Osaka University "Trackies 2001"

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Abstract. This is the team description of Osaka University "Trackies" for RoboCup2001. The hardware and software architecture are presented.

1 Introduction

The Robot World Cup Soccer Games and Conferences (RoboCup) are a series of competitions and events designed to promote the full integration of AI and robotics research. The robotic soccer provides a good test-bed for evaluation of various research, e.g. artificial intelligence, robotics, image processing, system engineerings, multi agent systems.

Osaka University "Trackies" has participated the RoboCup since the first one 1997. We have changed our robot system from a remote controlled vehicle to a self-contained robot because the remote brain system often suffered from much noise of camera image and motor command transmissions. On the other hand, we adopt an idea that the cooperative behaviors without any planning to emerge cooperation in the dynamic environment caused by multi robots in a hostile environment.

This paper presents the employed hardware, namely robots and computers, and a fundamental approach to control robots.

2 Hardware

Fig.1 show pictures of our mobile robots we designed and built. Fig.2 shows an overview of the robot system. The system consists of a motor driving unit, a vision system, and a control unit.

2.1 Control Unit

We use an on-board computer as a controller for the robot. It is a standard PC parts, and commercially available. Each PC has a 233 MHz Intel Pentium MMX CPU, 128 MB RAM and 160MB Silicon Disk Drive (as a hard disk drive). The operating system is Debian GNU/Linux, and we install the minimum system in the hard disk drive in order to communicate with external file server. The

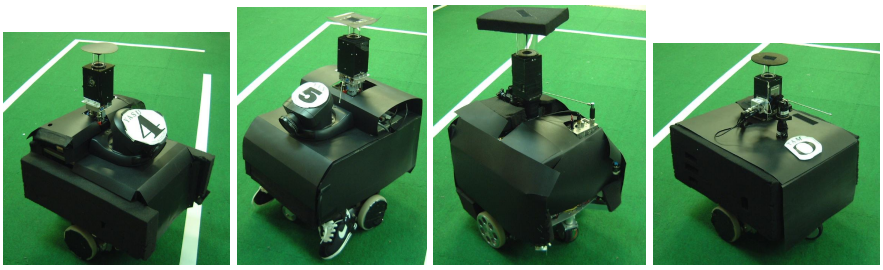

Fig. 1. Our mobile robots

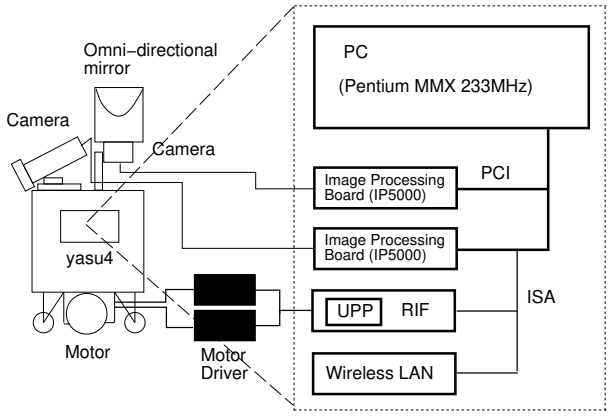

Fig. 2. An overview of the robot system

software development of our mobile robot is done on the external file server. For the communication between a robot and an external file server, wireless PCMCIA Ethernet cards (AT&A WaveLAN/IEEE) in PCMCIA to ISA adaptors are used. Each computer has one or two image processing board (Hitachi IP5005) or frame grabber for vision system, and one Robot Interface Board which has an Universal Pulse Processor for motor control.

2.2 Vision System

The robot has an omni-directional camera system with or without a normal camera system. Two robots have SONY EVI-D30 which has a motorized pan-tilt unit. An omni-directional camera system consists of a color CCD camera and a omni-directional mirror and is mounted on the robot as the camera optical axis is aligned with the vertical axis of the mirror. A simple color image processing is applied to detect the ball, goals, field, and obstacle areas in the image in real-time (every 33ms).

2.3 Motor Driving Unit

The driving mechanism, which is originally designed at Tsukuba University and now commercially available as a vehicle unit with motor, wheels, and control drivers, is a PWS (Power Wheeled System); the vehicle is fitted with two differential wheels. The wheels are driven independently by separated DC motors, and two extra free wheels ensure the static stability. Robot Interface Board generates PWM pulses, which controls the speed of the wheel. The pulses are sent to the motor drivers which drive the wheels.

3 Software

Our robot team consists of four robots. They all share almost the same basic hardware, but they differ in their behavior programming. Each member of our team has his/her own research issues, and is actively involved in the field of behavior learning, multi-agent learning and so on. We are making our efforts to apply these research results to our physical robots to check their validity of the proposed methods.

3.1 Multi-Layered Reinforcement Learning

Reinforcement learning has been receiving attention as a method for robot learning with little or no a priori knowledge and higher capability of reactive and adaptive behaviors [1]. Asada et al. have presented a series of works on soccer robot agents which chase and shoot a ball into the goal or pass it to another agent [2] [3] [4] [5] [6].

We proposed a method by which a hierarchical structure for behavior learning is self-organized in [7]. The modules in the lower networks are organized as experts to move into different categories of sensor output region and learn lower level behaviors using motor commands. In the meantime, the modules in the higher networks are organized as experts which learn higher level behavior using lower modules. Each module is assigned its own goal state by itself.

3.2 Genetic Programming

In applying some of evolutionary approaches to the robot in order to obtain purposive behaviors, the fitness (evaluation) function should be given in advance. We propose an adaptive fitness function in consideration of the change of the evaluation through the evolution. Based on the given priority, the robot modifies the fitness function to control the task complexity. In order to obtain the policy, we select a Genetic Programming (hereafter GP) method [8]. GP is a kind of genetic algorithms based on the tree structure with more abstracted node representation than gene coding in ordinary GAs. We applied the GP enhanced by the adaptive fitness function to a simplified soccer game in [9].

3.3 Strategy Learning For A Team

Team strategy acquisition is one of the most important issues of multi-agent systems, especially in an adversary environment. RoboCup has been providing such an environment for AI and robotics researchers. A deliberative approach to the team strategy acquisition seems useless in such a dynamic and hostile environment. We proposed a learning method to acquire team strategy from a viewpoint of coach who can change a combination of players each of which has a fixed policy. Assuming that the opponent has the same choice for the team strategy but keeps the fixed strategy during one match, the system estimates the opponent team strategy (player's combination) based on game progress (obtained and lost goals) and notification of the opponent strategy just after each match. The trade-off between exploration and exploitation is handled by considering how correct the expection is.

References

[1] J. H. Connel and S. Mahadevan. "Introduction to robot learning". In J. H. Connel and S. Mahadevan, editors, *Robot Learning*, chapter 1. Kluwer Academic Publishers, 1993.

[2] M. Asada, S. Noda, S. Tawaratumida, and K. Hosoda. Purposive behavior acquisition for a real robot by vision-based reinforcement learning. *Machine Learning*, 23:279–303, 1996.

[3] Minoru Asada, Shoichi Noda, and Koh Hosoda. Action-based sensor space categorization for robot learning. In *Proceedings of the 1996 IEEE/RSJ International Conference on Intelligent Robots and Systems*, volume 3, pages 1502–1509, 1996.

[4] Eiji Uchibe, Minoru Asada, and Koh Hosoda. Behavior coordination for a mobile robot using modular reinforcement learning. In *iros96*, pages 1329–1336, 1996.

[5] Yasutake Takahashi, Minoru Asada, and Koh Hosoda. Reasonable performance in less learning time by real robot based on incremental state space segmentation. In *Proc. of IEEE/RSJ International Conference on Intelligent Robots and Systems 1996 (IROS96)*, volume 3, pages 1518–1524, 1996.

[6] M. Asada, E. Uchibe, and K. Hosoda. Cooperative behavior acquisition for mobile robots in dynamically changing real worlds via vision-based reinforcement learning and development. *Artificial Intelligence*, 110:275–292, 1999.

[7] Y. Takahashi and M. Asada. Vision-guided behavior acquisition of a mobile robot by multi-layered reinforcement learning. In *IEEE/RSJ International Conference on Intelligent Robots and Systems*, volume 1, pages 395–402, 2000.

[8] John R. Koza. *Genetic Programming I : On the Programming of Computers by Means of Natural Selection.* MIT Press, 1992.

[9] Eiji Uchibe, Masakazu Yanase, and Minoru Asada. Behavior Generation for a Mobile Robot Based on the Adaptive Fitness Function. In *Proc. of Intelligent Autonomous Systems (IAS-6)*, pages 3–10, 2000.