RoboCup

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RoboCup: Today and Tomorrow – What we have learned

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What is RoboCup?

- Mission Goal: "By the mid-21st century, a team of autonomous humanoid robots shall beat the human World Cup champion team under the official regulations of FIFA."

- Problem Domain: Real-time sensor fusion, reactive behavior, strategy acquisition, learning, real-time planning, multi-agent systems, context recognition, vision, strategic decision-making, motor control, intelligent robot control, many more

Why Robot Soccer

- Competition forces reliability instead of optimal performance 1 in 100 times, valuable testing platform outside of laboratory, motivates students and spectators

- Interesting comparison: Computer chess vs. computer soccer

	Chess	RoboCup
Environment	Static	Dynamic
State Change	Turn Taking	Real Time
Information accessibility	Complete	Incomplete
Sensor readings	Symbolic	Non-Symbolic
Control	Central	Distributed

What is RoboCup?

- Why propose multiple leagues?
  - Vary size / budgetary constraints to promote wider competition.
  - Vary size constraints to promote different application technologies .
  - Vary regulations to promote various problem domains (on / offboard sensor fusion, implicit / explicit communication, strategies, etc) .

Current League Definitions in RoboCup

- Currently (1999) composed of three leagues:

    - Simulation League: eleven agents per team individually controlled, distributed sensing capabilities (visual, auditory).
    - Small-size real robot league: five agents per team, 15cm^3, play on ping-pong table, global vision allowed.
    - Medium-size real robot league: five agents per team, robot base diameter < 50cm, play on 3 ping-pong tables, global vision not allowed

Research Issues and Approaches Considered in Paper

- Agent architecture
- Combination of reactive / planning approaches
- Real-time recognition, planning, reasoning
- Reasoning and action in a dynamic environment
- Sensor fusion
- Multi-agent systems
- Behavior learning
- Strategy acquisition
- Cognitive modelling

Team Architectural Structure

What kind of architectures have been seen at RoboCup?

Type	CPU	Vision	Issues	League
A	1	1 global	Strategy	Small size
B	n	1 global	Sharing of information	Small size
C	1	1 global + n local	Sensor fusion, coordination	Small size
D	1 + n	n local	Multiple robots	Middle size
E	n	n local	Sensor fusion, teamwork	Middle size

Simulation League

- Interesting comparison of RoboCup-97 vs. RoboCup-98
    - Introduction of offside rule to diversify strategies, increase realism.
    - Ball speed reduced. Promotes dribbling, passing, teamwork.
    - Better stamina bound. Players tire after 50m dash, with cumulative long term fatigue.

Simulation League

- Interesting results of above changes:
  - Offside Rule: Strategic option of defensive "Offside Trap." Dynamic formation of teams, enforces look-before-passing.
  - Man Marking: Stronger teams use explicit man-marking (CMUnited-98), need to predict strategies of opponents.
  - Passing strategies: Require prediction of teammate actions to allow through-pass and back-pass.

RoboCup challenge in simulation

- Three strategic research challenges in simulation
  - Multi-agent learning: On / Offline learning, examples include interceptions, adaptive player positions, experience based player positions.
  - Teamwork: Strong teams generate a strategic plan, execute in coordinated fashion, monitor for contingencies, select remedial actions.
  - Agent modeling: Required for agent prediction of teammates and opponents.

Small-size real robot league

- Research challenges examined in small-size league
  - Hardware Innovation:
    - Sensor-activated kicking devices
    - Ball holding, shooting tools for goalie
    - Compact and robust designs
  - Efficient perception
    - Global perception challenge: Need reliable, real-time detection of multiple moving objects: ball, teammates, opponents.
    - Example: CMUnited-98: 30 fps used for decisions, prediction used for ball interception, goaltender behavior and pass/shoot decisions.
  - Individual and team strategy
    - Role based team structure common, with 1-2 defenders and 3-4 attackers
    - Example: CMUnited-98: Each attacking robot anticipates needs of team and positions itself to maximize probability of successful pass.

Middle-size real robot league

- Research challenges addressed in middle-size league
  - Optimal platform: Still unknown. Examples include Pioneer-AT, Nomadics' Scout, original designs
  - Sensors: No global vision. PC based image processors onboard, also standard sensors (bump, sonar, laser). Perception still problematic, particularly detecting other agents.
  - Kicking mechanisms: pneumatic, solenoid devices introduced, produce much higher acceleration than in RoboCup-97

Middle-size real robot league

- Research results:
  - Most teams use if-then static rules. Some learning, evolutionary approaches (Trackies), genetic programming used to teach agents being developed.
  - Vision remains main external source of sensing. Fixed cameras necessitate agent rotation to see (passive vision). Proposed panning camera use, multiple or omni-directional vision.
  - Environment modeling and localization use geometric field model to localize robots.
  - Communication generally implicit, though explicit is allowed. Explicit communication only used by one team (Uttori). Implicit communication considered interesting problem.

Future Issues

- Major progress from 97 to 98 in dynamic systematic teamwork, particularly in simulation and small-size arena. Progress will require greater recognition and prediction of agents

- Small-size league needs to examine size-restriction impact, robust global perception and radio communication. Also real-time adaptation of strategy, tactics through learned behaviors

- Middle-size league needs to examine the slow evolution of behavioral rules, individual agent skills, perception (color-based, edges, texture, optical flow, etc), obstacle avoidance (other agents, walls, etc).

Future Issues

- Proposed new leagues:
  - Sony Legged Robot League
  - Humanoid League
  - Fully Autonomous Humanoid League
  - Tele-operated Humanoid League
  - Virtual Humanoid League
  - RoboCup Rescue

Open Field for Questions