

Planning Competition for Logistics Robots In Simulation

Scenario and Challenges

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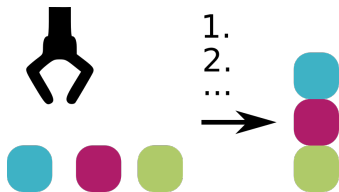
Tiago Vaquero, Eric Timmons, and Brian C. Williams

Massachusetts Institute of Technology



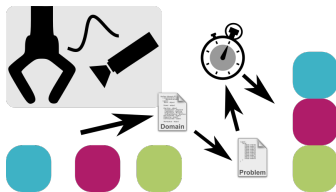
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Planning Perspective



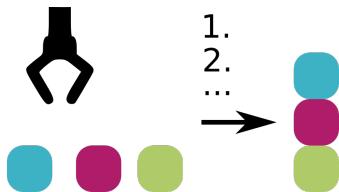
- Focus on plan generation
- Robotics not as testbed
- Execution gets less attention

Robotics Perspective



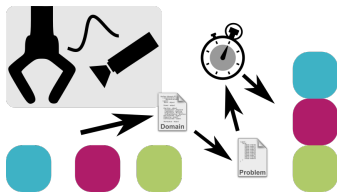
- Focus often on various topics
- Integration for evaluation
- Planning labor-intensive

Planning Perspective



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Robotics Perspective



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- Planning labor-intensive

Goals

1. Foster closer cooperation among communities
2. Develop grounded expertise with robotic scenarios, platforms, decision architectures, system integration and evaluation

RoboCup Logistics League



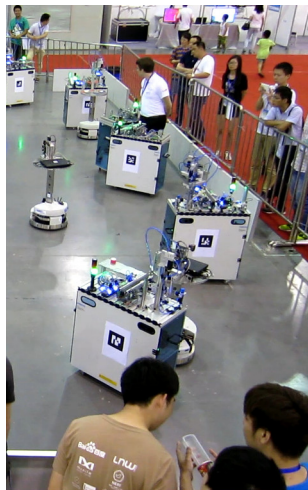
RoboCup Logistics League

Game Basics

- Task: In-factory production logistics
- Goal: variant production
- Two teams playing on common field
- Each team has 3 robots
- Multi-robot coordination task

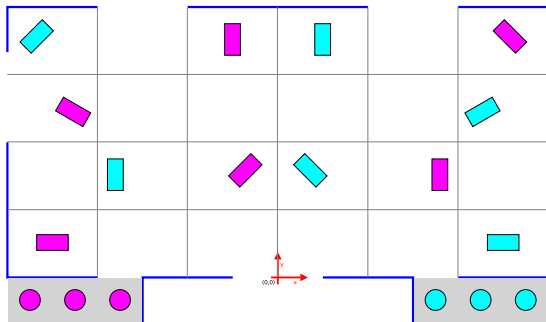
Two Game Phases

- *Exploration*: detect and report machines
- *Production*: produce and deliver by using processing stations spread across field

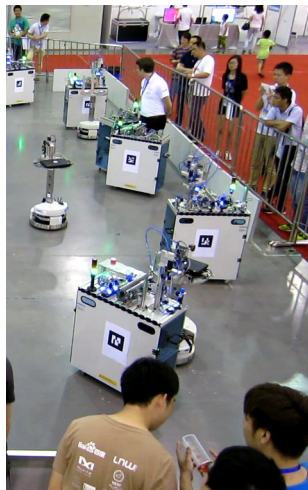


RoboCup Logistics League

Playing Field



- Team colors: cyan and magenta
- Exclusive machines spread across field
- Mirrored at middle axis



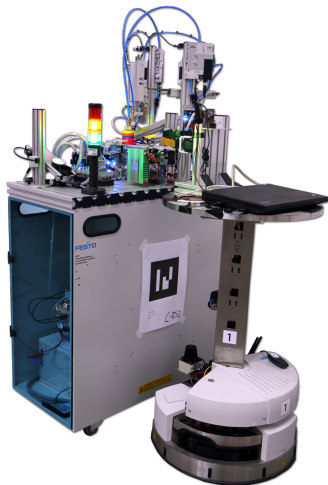
RoboCup Logistics League – Machines

Common

- Based on Festo MPS
- Marker to identify machine
- Signal light to indicate state
- Each team has exclusive set
- Similar handling for all types

Machine Types (per team)

- 1× Base Station (BS): retrieve bases
- 2× Ring Station (RS): mount colored rings
- 2× Cap Station (CS): buffer/mount caps
- 1× Delivery Station (DS): final delivery



Semi-autonomous Referee Box

Attention Message			
Robot 2 R-2/Magnum at 172.26.124.22 lost			
RefBox Log			
ded: 0)			
21:50:11.463 C: Machine C-RS1 finished processing, moving t			
o output			
21:50:11.463 C: Simulated output at C-RS1			
21:50:11.463 C: Machine C-RS1 MPS state DELIVERED (bases ad			
ded: 0)			
21:50:11.464 C: Machine C-RS1 finished processing, ready at			
output			
21:50:11.622 C: Client 23947429 (::ffff:127.0.0.1) disconn			
ected			
21:50:28.183 C: Machine M-CS1 recovered			
21:50:28.183 C: Machine M-CS1 switching to IDLE state			
21:51:46.036 C: Client 23947430 connected from ::ffff:127.0			
.0.1:58034			
21:51:46.069 C: Received state AVAILABLE for machine C-CS2			
21:51:46.069 C: Machine C-CS2 MPS state AVAILABLE (bases ad			
ded: 0)			
21:51:46.070 C: Machine C-CS2 broken: Input to C-CS2 while			
not prepared IDLE			
21:51:46.070 A: Input to C-CS2 while not prepared IDLE			
21:51:46.236 C: Client 23947430 (::ffff:127.0.0.1) disconn			
ected			
Orders			
1. 0/0/1	01:50-03:37 D2	2. 0/0/1	03:25-04:53 D3
3. 0/0/2	09:40-11:26 D2	4. 0/0/1	02:40-05:07 D3
5. 0/0/1	06:44-09:26 D3	6. 0/0/1	10:02-12:00 D3
7. 0/0/1	11:31-12:47 D2		
RefBox 0.9.0			
F2 STATE	F3 PHASE	F4 TEAM	F9 ROBOT F12 DELIVER

Machines			
C-B5	BS	Z9	RE
C-B5	DS	Z4	ID
C-RS1	RS	Z17	RE 2
C-RS2	RS	Z8	ID
C-CS1	CS	Z23	PR
C-CS2	CS	Z6	BR
M-B5	BS	Z21	ID
M-DS	DS	Z16	ID
M-RS1	RS	Z5	ID
M-RS2	RS	Z20	PR 1
M-CS1	CS	Z11	ID
M-CS2	CS	Z18	PR
Robots			
1 R-1 (CaroLogistics)	172.26.108.81	ACT	
2 R-2 (CaroLogistics)	172.26.108.82	ACT	
3 R-3 (CaroLogistics)	172.26.108.83	ACT	
1 R-1 (Magnum)	172.26.124.11	ACT	
2 R-2 (Magnum)	172.26.124.22	ACT	
3 R-3 (Magnum)	172.26.124.33	ACT	
Game			
State:	RUNNING		
Phase:	PRODUCTION		
Time:	10:42.199		
Points:	83 / 42		
Cyan:	CaroLogistics		
Magenta:	Magnum		

Tasks

- Determines randomized orders and machine failures
- Posts orders dynamically
- Scoring and evaluation
- Instructs MPS stations

Planning and Benchmarking

- Accountable environment agency
- Same controller in simulation
- Records extensive data
- Limited uncertainty

⇒ Repeatable benchmarks

Logs game information and all communication

RoboCup Logistics League – Production



Product Composition

- Products of four complexities (number of rings)
- Base (3 colors) + 0–3 rings (4 colors) + cap (2 colors)
- Order of ring colors is important
- Some ring colors require additional material
- Actual product variants randomized by referee box
- Orders have lead time of a few minutes



Order Elements (posted dynamically by refbox)

- Product to deliver (and number thereof)
- Time window in which to deliver

RoboCup Logistics League (RCLL)

- In-factory manufacturing logistics in Smart Factory
- Maintain and optimize material flow in production
- Competition under the RoboCup umbrella

RCLL as a Planning Competition and Benchmark

- Cooperative and competitive aspects, partially observable, non-deterministic, dynamic
- Typical: local, distributed, incremental strategy
- Desired: planning for global optimization
- Challenges: coordination, execution, robustness

Planning and Execution Competition (PExC)

RoboCup Logistics League (RCLL)

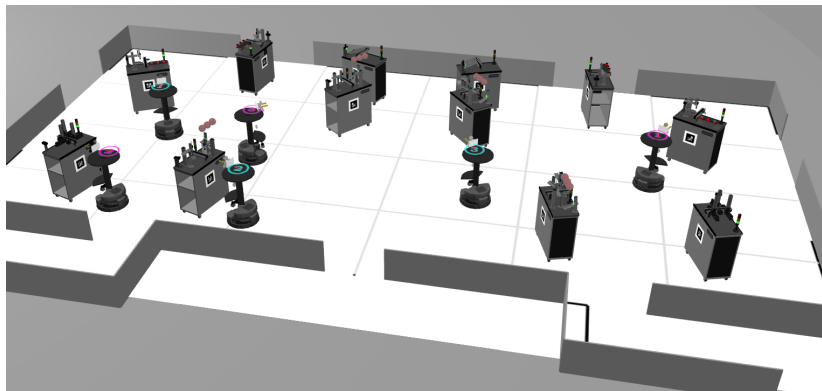
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Medium complex benchmark domain focusing on efficient *planning/scheduling* and **execution integration**

RoboCup Logistics League – Simulation



- Readily integrated 3D simulation with environment agency
- In competition in Kubernetes cloud setup

Fawkes Robot Software Framework

- Functional software components
- Lua-based Behavior Engine for skill execution
- Path planning and locomotion

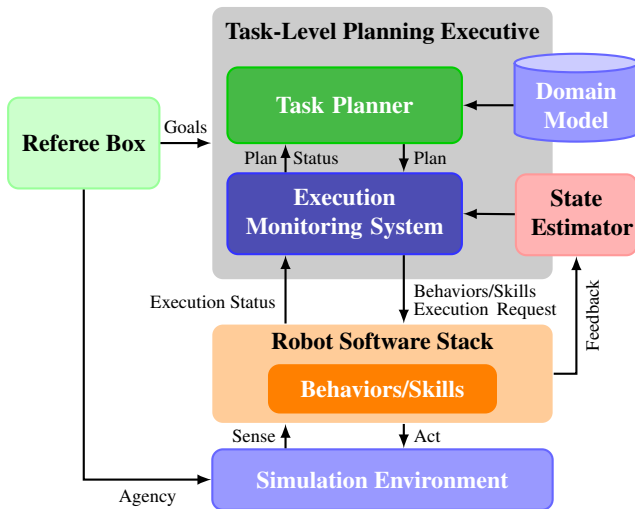
ROS

- Full integration with simulation
- Encapsulates communication with referee box
- Visualization tool

Pre-defined (extensible) Actions

- Basic set of actions required
- Extensible by custom actions

Planning System Architecture



Challenge

Integrated planning and execution in a medium complex simulated robotics industry-inspired scenario

Focus

- Multi-robot Task Planning and Coordination
- Planning and Execution Integration

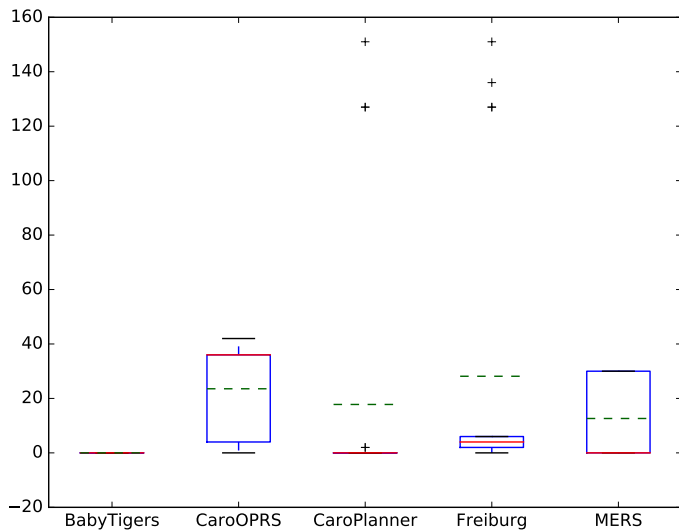
Timeline

February: Call for Participation

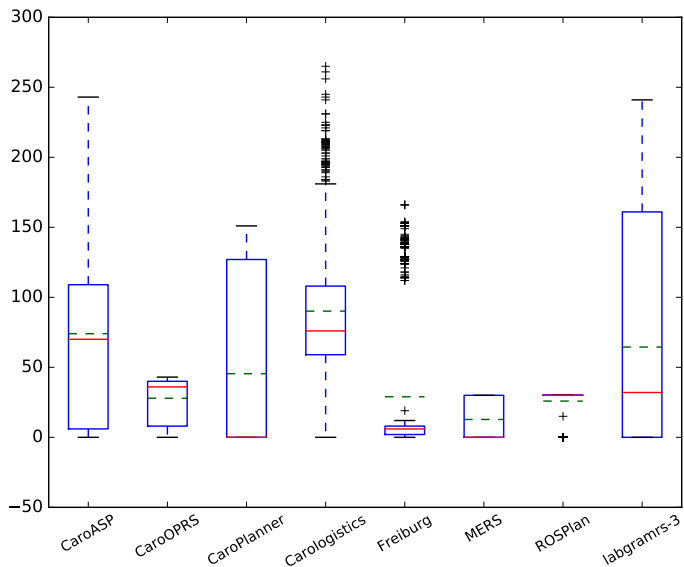
May: Qualifiers

June: Competition at ICAPS

Results 2017



Results 2017



Hands-on Production Example

