Research using the RoboCup Domain

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Outline

- Introduction to RoboCup
- RoboCup at the University of Auckland
- Research Challenges
- RoboFesta and RoboFesta NZ
- Conclusion

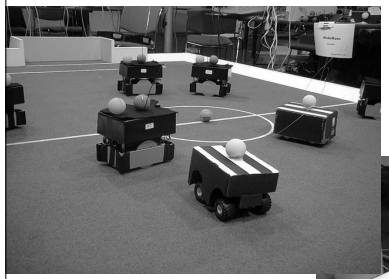
What is RoboCup?

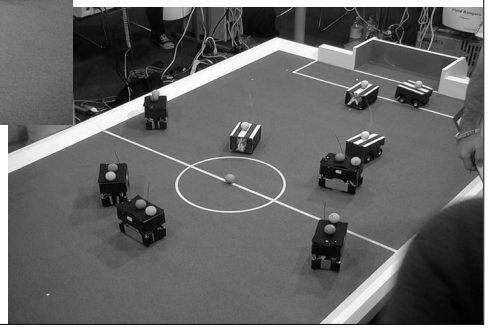
- RoboCup is a competition of robots playing soccer
- 1991: Alan MacWorth posed this as a challenge problem for AI
- 1997: Dr. Hiroaki Kitano organized the first competition in Japan
- Yearly event. 2000 World Cup in Melbourne

RoboCup Domain

- Autonomous agents playing soccer:
- Small League
  - 5 Players/team
  - Golf ball (Orange)
  - Table tennis field (Green)
  - Goal Box: Yellow and Blue
  - Team colors: Yellow and blue

Pictures from RoboCup 2000



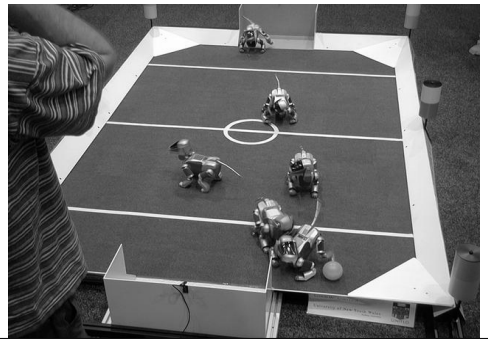


RoboCup Federation

- Simulator league: Software agents. The game is played using a virtual soccer server. Humans or robots?
- F−180: Small league. 18 cm diameter. Teams of five robots. Global vision system is allowed. Some local vision teams.
- F−2000: Medium league. Teams of three robots. Local vision and other sensors only
- Sony Legged League: Teams of Three Sony AIBOs.

Sony Legged League

- UNSW rolled over everybody.
- Secret weapon: new walk and new kick



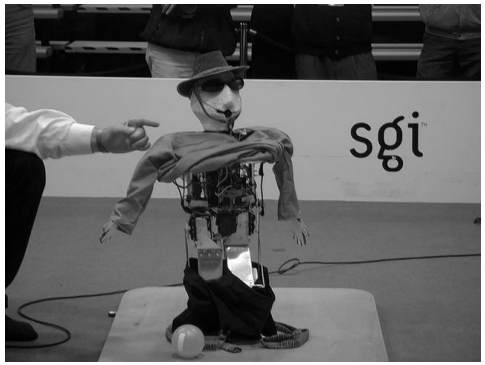
Not just Fun and Games

- Workshop: Scientific developments are presented in a conference style forum
  - > 100 Submissions
  - Distinguished Science Award (4 Papers)
- Humanoid Robot Exhibition
  - New league in 2001/2
- Humanoid Soccer Match
- 2050: Beat the World Champion

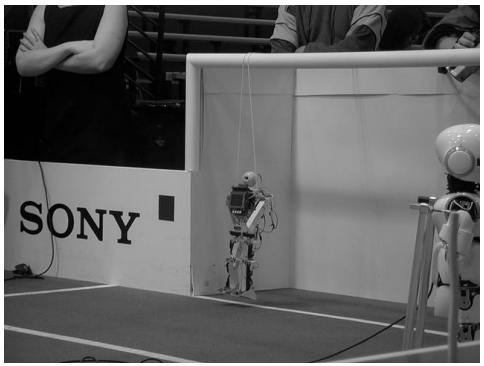
Humanoid Robot Exhibition

French Humanoid Robot

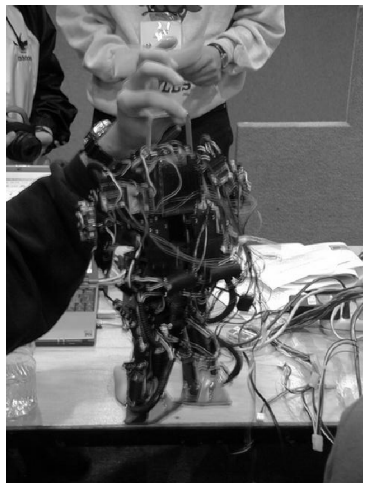
French Humanoid Robot



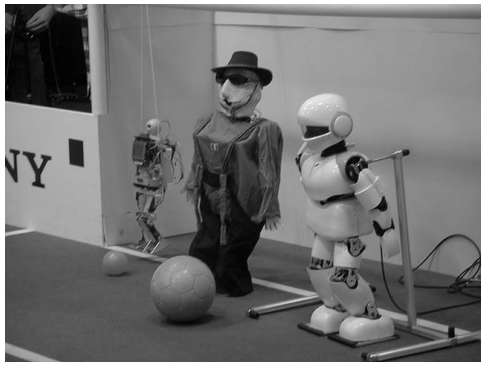
Johnny Walker



Future University of Japan



Humanoid Robot Exhibitions



Humanoid Robots Summary

- 23−26 DOF
- Best walking from the Future University (Japan)
- Force sensors in the feet. No acceleration sensors
- Actuated ankle (But which axis?)
- The bigger, the harder to control

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Jacky Baltes' Background

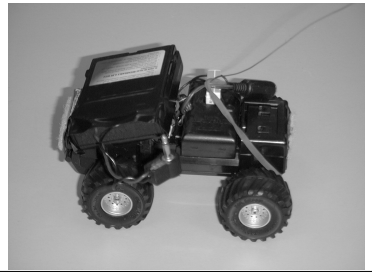
- AI
- Dissertation: A Learning Multi−Strategy Planning System
- Disillusionment!!!
- No AI Failures
- No AI Benchmarks
  - UCSD Machine Learning Database
  - Drew McDermott Planning Competition
- Benchmark Sets may be biased (Holte '91)

RoboCup and the University of Auckland

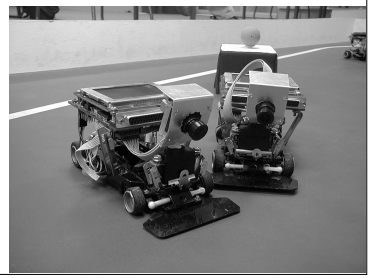
- University of Auckland competed at the last three games
- In 2000, we competed with two teams in the small sized league
- All Botz: Global vision system. Competed previously. Toy cars.
- 4 Stooges: Local vision team. Fully autonomous. Based on Braeunl's Eyebot Controller and CMOS Camera. Old All Botz toy cars as base

University of Auckland RoboCup Teams

All Botz:
Video on the ceiling
No internal processing



4 Stooges:
Fully Autonomous
CMOS camera
MC68332 local controller



Research Goals

- All Botz
  - Computer Vision
  - Camera calibration
  - Robust control
  - Path Planning in Highly Dynamic Environments
- 4 Stooges
  - Egomotion estimation, Optical Flow
  - Localization
  - Local Path Planning

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  - Control
  - Path Planning
  - Task Planning
  - Subsumption Architecture
  - Multi−Agent Systems
- RoboFesta and RoboFesta NZ
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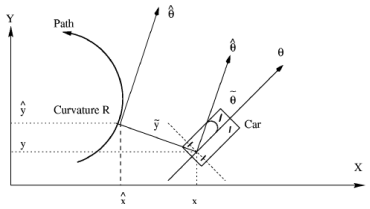
What are the Problems?

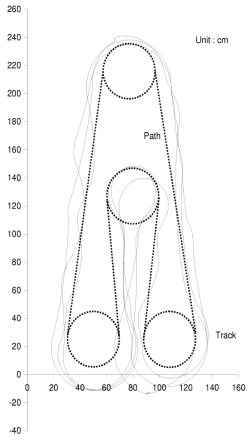
- Hardware − Mechanics, Electronics, Sensors, Actuators
  - Cheap, reliable, flexible
- Software − Complex, Non−Intuitive
  - Real−Time
  - Performance
  - Debuggable, Testable
- Vertical Integration
- Complete System Design

Multi−agent Cooperation
AI, Learning, Planning, ...
Path Planning
Path Following Control
Networking
Computer Vision
Real−Time Operating Systems
Hardware (Actuators, Sensors)

Path Following

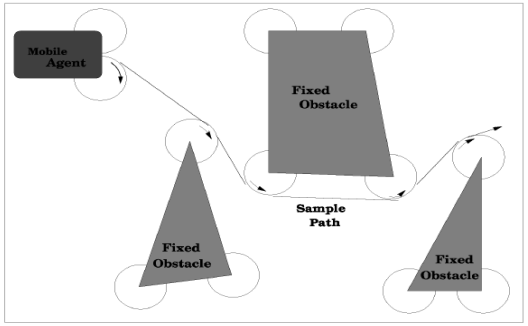
- Non−holonomic control problem
- Non−linear
- Reinforcement learning





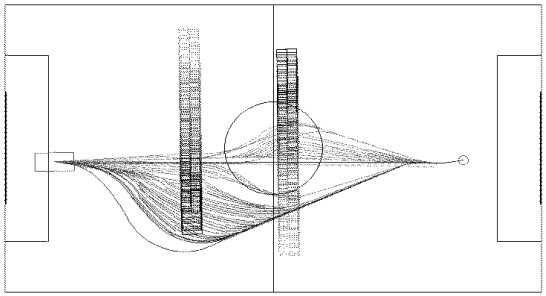
Path Planning

- A Mobile Robot must be at the right place at the right time
- Find a way through a set of obstacles (static or dynamic)



Adaptive Path Planning

- Multiple moving obstacles
- Real−time constraint



Task Planning

- When to shoot? When to pass?
- Play defensively / offensively
- Symbolic AI
  - (ball my−team) and (goal−shot blocked) and ...
- Reactive systems (Situated Activity)
  - If the ball is in front of me and ... then shoot
  - If the ball is behind me then turn ...
- Balance between reactive and strategic planning

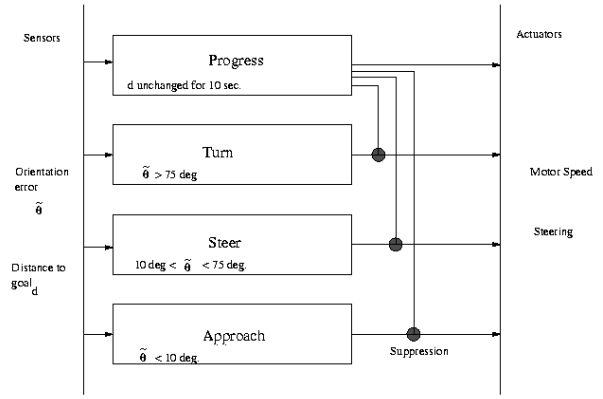
Subsumption Architecture

- Path generation is an expensive operation
- Bicchi's path planner. Complexity is too high for real−time path planning
- Combine path planning and control
- Approach point in the distance
- Subsumption architecture (Brooks)
  - Layered architecture. Higher levels influence lower
  - Direct connection from sensors to actuators
  - No symbolic world representation

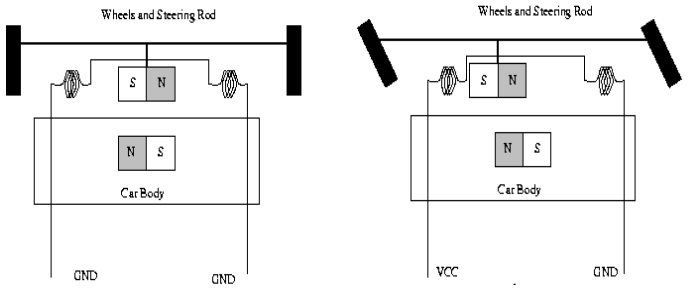
Behaviors

- Approach: Fires if angle error <= 10 deg. Fast forward with gentle control
- Steer: Fires if 10 > angle error < 75 deg. Sharp steering, go forward
- Turn: Fires if angle error >= 75 degrees Stop and turn approximately 90 degrees to target
- Progress: Fires if distance to goal has not decreased for more than 10 secs. Back up and turn randomly

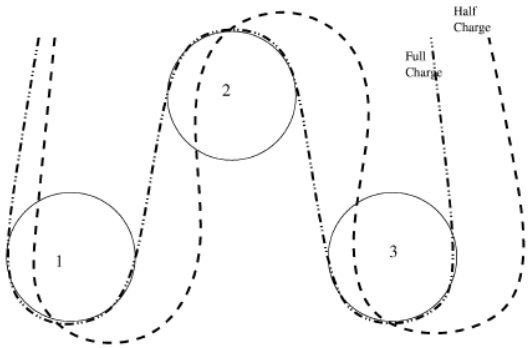
Subsumption Architecture



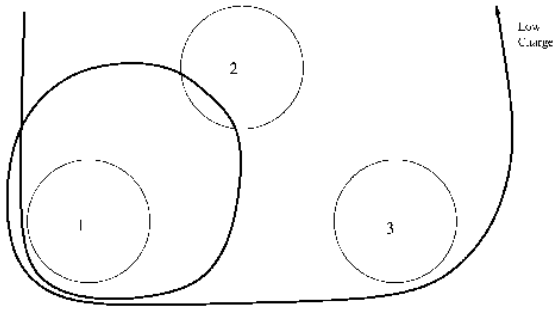
Toy Car Steering: Surprise!



Path Following Control



Path Following Control



Multi−Agent Systems

- A lot of MAS research is ill defined? What are the problems? Questions? Evaluation Methods?
- New word for Distributed AI
- Many cheap robots (Pile of PCs Computing, Redundency)
- Coordination to achieve goals
  - Agent − Agent: Two robots lift a log
  - Agent − Human: Following task
  - Role Assignment Function
- Communication: Explicit or Implicit

Multi−Agent Systems

- Multi−Agent Learning
- Create models of other agents internal state
- Major difference to Distributed AI
- Belief − Desire − Intention (BDI) Model

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RoboFesta

- RoboFesta
  - Olympics of robotics games
  - Organized by Japanese Government
  - Science and Technology Literacy
  - Executive Committee
- Groups of children will attend. RoboCup Junior.
- Games
- Forum
- Exhibition

RoboFesta NZ

- New Zealand run off competition is organized by the CITR
- February 17th 2001
- Call for Participation available
- Advanced: RoboCup Grand Prix, Treasure Hunt, RoboCup, BEAM
- Entry Level: RoboCup Jr, RoboCup Rescue Jr., Grand Prix Jr, Entertainment Robots
- Looking for Sponsors!

RoboCup Rescue

- Robin Murphy from the University of Florida
- Urban Search and Rescue (Oklahoma City)
- 4 hrs before anything happens
- 15% of the survivors are found in enclosed spaces. 10 rescuers 4 hrs.
- 5% of the survivors are entombed. 10 rescuers 10 hrs.
- Excavate in 20 minutes
- Dogs can only work for 2 hrs.

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Conclusion

- RoboCup is an ideal development because
  - Research is grounded. No simulation
  - Challenging Problem
  - Environment is changing
  - Active Opponent
  - Only multi−agent game
- Not always the best research wins
- At least we can evaluate different aspects

Research Results

- Obvious transfer for path planning and control to other mobile robot systems
- ATT uses Peter Stone's multi−layer learning architecture for better routers, telephone exchanges etc.
- Calibration of out door scenes using our calibration method
- Takeo Kanade: Robotics > IT