Essex Rovers 2001 Team Description

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Abstract. This article introduces our research efforts to build the Essex Rovers'01 robot soccer team participated in the RoboCup-2001 competition. A modular design for implementing a behavior-based hierarchy is introduced, which consists of three modules such as *Perception* module, *Cognition* module and *Action* module. This architecture is used for the team to achieve intelligent actions in real time. The implementation aspect of these three modules are briefly described.

1 Introduction

We are interesting in competing in the RoboCup Sony legged robot league since it is an excellent forum to promote the research in the many areas such as artificial intelligence, robotics, sensors, and agent technology. Currently, we have developed a behavior-based hierarchy for our Essex Rovers robot soccer team to achieve intelligent actions in real time [3]. This architecture is based on a modular design, which aims at easy design, flexible implementation and future extension. Moreover, neural networks based color detection algorithm and the fuzzy logic based controller are investigated, including an evolutionary approach to learning a fuzzy logic controller(FLC) employed for reactive behavior control of Sony legged robots. See [1] [2] for more details.

This article introduces our current research efforts to build a multi-agent system for cooperation and learning of multiple legged robots in the RoboCup domain. More specifically, a modular architecture designed for Essex Rovers is briefly introduced in section 2. Section 3 describes the method for color detection and object recognition. Both low-level behaviors for autonomy and high-level behaviors for cooperation are presented in section 4 . Section 5 addresses the motion control and walking problems in the locomotion of quadruped walking robots. Finally, brief conclusions and future work are summarized in section 6.

2 A Modular Architecture

The main objective for our Essex Rovers team is to build a firm research platform on which future work on multi-agent systems can be done. Currently, a multi-agent approach is adopted here to achieve real-time performance, and the modular architecture is adopted in overall agent implementation. More specifically:

A. Birk, S. Coradeschi, and S. Tadokoro (Eds.): RoboCup 2001, LNAI 2377, pp. 697–700, 2002.

- Perception – This module includes a multi-sensor system and a local map. The sensors being used are a color vision system, an infrared range sensor, five touch sensors, eighteen optical encoders, two microphones, and 3 gyros. Incoming visual, proximity, ranging and auditory information is processed by on-board computer. Neural networks based color detection algorithm is used to handle uncertain and changing lighting condition. A local map is then built and updated dynamically as long as new sensory data is available.
- Cognition – This module consists of both high-level behaviors for learning and team formation and low-level behaviors for safeguard and game playing. This is a typical hierarchical architecture that is to merge the advantages of traditional planning based approach and the behavior-based approach. Based on information from the perception module, it selects an action to perform and sends the result to the Actuators module for execution. This is the most complex module since it does the "thinking" and "reasoning" for each robot agent.
- Action – This module includes one speaker and 18 micro servomotors. Each leg has three joints driven by three servomotors. The synchronization of quadruped legs for each robot is extremely important for robot actions such as kicking the ball and moving towards the goal. A fuzzy logic controller is used here to deal with uncertainty in sensory data and imperfect actuators. The speaker can be used to communicate with teammates for team formation and cooperation.

3 Color Detection and Object Recognition

GCD is a threshold method presented by the researchers from the University of New South Wales (UNSW) in Australia. The motivation of this method is to avoid the rectangle threshold in YUV color space and achieve considerable high performance with software solution. The primitive method is to decide if a pixel belongs to a color or not by a huge table GCD.

We developed an interactive tool by using Microsoft Visual C++ to generate the GCD Table for image thresholding. It is a window-based tool and makes manual color separation easy by moving mouse only. Furthermore it also provides the ability to simulate the image processing with same C++ code employed in real robots. The most benefit of using the GCD method is the flexibility. By using it, the system can recognise up to 255 colors with a single table and achieve the high accuracy of color detection. With the non-rectangle threshold, there is nearly no confusion between two colors.

The process of object recognition in the *Perception* module is divided into three stages: image capture, image segmentation and image representation [3]. In the image segmentation stage, the threshold image may contain noise due to the luminance condition. We use morphology filters to de-noise the image since the detected object's shape is known a prior. For a binary image, there are two operators normally used in a morphology filter, namely dilation and erosion. Morphologically filtering an image by an opening or closing operation corresponds to the ideal non-realizable band-pass. In image representation, the similar adjacent pixels have to be grouped into the connected regions. This is typically expensive operation that severely impacts real time performance. We calculate the run length encoding (RLE) to represent the image in order to make our next image operation based on RLE not on individual pixels.

4 Robot Behaviors

One of important issues in the design of the *Cognition* module is to synthesis both low-level basic behaviors and high-level cooperative behaviors of multiple Sony legged robots. Low-level behaviors enable individual robots to play a role in a specified task or game. However, high-level behaviors enable a team of robots to accomplish missions that cannot easily be achieved with an individual mobile robot. Although many different behaviors can be synthesized for the co-ordination of multiple robots, several useful behaviors are identified in this application, which can be categorized into two levels as follows:

- Low-level behaviors in the Action module for mobility
  - Walking behavior - A number of simple behaviors such as *ForwardWalking, BackwardWalking, SideWalking* and *Rolling*, are designed by trial and error to make the robot move fast and more flexible.
  - Safeguard behavior - to achieve good stability and to protect robots from colliding with other objects.
  - Game-playing behaviors - to enable each robot to play a role in the competition, including *Approaching-the-ball*, *Kicking-the-ball*, *Passing-the-ball*, *Shooting-the-gaol*.
- High-level behaviors in the Cognition module for cooperation
  - Position behavior - to find out where each robot is and where is the goal in order to position itself at a good position at any moment. This is in fact a reactive planner to generate locally optimal strategies to direct low-level behaviors. It is very important for each robot to play an effective role in the competition.
  - Formation behavior - to enable multiple robots to form a team where each robot makes its own contribution towards a common goal.
  - Learning behavior - to learn from its own experience and from other mobile robots. Learning here includes both evolving fuzzy rules for low-level behaviors and searching optimal policy for high-level reactive planning.

Additional cooperative behaviors can be synthesized during the next stage of our research, for instance homing behavior and role switching behavior. This should be easy to implement in our modular design.

5 Action/Walking

The robot walking behavior plays key role in the RoboCup Sony Legged robot competition. Following successful results achieved by the UNSW team, we have developed a number of custom walking commands instead of using the normal walking commands provided by *MoNet* objects of *Aperios*.

A number of simple behaviors such as *ForwardWalking, BackwardWalking, SideWalking* and *Rolling*, are designed by trial and error to make the robot move fast and more flexible. Head motion for finding the ball is also designed to reduce time delay between the time when the robot finds the ball and the time when the command is executed. The head angles are recorded when the ball is founded and then head is moved back to that position after the current command is finished.

6 Conclusions and Future Work

This article presents our effect on training Sony legged robots for the competition in RoboCup-2001. The behavior construction and vision processing are two key aspects being focused by our team. The behaviors serve as basic building blocks for our modular software system. The structure of two level behaviors can decomposite the task into contextually meaningful units that couple perception and action tightly. Fuzzy logic implementation further enhances the abilities of the system in face of the uncertain situation.

Based on the current system, both the robot's learning and evolving abilities will be focused for the next competition, particularly on the vision system and cooperative behaviors. The main shortcomings for our team in RoboCup-2001 are inaccurate visual tracking and inefficient kicking, which will be addressed.

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References

1. D. Gu and H. Hu, Evolving Fuzzy Logic Controllers for Sony Legged Robots, Proc. of the RoboCup 2001 International Symposium, Seattle, Washington, 4-10 August 2001.
2. D. Gu and H. Hu, Fussy Behaviour Learning for Sony Legged Robots, EUSFLAT 2001 - European Society for Fuzzy Logic and Technology Conference, De Montfort University, Leicester, UK, September 5-7, 2001.
3. H. Hu and D. Gu, Reactive Behaviours and Agent Architecture for Sony Legged Robots to Play Football, International Journal of Industrial Robot, Vol. 28, No. 1, ISSN 0143-991X, pages 45-53, January 2001.