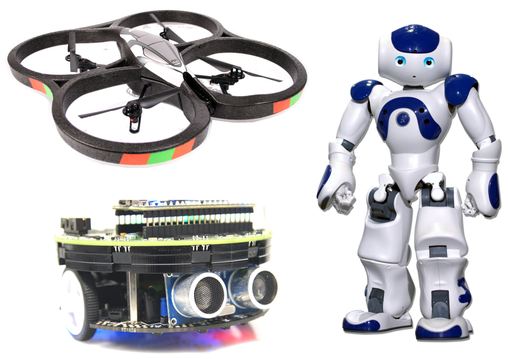
```
statemachine SM {
 requires IFace
 initial SearchObject
  state SearchObject {
    during randomWalk()
    transition { from SearchObject to FollowObject
                 trigger objectSeen }

  state FollowObject {
    during moveTowardsObject()
    transition { from FollowObject to SearchObject
                 trigger }
  }
}
```

Simulation

V-REP | ARGoS | ...

Simulation scenario in ARGoS

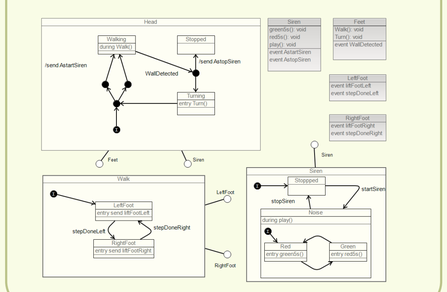
Deployment



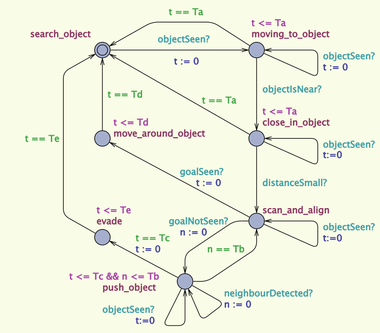
Analysis

- Model-checking using FDR3 with CSP semantics.
- Model-checking using UPPAAL with timed automata semantics for analysis of properties concerning continuous time.
- Theorem proving using Isabelle/UTP.

RoboChart



Analysis



Model-checking using UPPAAL

Model-checking using FDR3

Deployment

Simulation

V-REP | ARGoS | ...

Simulation scenario in ARGoS

www.cs.york.ac.uk/circus/RoboCalc

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