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

- 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)
- Light on a robocup field is very inconsistent.
- Automatic White Balance/Exposure to automatically adapt to changing light.
- Automatic Mask Generation to prevent misinterpreting the robot for obstacles
- Omni Directional Distance Calibration to make it possible to measure distances on the ground
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

- 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
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"

Goalie

- BGameStopped
- BGoaliePenalty
- BGoalieGetAwayFromGoalPosts
- BGoaliePositioningChipKick
- BGoalieRaisedBall
- BGoalieFetchBallNearGoalPost
- BGoalieAttackBall
- BGoalieFetchBall
- BGoaliePositioning
- BGoaliePatrol

decreasing priority
FSM / BDI Comparison
FSM / BDI Comparison
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
EXAMPLE 1

Static ball, approach from different positions dependent of goal direction
EXAMPLE 2

Moving ball

Necessary data:
- relative ball position
- relative ball speed
EXAMPLE 3

Dribbling to a position / goal
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.
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

The diagram illustrates the timing of different processes:
- Image captured: ~70 ms
- Odometry integrated: ~15 ms
- Action selected: 40-100 ms
- First reaction on action: <1000 ms
- Time gap: ~150 ms

Note: Robot moves up to 40 cm during this time!
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
Reinforcement Learning

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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
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