A Model Checkable UML Soccer Player

Third Workshop on Model-Driven Engineering Tools (MDETools '19)
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Valentin BESNARD [1] Ciprian TEODOROV [2] Frédéric JOUAULT [1]
Matthias BRUN [1] Philippe DHAUSSY [2]

[1] ERIS, ESEO-TECH, Angers, France

[2] Lab-STICC UMR CNRS 6285, ENSTA Bretagne, Brest, France

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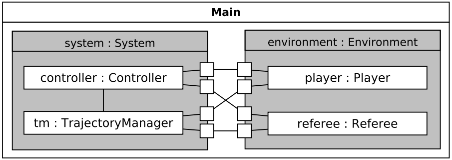
Model Design: System Component [1]

Modular UML Model

Different environment models can be connected to the system at different times:

- A concrete environment model for actual execution with the soccer simulator
- Or an abstract environment model for model analysis



System Component

- *Controller*: Manage the high-level strategy of the robot
- *TrajectoryManager*: Manage trajectories of the robot

[1] Our github repository: `https://github.com/ValentinBesnard/mdetools19-emi`

Model Design: Environment Component

Abstract Environment Model

Goal

Closes the system for the verification step (executable model)

Specificities

- Relies on some abstractions of the physical environment
- Focuses on the verification of control flows

Usage

For verification and validation activities

Model Design: Environment Component

Abstract Environment Model

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Concrete Environment Model

Goal

Links the system with the actual soccer player

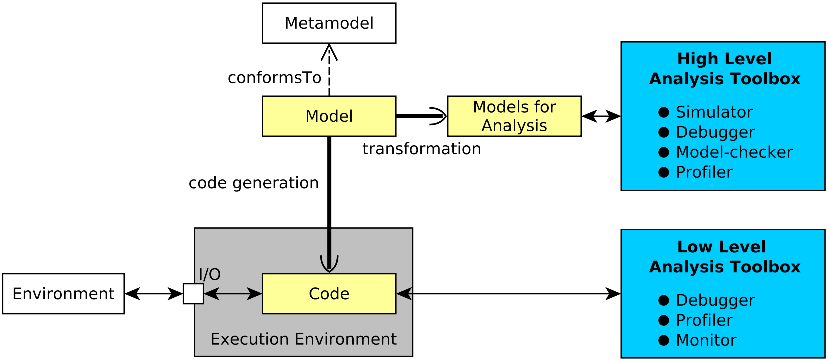
Specificities

- Implements a TCP client to interact with the player
- Implements a TCP client to be notified by the referee

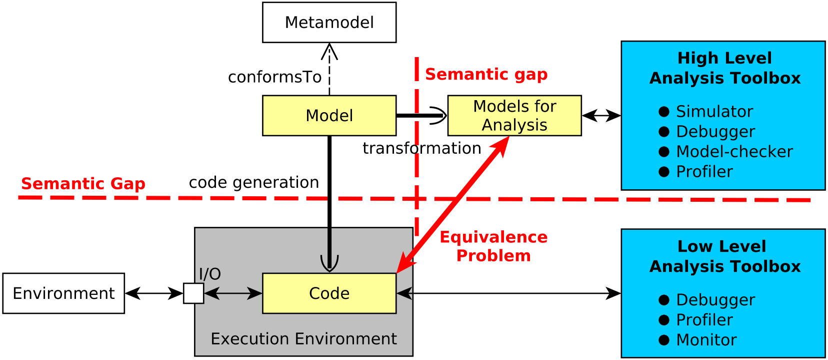
Usage

For actual model execution

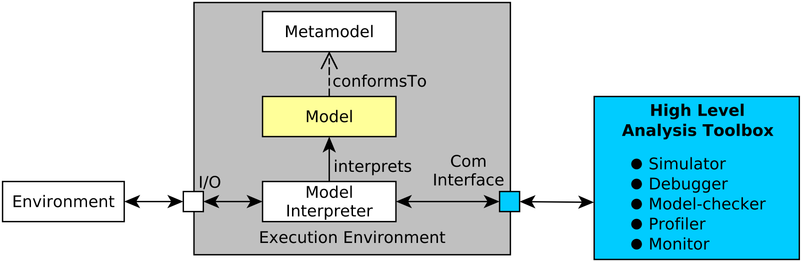
Tool Presentation: Classical UML-based Approaches



Tool Presentation: Some Problems

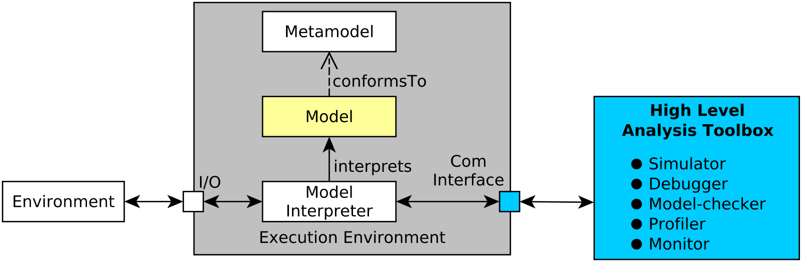


Tool Presentation: Our Approach



A unique implementation of the language semantics
for all activities: simulation, verification, and execution.

Tool Presentation: Our Approach



- EMI: an implementation of this approach for UML [Besnard et al., 2018]
- Use the OBP2 tool [Teodorov et al., 2017] for:
  - Trace-based simulation
  - Model-checking
- Perform runtime monitoring using UML observer automata [Besnard et al., 2019]

Results

Connect the OBP2 (`https://plug-obp.github.io/`) model-checker to EMI to verify safety and liveness LTL properties, for instance:

1. The player finally goes to the shooting position or aborts its action after having taken the ball.
   `"[] ((playerHasBall && goToBall) -> <> (goToGoal || listenReferee))"`
2. The player is never in the wrong direction when shooting.
   `"[] !(inShootPos && !goalDirection)"`

Model-checking results

- 2 safety properties and 6 liveness properties successfully verified on the system
- Composed of 16,844 configurations linked together with 31,370 transitions
- 4.3 seconds and 28 MB of memory (on a laptop with 8 CPU cores 4 GHz, 16 GB RAM, running a Linux OS)

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Execution results

- Scores on average 10 goals per match (when playing alone)
- Monitors execution of the model at runtime

Conclusion and Feedbacks

A solution to the MDETools'19 challenge

- Design of a modular UML model with two different environment models
- Analysis of the model with different V&V tools

$\Rightarrow$ Implementation of a real case study from the community

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- Two versions of the model:
  - First simple prototype for design assessment (a couple of hours)
  - Second version as modular UML model (one week)

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Analysis activities

- Simulation: Helps to identify design mistakes at early design stages
- Model-checking: Detects full event pools that block model execution

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EMI limitations

- Only a subset of UML is supported
- No support for time or real-time constraints

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Possible UML soccer player improvements

- Implement a pathfinding algorithm to optimize trajectories
- Support several shooting positions

Bibliography

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