Temasek Polytechnic RoboCup Team-TPOTs

Nadir Ould Khessal

Temasek Engineering School, Temasek Polytechnic
21 Tampines Avenue 1 Singapore
nadirok@tp.edu.sg

1. Introduction

TPOTS is a Team of small size robots designed using a hybrid control architecture distributed among the robots and the host computer. The major characteristic of the RoboCup soccer competition is the dynamic nature of the environment in which robots operate. The only static object in the competition field is the field itself. Team and opponent robots as well as the ball can be placed anywhere in the field, be it a purposeful strategic positioning, a missed action or a forced displacement. This has led many researchers to shift from the traditional model-based top down control [1,2] to a reactive behavior based approach [3,4,5,6,7]. Robots need not waste a huge amount of resources building maps and generating paths that might prove useless at the time of action. Instead robots are supposed to react to the actual changes in the environment in a simple stimulus-response manner [8]. However due to the size limitations imposed by the RoboCup small robots league (15cm diameter circle) and rich visual input, on-board vision proved to be a complex and expensive task.
The 1999 RoboCup competition was the first world RoboCup experience for TPOTS. The team played three games in the round robin stage during which it scored 13 goals and conceded 10 (Table 1).

	CMUnited	Linked 99	Rogi2
TPOTS	0-4	9-0	4-6

Table 1. Temasek Polytechnic RoboCup team-tpots games results

In this Paper we will describe the overall architecture of TPOTS. Detailled descriprion of the Multi-Agent System (MAS) architecture can be found in [9].

2. TPOTS Development

Our approach in implementing the control architecture of the robots is based on dividing each robot controller into two parts: Embedded agent running on the on-board processor and situated in the environment (field) and Remote agent running in the off-board host computer and situated in an abstract model of the field. The embedded agent consists of several reactive behaviors competing with each other through the use of activation levels (inhibition and suppression). The main role of the

M. Veloso, E. Pagello, and H. Kitano (Eds.): RoboCup-99, LNAI 1856, pp. 683–686, 2000.

embedded agent is to execute commands issued by the remote agent and navigate safely the soccer field while avoiding other robots and obstacles. The remote agent on the other hand implements strategies generated by the reasoning module.

Team Members:

Nadir Ould Khessal
- Affiliation: Temasek Eng. School
- Country: Singapore.
- Position: Lecturer.
- Attended the competition.

Sreedharan Gopalsamy
- Affiliation: Temasek Eng. School
- Country: Singapore.
- Position: Lecturer.
- Attended the competition.

Lim Hock Beng
- Affiliation: Temasek Eng. School
- Country: Singapore.
- Position: Lecturer.
- Did not attend the competition.

Kan Chi Ming, Dominic
- Affiliation: Temasek Eng. School
- Country: Singapore.
- Position: Lecturer.
- Attended the competition.

Chia Loong Suan, Alex
- Affiliation: Temasek Eng. School
- Country: Singapore.
- Position: Technical Staff.
- Attended the competition.

Hang ping
- Affiliation: Temasek Eng. School
- Country: Singapore.
- Position: Student.
- Attended the competition.

3. TPOTS System Architecture

The system hardware consists of a Pentium host computer, a vision system based on Newton labs Cognachrome vision card, RF transmission system and five robots (figure 1).

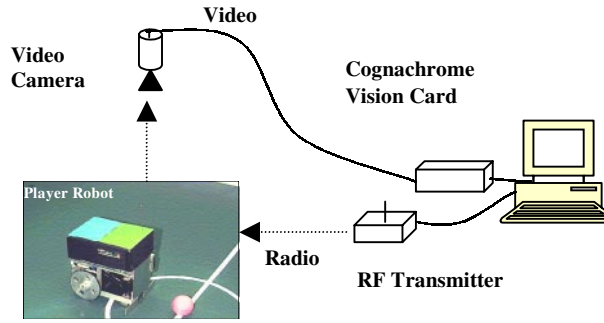

Fig. 1. System Overview

3.1 On-Board Perception

Each robot is equipped with three infrared sensors capable of detecting objects within the range of 20 cm. The on-board agent to avoid other robots placed in its path uses these sensors.

3.2 Off-Board Perception

Remote agents use the vision system as their perceptual module. A global vision system, which consists of color camcorders and a special image processor (MC68332), is used. The system is able to segment and track the robots and ball at a high frame rate. Each robot has two color pads. The image processor is trained to see the different colors and gives the locations of the center of gravity of the two color pads. Hence the orientation and robot position are known. Color pad areas are used to distinguish between different robots and minimize latency.

3.3 Agents Communication

The host computer transmits commands to the robot via radio transceivers utilizing UHF radio waves. Each robot has its own transceiver and a unique node address. The low-powered wireless system transmits less than 1mw of power and is effective over distances of 3 to 30 meters. Two-way communication rates of up to 38.4Kbps are possible. The command set is transmitted as text code piggybacking on the transmission protocol. Commands are sent and received from the transceiver using an RS-232 interface.

4. TPOTS Behaviors and Skills

4.1 Embedded Agents

Obstacle avoidance is the main autonomous task done by the robot. Using the three infrared sensors, the robot moves away from obstacles using the *Avoid Left* and *Avoid right* machines. The robot than moves a certain distance until a straight-line path to the target position is clear. The remote agent detects that the robot is out of the previously computed path and re-computes and transmits a new path.

4.2 Remote Agents

Intercept_ball: This machine enables the robot to move behind a predicted ball position before kicking it towards a target area. The target area could be the opponent goal keeper area (in an attempt to score a goal), a clear area in front of a team member (ball passing) or simply the opposite side of the field, in the case of a defending robot.

Follow: This machine is designed to keep the robot following a target object. The target can be the ball, a team robot or an opponent robot. This is done to keep the robot nearer to the ball and therefore in a better position to intercept the ball.
***Homing*:** Depending on the strategy being executed robots could be required to be placed at a certain position for the purpose of forming a defense wall for example.

5. Conclusion and Future Work

We will continue our research on developing further the distributed MAS architecture. However, work towards entering the Melbourne 2000 competition will focus on the development of a robust vision system, capable of adapting to the varying lighting conditions.

References

1. Albus, James S. *Hierarchical Control Of Intelligent Machines Applied to Space Station Telerobots*. IEEE Transactions on Aerospace and Electronic Systems, Vol. 24. NO. 5 Sept. 1988.
2. Housheng Hu and Michael Brady, *A Parallel Processing Architecture for Sensor Based Control of Intelligent Mobile Robots*. Robotics and Autonomous Systems, vol.17,1996, pp 235-257.
3. Brooks, Rodney A.. *Achieving Artificial Intelligence Through Building Robots* A.I.Memo 899, Artificial Intelligence Laboratory, MIT, May 1986.
4. Brooks , Rodney A. *Intelligence without Reason*. Computers and thought, IJCAI-91, Also A.I. Memo 1293 Artificial Intelligence Laboratory, MIT.
5. Maja J. Mataic. *Interaction and Intelligent Behavior.* Ph.D. Thesis, Department of Electrical Engineering And Computer Science, Artificial Intelligence Laboratory, MIT, 1994.
6. Arkin, Ronald C. *The Impact of Cybernetics on the Design of a Mobile Robot System: A Case Study*. IEEE Transactions on Systems, Man , and Cybernetics Vol. 20 No 6 Nov./DEC 1990.
7. Kenneth Moorman and Ashwin Ram.. *A Case-Based Approach to Reactive Control for Autonomous Robots*. AAAI Fall Symposium " AI for real time Mobile Robots", Cambridge MA, Cot 1992.
8. Brooks, Rodney A.. *A Layered Intelligent Control System for a Mobile Robot.* IEEE Journal Robotics And Automation . RA-2, March 1986, 14-23.
9. Nadir Ould Khessal. *Towards a Distributed Multi-Agent System for a Robotic Soccer Team.* In Ed. Manuela Veloso, Enrico Pagello and Hiroaki Kitano, *RoboCup-99: Robot Soccer World Cup III*. Springer Verlag, 2000, in this volume.