A ROS-based framework for collaborative robot teams

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VERTEILTE SYSTEME

CARPE NOCTEM
ROBOTIC SOCCER
DIVIDE ET IMPERA

Outline

RoboCup

RoboCup is a multi-national research effort aiming at:

- Combining and advancing artificial intelligence, robotics, and related fields
- Providing a setting for comparison of different approaches
- Improving public visibility

Robotic Soccer & the Middle Size League

- Five robots per team
- Fifteen minutes per half time
- 18 x 12m field
- Robots are 80cm high, and weigh ∼35kg
- FIFA rules apply

Carpe Noctem

Founded in 2005, Carpe Noctem participates in RoboCup succesfully since 2006:

- 2006: 7th at WC in Bremen
- 2007: 5th at GO in Hannover
- 2008: 4th at GO in Hannover
- 2009: 4th at GO in Hannover
  5th at WC in Graz
- 2010: 4th at GO in Magdeburg
- 2011: 3rd at GO in Magdeburg
  7th at WC in Istanbul
- 2012: 4th at DO in Eindhoven

Carpe Noctem Robot

- Specifically designed hardware platform

Carpe Noctem Robot

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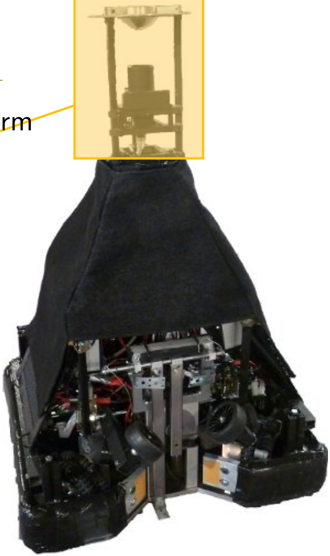
- Omnidirectional camera

  IEEE1394a, 640 × 480, 30 fps



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  Intel Core i7, 4 GiB
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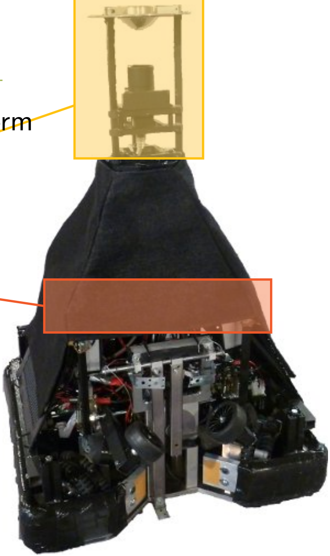

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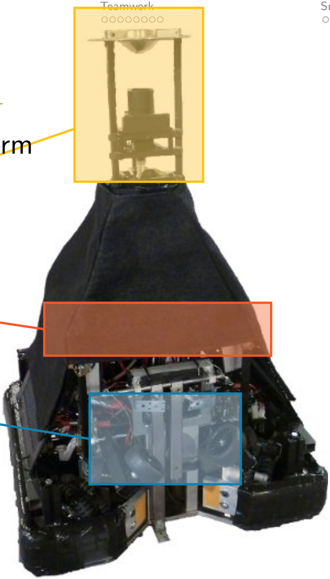
  350 V, 12 m Kicking Range



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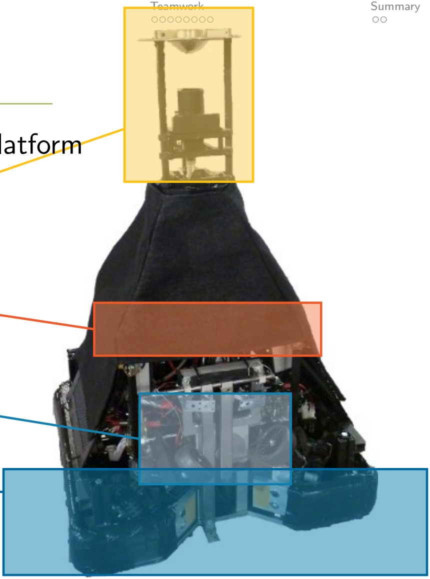
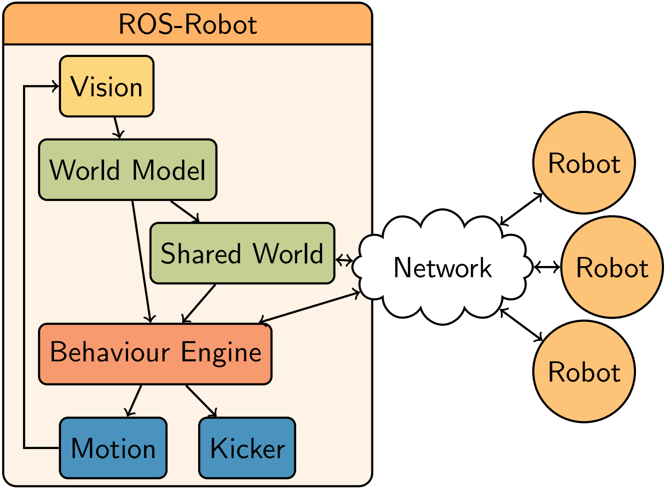
- Holonomic Drive
  4 Maxon 200W
  Up to 5 $\frac{m}{s}$; Maxon MC



ROS Architecture Overview



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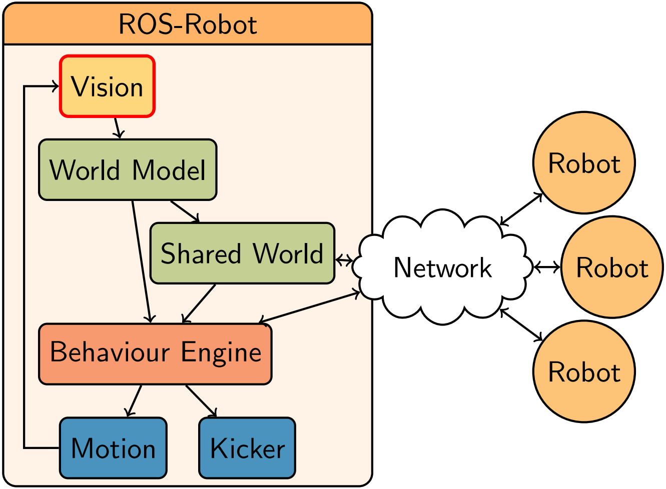
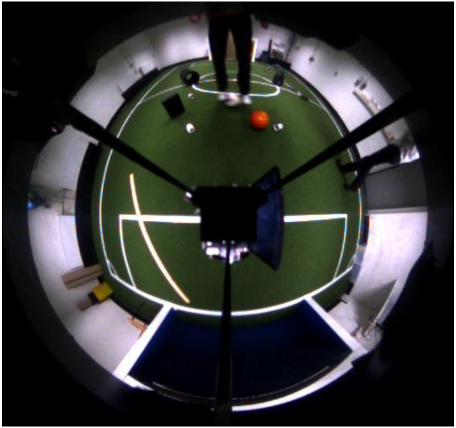
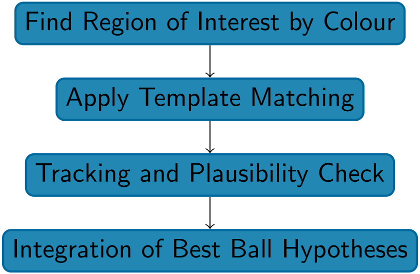


Robot Camera Perspective

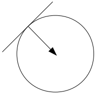


Balldetection

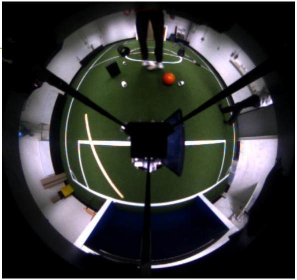


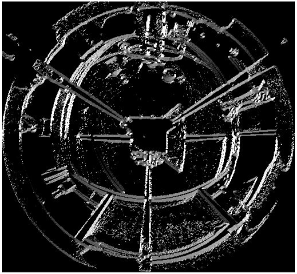
Template Matching

From the insight, that every normal vector of a ball edge is directed to the ball center, the template matching makes use of the edge direction.



About 12 representative pixels are enough for a suitable classification and reduces computation time.





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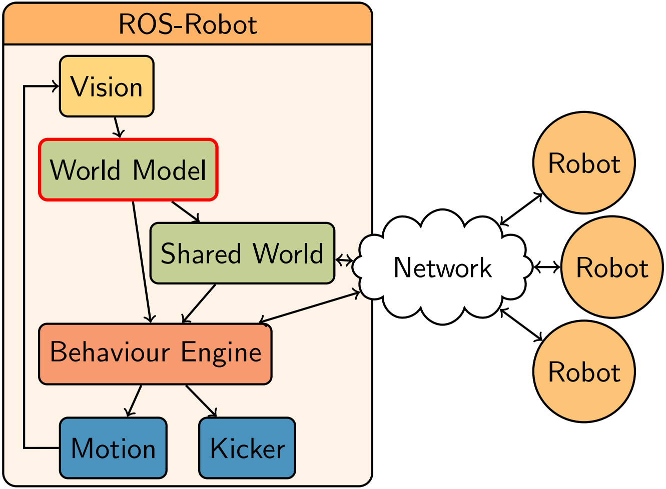
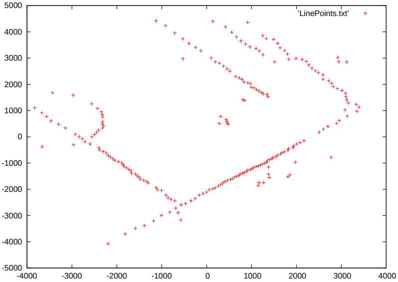
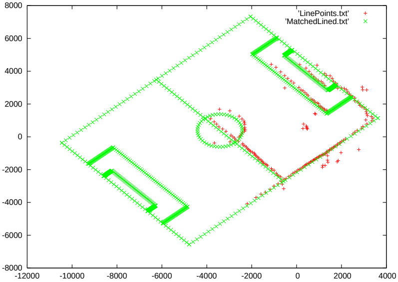


Localisation





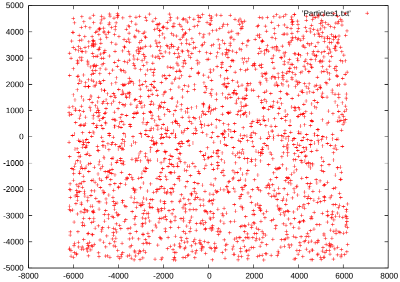
Line points

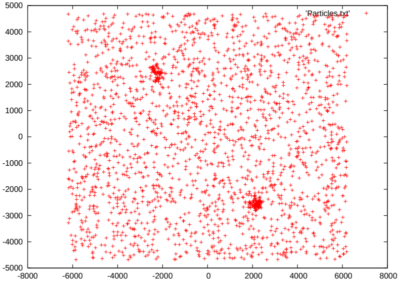
These line points were extracted from the omni-vision image

Line points compared to reference set

An overlay extracted line points and a reference with perfect line points

Particle Filter





Particle initialisation

A new set of particles as position hypotheses

Particles after second iteration

Already clearly converged towards two possible positions

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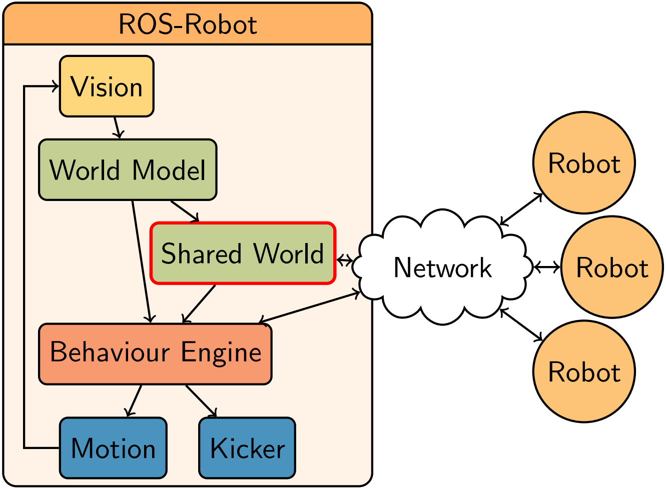

Sensor Fusion

Quality of the extracted information is limited due to:

- Sensor noise
- Limited sensor range
- Estimation errors

To extract more precise information we use sensor fusion techniques to combine the individual informations to a global view, such as:

- Shared ball detection
- Obstacle merging

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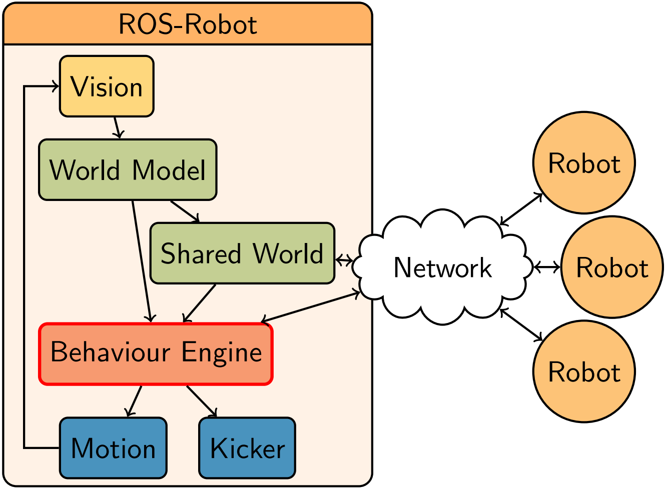

Teamwork in Dynamic Domains

Teams of agents cooperating in dynamic domains require:

- A language to describe team plans ("recipe") from a global perspective
- Ease of Modelling: simple and intuitive way to model multi-agent plans
- Formal semantics according to which these plans are executed
- Fast reaction of the team to changing situations
- Robustness towards breakdown of individual agents

Modelling Language: ALICA

A Language for **I**nteractive **C**ooperative **A**gents

Core Language Elements:

- *Behaviours* – atomic single-agent action programs

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- *Plans* – abstract multi-agent activity descriptions
- *Plantypes* – sets of alternative plans
- *Tasks* – denote specific activities within plans
- *Roles* – descriptions of capabilities

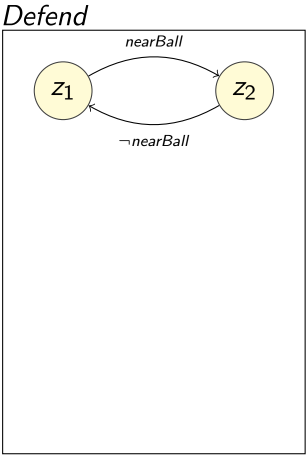
Plans

- A plan is a recipe for achieving a goal or maintaining a condition

Defend

Plans

- A plan is a recipe for achieving a goal or maintaining a condition
- Consisting of *states* and *transitions* between them



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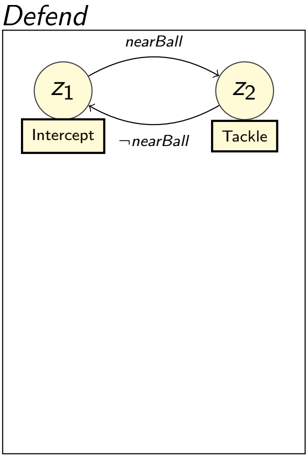

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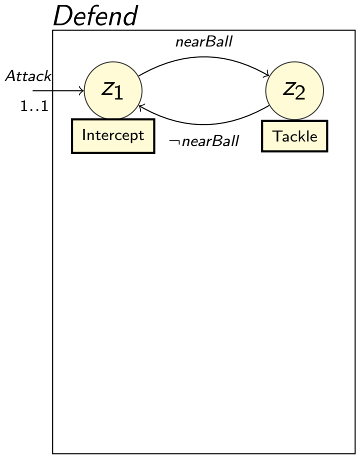

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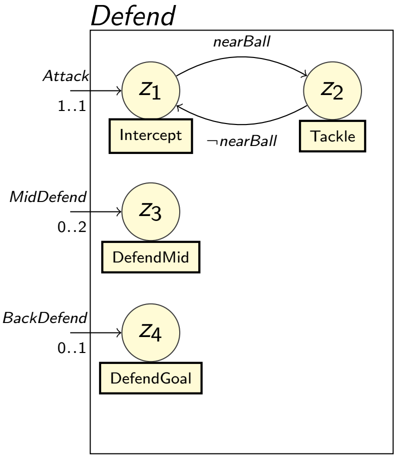

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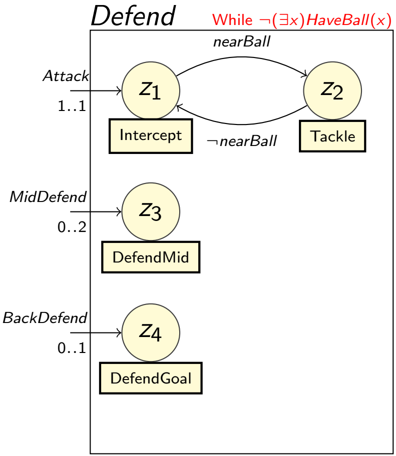
- Annotated by Pre-, Post-, and Runtime Conditions

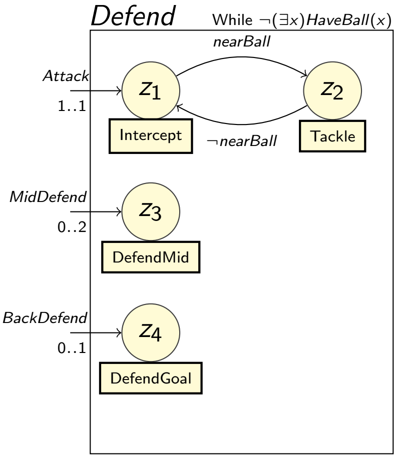


Plans

◇ Evaluated by a Utility function:

$$\mathcal{U}\colon \mathcal{L} \mapsto \mathbb{R}$$

$$\mathcal{U}_p(B) = 1 - \frac{Distance(Attacker, Ball)}{maxDistance}$$



Plantypes

- A Plantype is a set of plans
- Provides a nondeterministic choice

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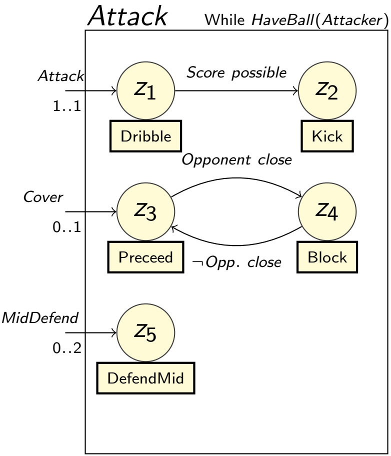
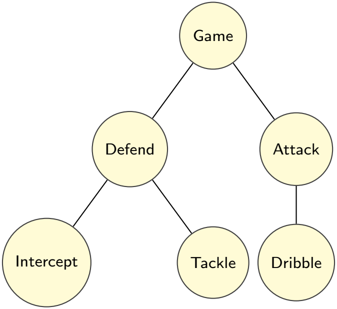
Example

Let Plantype *Play* contain *Defend* and *Attack*.



Plan Hierachy

Plans, States, and Plantypes span a (finite) tree structure:



Example

- Tackle occurs in a state in Defend
- Hence Tackle is a plan possibly executed in Defend

Task Allocation

A task allocation is

- computed locally by each agent
- acted upon *before any communication takes place*
- assigning all relevant agents to a plan p in a given plantype P, such that adopting the allocation will:

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  - Satisfy plan conditions
  - Not violate consistency constraints (e.g., an agent can take on only one task within a plan)
  - Maximise the plan's utility

General Alica

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- Expressivity: Propositional ALICA is as expressive as finite-state automata.

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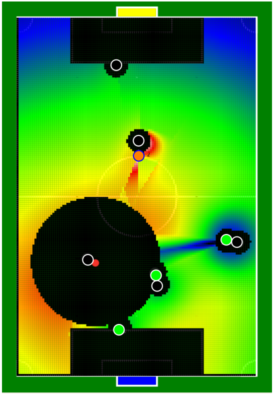
Many behaviours for (almost) the same problems

CornerOppPosBlockGoal, CornerPosLongReceiver, ThrowInOppPosBlockSide, GoalKickPosSecondDefend,. . .

General Alica



Goals:

- Computational Effort
- Noisiness
- Coordination

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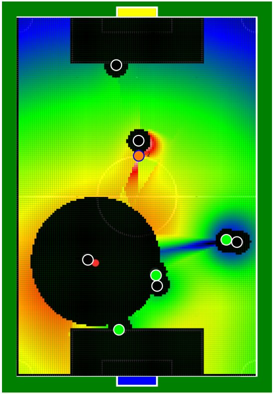

Goals:

- Computational Effort
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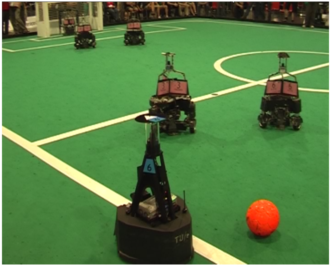
Solution:

- Declerative variable definition for plans/behaviours
- Distributed constraint solver for coordination

Summary

- An expressive language for modelling teamwork
- Allows for swift reaction to changing situations by individual agents
- Robust against communication issues



Thank you for your attention!

Any questions?