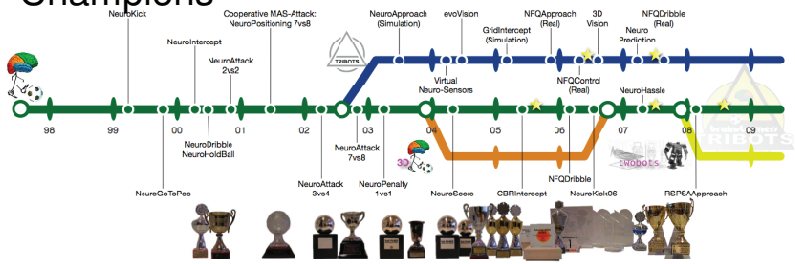
Brainstormers-Tribots / openTribot

Overview

- Hardware
- Software
  - Framework
  - Image Processing
  - World Modeling / Self-Localization
  - Behavior and Skill Architecture
  - Reinforcement Learning
  - Teamplay
- Current Projects
  - OpenTribot
- Future Work

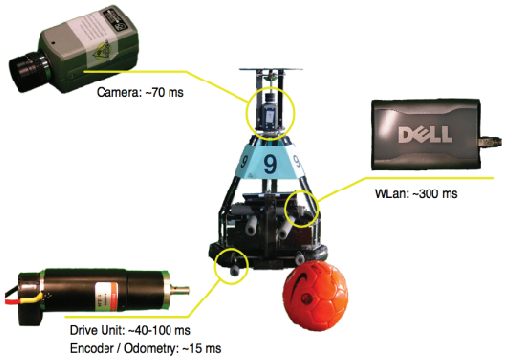
Brainstormers / Tribots

- 2003 – 2009 Project Group at Uni Dortmund, then Osnabrück
- 2 times Robocup Mid-Size World Champions (2006 & 2007)
- 4 times RoboCup Mid-Size German Open Champions



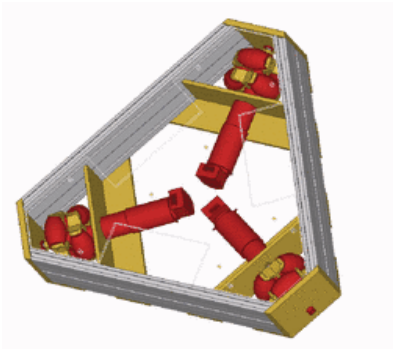
Hardware of a Tribot Soccer Robot

- Custom 3- wheel Omnidirectional Base and Omnidirectional Firewire Camera
- Small Notebook running Linux
- Can-Bus Interface for Robot Motor Control
- Pneumatic Kicking Device
- Wi-Fi for Communication



Hardware of a Tribot Soccer Robot

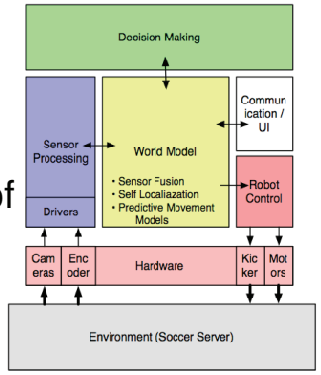
Stefan Welker – Prof. Dr. Martin Riedmiller



Software Framework

Stefan Welker – Prof. Dr. Martin Riedmiller

- Worldmodel / Decision / Robot Control units
- Module based, Framework allows replacement of hand-written parts through learned / ai based parts
- Ability to act as a team (via wireless communication)



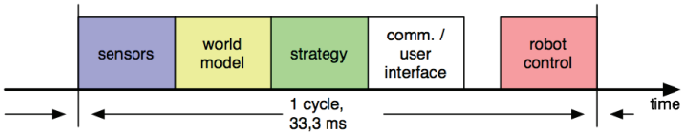


Image Processing / Omnicam

Stefan Welker – Prof. Dr. Martin Riedmiller

- Light on a robocup field is very inconsistent.
- Automatic White Balance/ Exposure to automatically adapt to changing Light

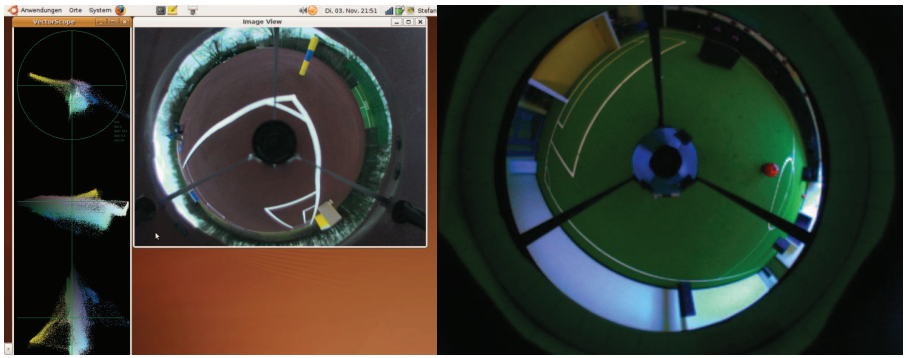
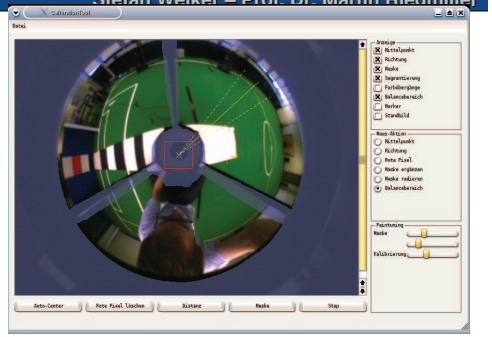


Image Processing / Omnicam

Stefan Welker – Prof. Dr. Martin Riedmiller

- Automatic Mask Generation to prevent misinterpreting the robot for obstacles
- Omni Directional Distance Calibration to make it possible to measure distances on the ground



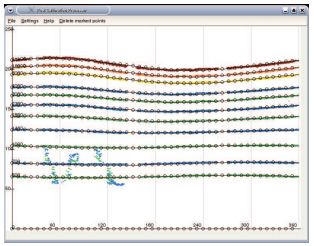
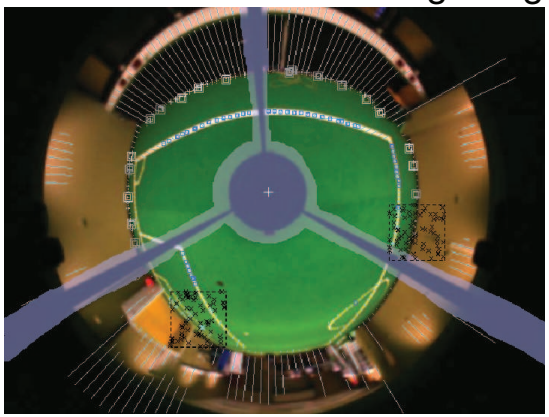


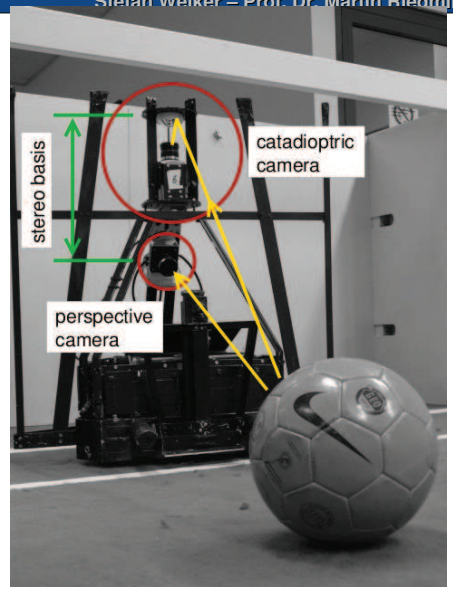
Image Processing / Omnicam

- Omnidirectional Vision Debug Image



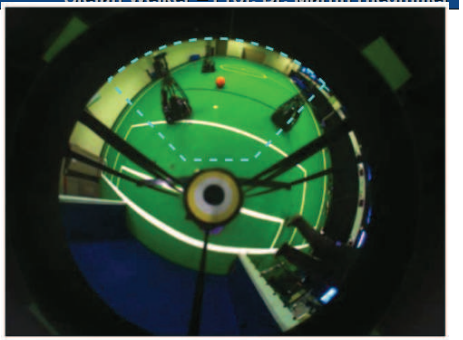
Stereo Camera Configuration

- Goalkeeper needs to detect chip kicks, the need for 3d ball detection arises
- Stacked mechanical setup
- Stereo basis ca. 28 cm



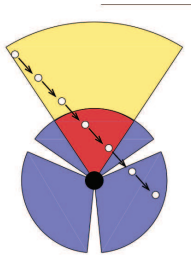
Stereo Camera Configuration

- completely different images due to
  - different camera types
  - fields of view
  - Distortion
  - resolution
- limited computation time



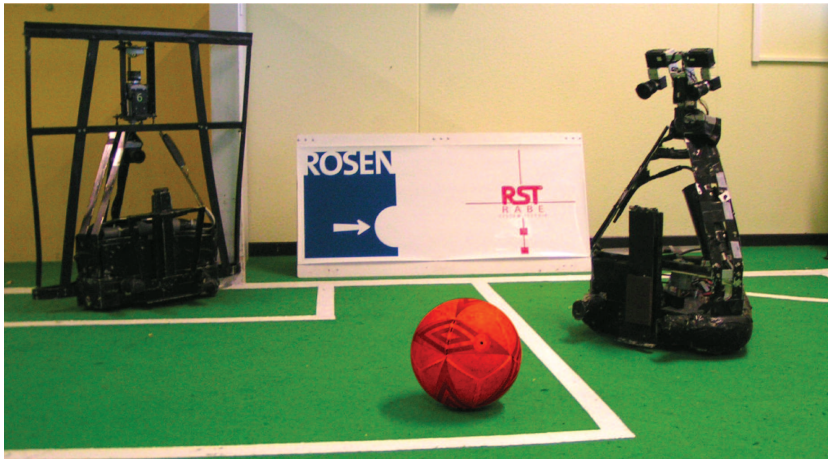
Stereo Camera Configuration

- Incomplete data problem while tracking ball
- Approach: CM Completion / Maximization, Regression



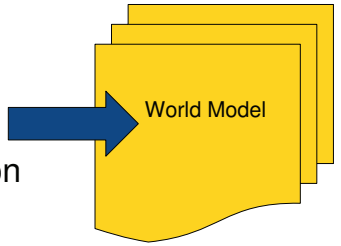
Pan Tilt Stereo Camera

- Possible Future Camera Configuration ?



Software – World Model

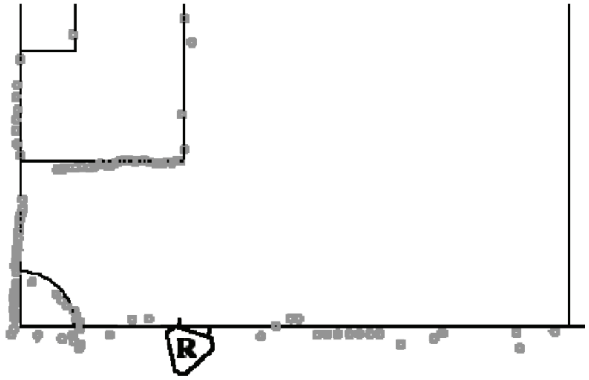
Sensors,
old State,
Communication



- Sensor Fusion & Models used in the World-Model
- Self-localization
- Ball-model (robust regression / multiple hypothesis checking)
- Self-model (robust regression / MLP)
- Teammate / Opponent-Model (shared WM, robust regression)

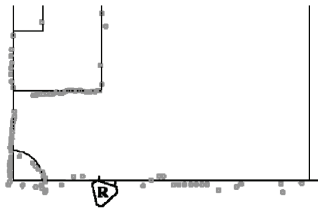
Software – Self-localization

- Line transitions from the omni camera have been converted to real distances



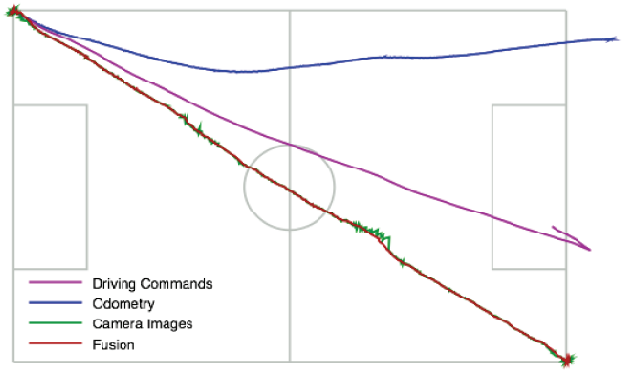
Software – Self-localization

- An error metric for matching the lines to the field model can be calculated



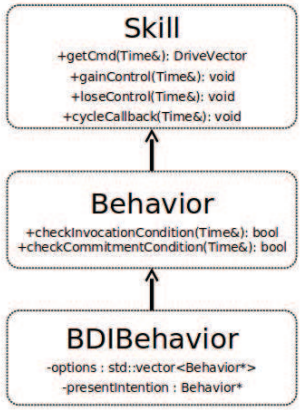
Software – Self-localization

- Minimization using gradient descent with R-Prop



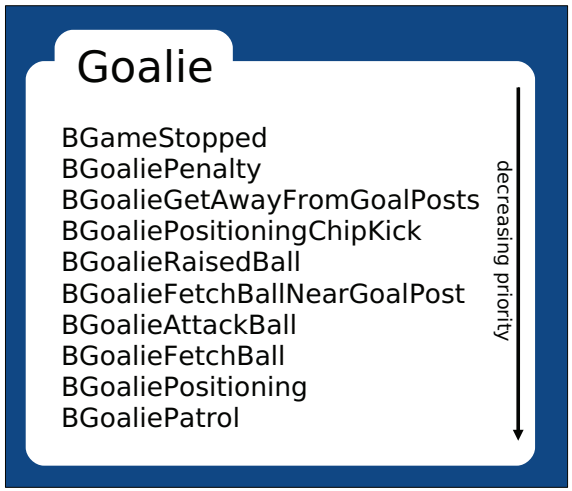
Robot Behaviors and Skills

- Robot behavior is defined by using a class Framework oriented on the BDI approach (Belief / Desire / Intention)
- Complicated Graph-based state machines are avoided using arbitration

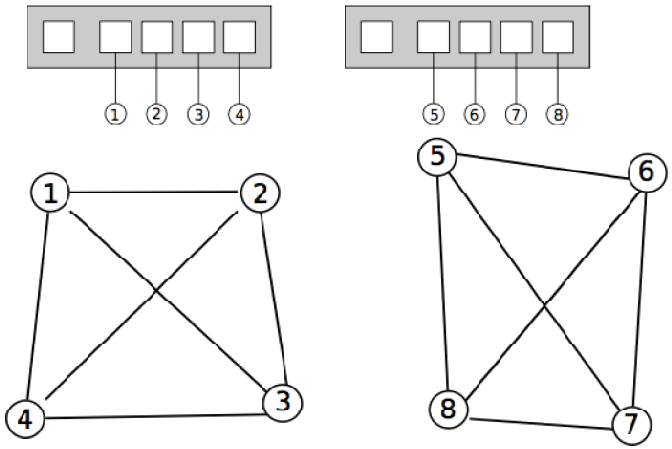


Example of Goalie Arbitration

- Goalie ”Stack”



FSM / BDI Comparison



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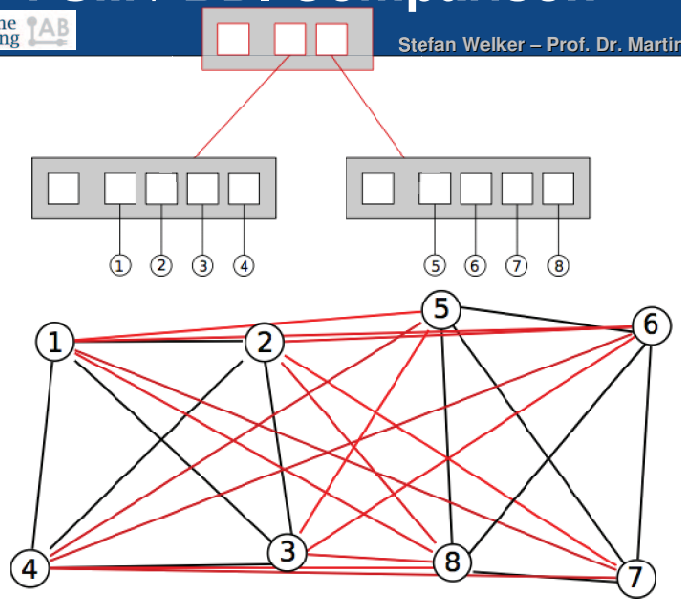


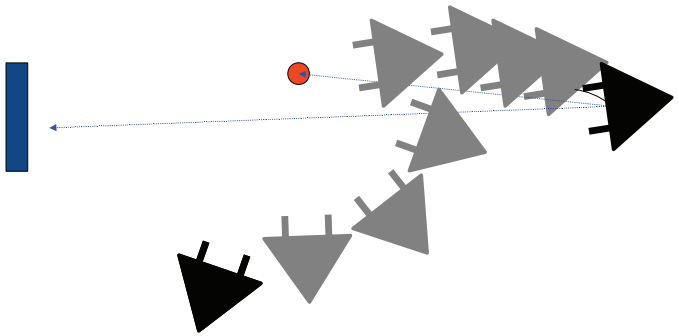
Some Important Skills

- Get the ball !
  - Must always work faster than the enemy robot ;)
  - Rolling ball must be no disadvantage
  - Must work everywhere on the field
- Dribble the ball
  - Move to a position not loosing the ball on the way
  - The ball could roll away
- Shoot if the chance to score is high
  - Don't dribble too much in front of the enemy goal

Skill Implementation

EXAMPLE 1

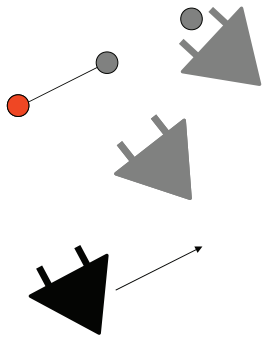
Static ball, approach from different positions dependent of goal direction



Skill Implementation

EXAMPLE 2

Moving ball

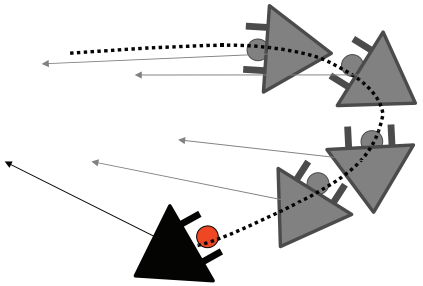


Necessary data:
-relative ball position
-relative ball speed

Skill Implementation

EXAMPLE 3

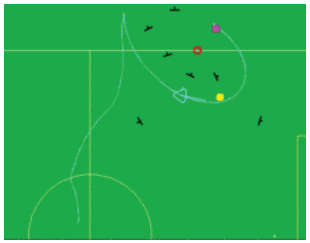
Dribbling to a position / goal



Skill Implementation

EXAMPLE 4

Trajectory Planning

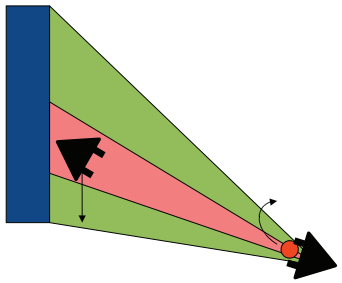


- Trajectories are planned based on a geometric analysis of the configuration of the field and the dynamic properties of the robot.
- We do not generate whole trajectories but only way-points
- The trajectory is replanned every 33 ms to cope with the dynamic environment.

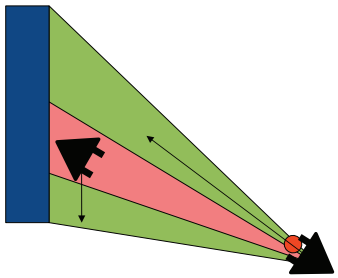
Skill Implementation

EXAMPLE 5

Shooting at the goal looking for a free spot



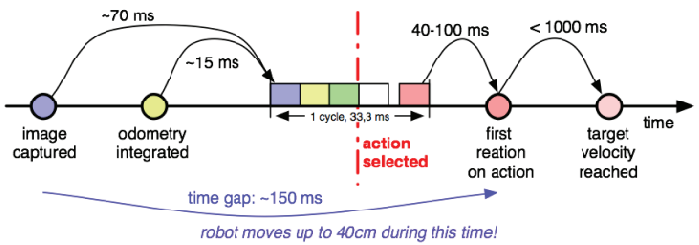
Approach some more, aim at right goal post...



Shoot !!!!

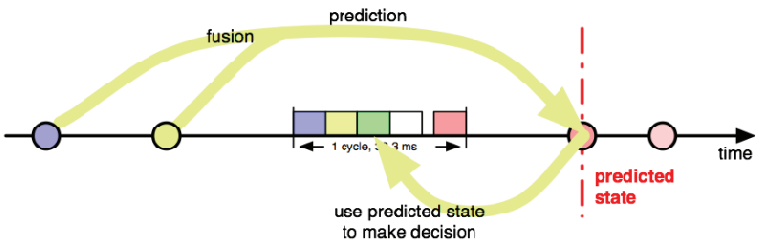
Learning on a real system

- Using real hardware for Learning presents challenges
  - Testing is a lot of work => Algorithms that learn fast are needed.
  - Delays make the state non markovian



Learning on a real system

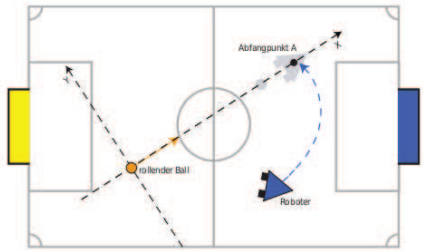
- Approach : Prediction of the state



Model free Reinforcement Learning without a simulation is possible !

Reinforcement Learning

- **Catching a passed Ball (Keeping the ball from jumping away)**
- Keep the Ball from rolling away while Dribbling and Moving Omnidirectionally
- Omnidirectional Motor Control
- Learned Skills were actually used during Robocup Tournaments



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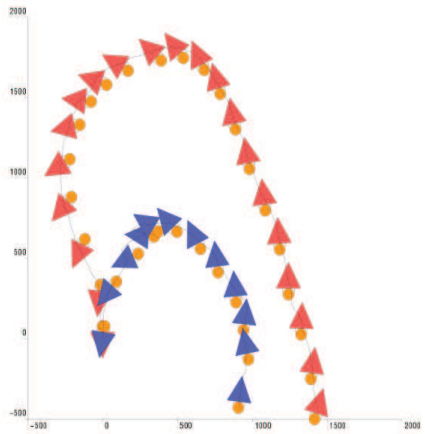

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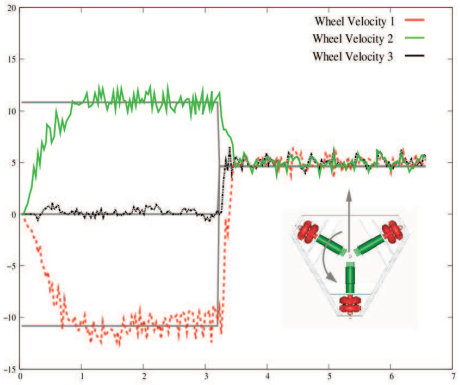
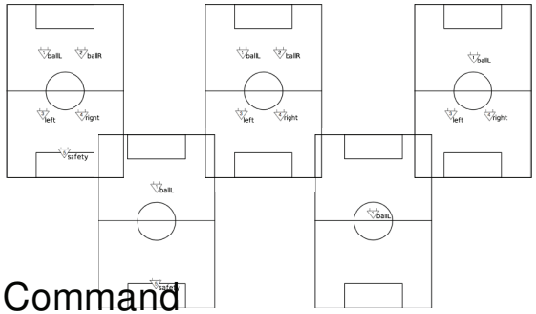
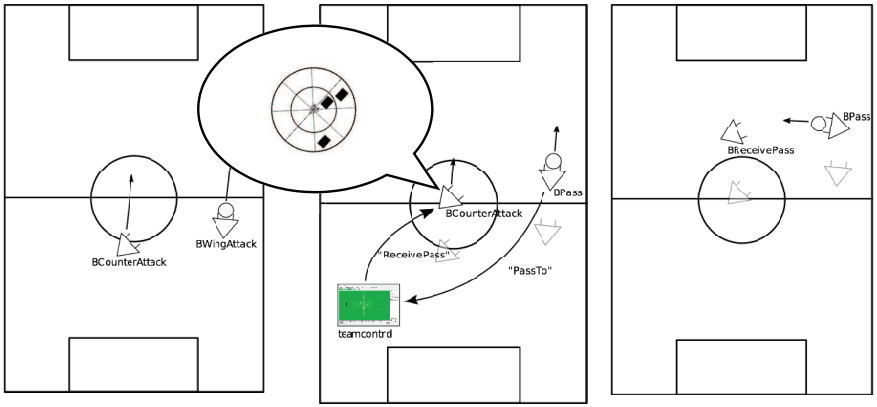


Teamplay / Cooperation

- Hard to implement Useful Robot Cooperation
- Implicit Cooperation through Knowledge / Explicit Cooperation through Communication
- Dynamic Role Change
- Defense Rotation
- Subteams
- Passing
- Dynamic Chain of Command



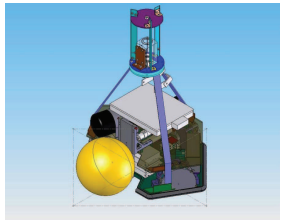
Example: Pass



Current Project: openTribot

- DFG funded Project
- Open Source Hardware / Software Platform for the Robotcup MidSize League
- Designed in Cooperation with Harting KgaA

Deutsche Forschungsgemeinschaft DFG



HARTING

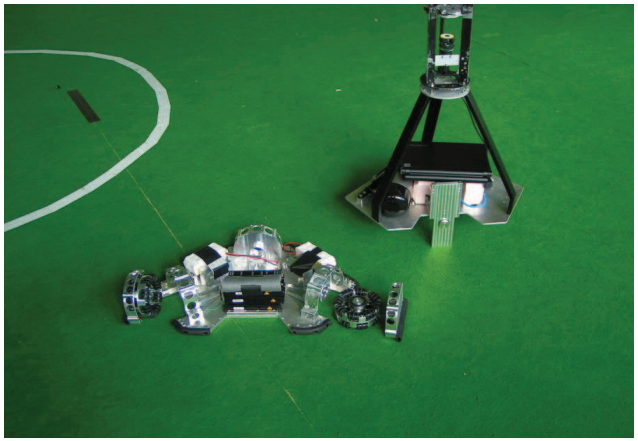
Pushing Performance

openTribot Hardware

- Custom 3- wheel omni-drive, with powerful brushless motors, strong lipo batteries (5 m/s)
- Omnidirectional USB camera
- Netbook w/ Linux
- Can-Bus, high Pressure Kicking device, 6-dof IMU
- Modular design

Prototype Hardware

- Custom CNC milled chassis



Future Projects

- Making the Robot intelligent enough to play in a mixed team with other Robots
- Optimize Robot performance
- Elaborate on the Learning aspect
- Making the Setup easy
- Rent-A-Robot
- Technical Challenges in Robocup

Videos online

- Check our site
  http://ml.informatik.uni-freiburg.de
  for links to videos
  or search Tribots Robocup in Google Videos!

Thank you for your attention !

- If you are interested you are welcome to get involved in our projects !
- Please come by my office on Thursdays if you like !
  (Building 79, Room 0 00 06)
- Feel free to join the Robocup AG Mid-Size in the next semester.

  http://ml.informatik.uni-freiburg.de/people/welker/info