Cerberus 2002

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Abstract. Cerberus is a joint effort of Boğaziçi University (Turkey) and Technical University of Sofia, Branch Plovdiv (Bulgaria). This year many of the used algorithms have been updated. Especially, new image processing, localization and locomotion codes were developed.

1 Introduction

Cerberus is an international team which participated in Sony's Legged Robot League in RoboCup 2001 for the first time. The team did not have ample time in 2001 for the preparations. This year starting immediately after Robocup 2001 based on the observed deficiencies like slow walking styles, problems with image processing, we decided to build a larger team allowing the ability work these problems in details. Many of the algorithms used in the previous team's code were either updated or in some cases were written from scratch. The team mainly works on locomotion, localization, vision and planner and behavior control.

2 The Development Team

The team is a joint effort of Boğaziçi University (Turkey) and Technical University of Sofia, Branch Plovdiv (Bulgaria).

The Turkish Team Assoc. Prof. H. Levent Akın, the head of the Artificial Intelligence Laboratory at the Department of Computer Engineering, leads the Turkish team. The Turkish team has four subteams:

- **Vision and image processing:** Olcay Taner Yıldız, Onur Dikmen, Kaan Tarıman and Yiğit Demirelli.
- **Localization:** Hatice Köse and A. Naz Erkan.
- **Locomotion:** Levent Santemiz, Burak Turhan and İlkem Ahu Şahin.
- **Planner and behaviors:** Çiğdem Gündüz, Alp Sardağ, Ferit Erin and M. Derya Arıkkan

The Bulgarian Team The Bulgarian team is led by Dr. Petya Emilova Pavlova from the Department of Optoelectronics and Laser Technics at the Technical University of Sofia, Plovdiv branch. The Bulgarian team has three subteams:

- **Vision and image processing:** Ivan Kalvachev, Iglika Kostova, and Georgi Raykov.
- **Locomotion:** Assoc. Prof. Andon Topalov, Jordan Tombakov and Nikola Shakev.
- **Behaviors:** Assoc. Prof. Andon Topalov, Nikola Shakev and Ivan Kalvachev.

3 The Architecture

The main purpose of our team was to build a research platform, which allows robust and efficient carriage of quadruped robots playing football. A modular architecture has been adopted and implemented. The components of the architecture are described briefly below.

3.1 Vision Module

We have implemented camera calibration for changing lighting conditions. For color classification, Multi-Layer Perceptrons (MLP) are used. There are 3 input units, (Y, U and V values of pixels) and 11 output units, representing color classes. Training sets are prepared using a special program. MLP has been trained with over 150000-size data set generated by labeling various pixels in the images taken by the robot. The MLP classification works with less than 6% error rate.

The regions are found with an iterative algorithm, in two passes. First, regions are found by considering groups of pixels of the same color. In the second pass, regions with the same color but different region numbers are merged. The algorithm also calculates areas, bounding boxes, centroids and the confidences of regions. These features are used in object recognition.

For object recognition, objects are searched in the swarm of regions. For each possible object, regions with appropriate color are investigated beginning from the largest and identified.

We have developed two different algorithms for approximating the ball distance. The first model uses the k-means method The second method uses regression trees for calculating the ball distances. The developed codes are also used for calculating beacon and goal distances. Under current field conditions the robot can recognize the ball, the goals and the beacons with considerably good accuracy.

3.2 Localization Module

The localization module of Cerberus team uses a global grid based algorithm (9 × 14 grids). The algorithm optionally uses odometry. The steps are described below:

Initialization (optional): Since our algorithm is global, it does not require a priori knowledge about the initial location of the robot. But if this information is available, it makes use of it to converge faster.

- **Calculation of fuzzy weights:** The vision module analyzes each screenshot, and reports the objects which are seen, together with their relative distance and heading to the robot. Localization module uses only the beacons to localize the robot. For each seen beacon, a new fuzzy weight for each grid is calculated using the fuzzy membership function in Figure 1. In the figure, d is the distance of the beacon to the robot sent by the vision module, and x, and y are the parameters to handle.
- **Grid weight update:** A window based approach is used for updating the weights of each grid. The history of each grid is hold, and used for weight calculation in this method. The most recently calculated n weights are hold in the window of each grid. Each window has a weight indirectly proportional with the age of the information in the window. When the new weight is calculated, it is combined with the contents of the windows by a weighted summation, and this newly calculated weight is placed in the last window as the most recent weight. In case the robot is explicitly moved to another location by a human being, the windows are cleared.
- **Processing of new visual data:** Whenever new visual data comes from the Vision module go to step 2. If more then one beacon is seen in the same screenshot, for each beacon, go to step 2.

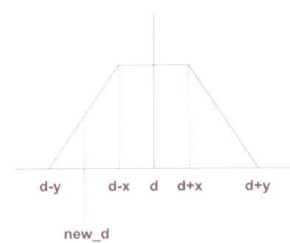

Fig. 1. Fuzzy membership function for visual data

3.3 Locomotion Module

Several walking and kicking styles were developed:

- **Walking styles:**A trot based walking style was developed in which the center of gravity of the robot was pushed a bit forward by using straight hind legs and L-shaped forelegs. We increased the stability by using positive shoulder angles in the forelegs and hence performed a straight stable walk. We created 3 walk styles according to their speeds. A stable turning gait was also developed.

Kicking styles: We tried to work on a single kick by using only one fore leg for the kick while maintaining stability by adjusting the center of gravity by the position of the other three legs. We generated a head kick that can jump to ground, pull the ball near to the head and kick the ball with head. This move had the most power and straightness in all other kick types.

3.4 Planner and Behavior Module

The behavior module currently consists of several basic behaviors that can be switched by the planner module depending on the type of the player in order to achieve more complex behaviors and different team strategies during the game. We designed two types of players and an auxiliary agent:

- **Goalie:** This player, depends mainly on localization to maintain its position relative to the goal. It has a simple FSM at present. It only searches ball with head scan and when found, it checks the distance to the ball to determine if it is smaller than a threshold value. If so, it does a blocking movement.

Fig. 2. FSM of Forward Player

Forward: An ideal forward player should always approach to the ball in a trajectory movement aligning with the opponent goal. To determine the low level behaviors necessary for such an attacker we are using a neurofuzzy inference system trained using reinforcement learning with inputs such as distance and angle to the ball and to the opponent goal. The FSM of our forward player is given in Figure 2.

4 Acknowledgements

Our work is supported by Boğaziçi University Foundation and Boğaziçi University Research Fund project 01A101.