RoboDragons 2008 Team Description

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Abstract. After the two years of joint project (2004, 2005) with CM-Dragons, RoboDragons, being stimulated by CMDragons, developed some unique techniques that make the RoboDragons system be flexible and robust. This paper gives a brief overview of the RoboDragons system and its unique techniques. These include camera layout system, high precision ball extraction and positioning of the robots in the cooperative play based on the dominant region method.

1 Introduction

RoboDragons 2008 builds on the RoboDragons 2007 system and the continuing research. Each RoboDragons robot consists of four omni-directional wheels, a dribbling device, two kicking devices (for chip kick and straight kick) and computer boards for controlling the robot. Five robots make our team, and they are controlled by a host computer beside the field. Over-field cameras capture the field images and send them to the host computer.

In the RoboDragons system, we have the following four distinctive techniques.

- Camera layout system: For any given number of cameras, this system calculates the best layout under the condition that it minimizes the occlusion probability of the ball by robot. While we assumed that the probability distribution of robots on the field was uniform last year, we give much real distribution which is computed from the logs of the past RoboCup SSL competitions this year.
- Procedure to extract a partially occluded ball in high precision: It employs the statistical features of the pixels area of the color marker and its neighborhoods[4], i.e. the higher order local autocorrelations (HLAC) features and the support vector machines (SVM) are combined to realize an extraction method which is robust to the change of the occluded direction and the change of the lights.
- Cooperative skill among 3 robots: We named this skill 1-2-3 shoot[1], which performs a series of passes and then a goal shoot. To put each robot into its appropriate position is imperative to achieve such a cooperation in success. The Dominant Region method [2] is available for evaluating the position of each robot in the 1-2-3 shoot.

In this paper, we give a brief overview of the RoboDragons system and then three distinctive techniques.

2 Overview of the RoboDragons system

In this section, we describe the overview of our robots and software system.

2.1 Robots

Figure 1 shows a configuration of the RoboDragons 2008 robot platform. The features of the robots are shown below.

- Each robot has four omni-wheels that allow it to move in any direction.
- Each robot has a main kick device and a chip kick device, and a dribble device. The main kick device is driven by a solenoid and the chip kick device is driven by two solenoids.
- For each robot, one Hitachi SH2 processor is employed as a control processor which runs at 24MHz.
- Lithium-Polymer batteries are used.
- The number of small tires of the Omni wheel is 15, while it was 12 for our old robot. It makes the movement of the robot smooth.

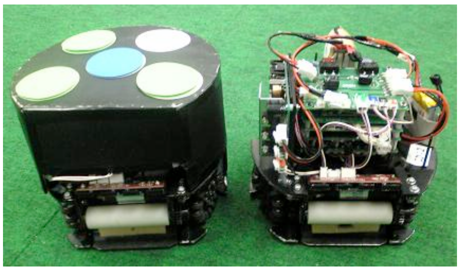


Fig. 1. RoboDragons 2008 robots; with external cover and with internal structure exposed

2.2 Software system

Figure 2 shows the overview of the RoboDragons software system. The features of the system are as follows:

1. Host computer is Athlon64 X2 4200+ with 512MB memory and Debian GNU/Linux OS.
2. Two or more Panasonic DVR-D310 cameras with RAYNOX HD-5050PRO lens and capture cards with Philips SAA7133 are used. Each camera grabs an image of size 640 $\times$ 240 pixels in every 1 / 60 seconds.

3. Each module(shown in box) in Fig. 2 is implemented as a thread.
4. Two or more image processing modules process the grabbed images from multiple cameras to produce the positions of the robots and a ball. They are integrated by the *coords integrator* module.
5. The soccer module consists of strategies, tactics and path generation sub-modules, and it produces an action command for each robot.
6. Finally, radio module sends the command to each robot through the radio system.

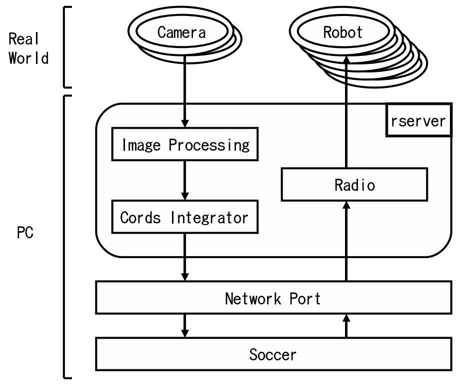


Fig. 2. RoboDragons system: overview

3 Camera layout system

In this section, we explain the camera layout system. Using this system, even if the size of the field is changed, we can decide the low-risk camera layout, at once.

The camera layout system uses the risk criterion. Here, the risk means how high the ball is occluded by the robot[3] .

Last year, we assumed that the probability distribution of robots on the field was uniform distribution. This year, we newly computed it from the logs of the past RoboCup SSL competitions(Fig. 3). Figure 4 and 5 show new results of 2 to 4 cameras layout based on this distribution.

4 High precision ball extraction

Our vision system has a high precision method which extracts partially occluded ball base on the statistical features of the pixels area of the color marker and its neighborhoods[4].

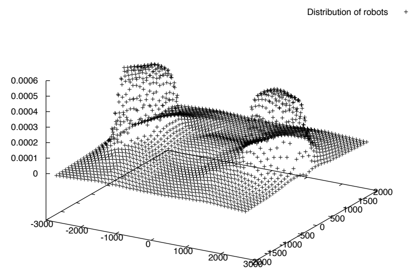
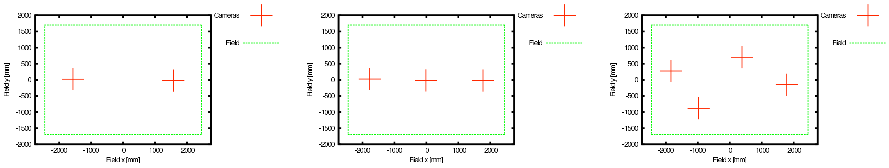
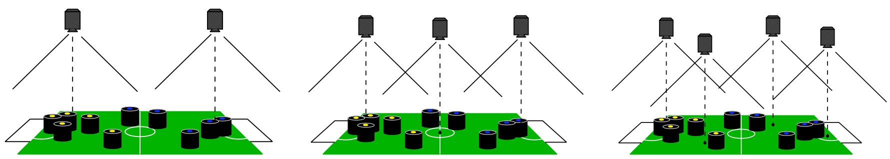


Fig. 3. the probability distribution of our robots.



(a) 2 cameras (b) 3 cameras (c) 4 cameras

Fig. 4. multi-cameras layout (location)



(a) 2 cameras (b) 3 cameras (c) 4 cameras

Fig. 5. multi-cameras layout (over view)

This method specifically uses higher order local autocorrelations (HLAC) features and support vector machines (SVM). Figure 6 shows the flow of the high precision ball extraction. First, the system calculates HLAC features by using 35 operators for each pixel which belong to class 1 (i.e. ball) and class 2 (i.e. noise), respectively. The number of dimension of HLAC features is 35 x 3 = 105 because each pixel's value is composed of Y, U and V values. Next, HLAC features are classified to class 1 and class 2 by SVM. The combination of HLAC and SVM realizes a robust extraction to the changes of direction (occlusion occurs in any directions) and also to the changes of lighting.

By this method, Our vision system can extract a partially occluded ball, 94.23% for 5 to 8 pixels area and 80.06% for 3 to 4 pixels area, and worked more than 60fps.

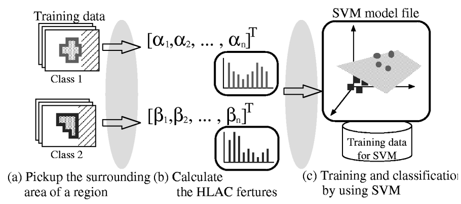


Fig. 6. The flow of the proposed method.

5 Cooperative play

5.1 Cooperation by 3 robots

Dominant region method

The dominant region method is a kind of Voronoi diagram. It is calculated with respect to two agents, one of which is a teammate and the other is an opponent. The diagram divides the area of the soccer field into two regions, where one region is the one that the teammate can get to faster than the opponent, while the other is the one that the opponent can get to faster.

Calculation of the dominant region

Figure 7 shows an example of the dominant region. The shaded area is a dominant region for the teammate robot and the other is for the opponent. In the following, we show how to compute the dominant region.

Let v_1 and a_1 be an initial velocity and an acceleration of the teammate robot, and v_2 and a_2 be those of the opponent. Let (x_1, y_1) and (x_2, y_2) be the current positions of the teammate and opponent robot, respectively. Then, for given position (x, y), the distance between each robot and the position is computed by the following equation.

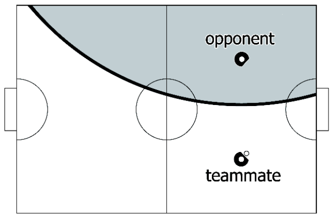


Fig. 7. An example dominant region

$$L_i = v_i t_i + \frac{1}{2} a_i t_i^2 = \sqrt{(x - x_i)^2 + (y - y_i)^2}, \qquad (1)$$
$$i = 1(teammate), \quad i = 2(opponent)$$

Solving Eqs (1) with respect to t_1 and t_2, respectively, we obtain an arrival time,

$$t_i = \frac{-v_i + \sqrt{v_i^2 + 2a_i \sqrt{(x - x_i)^2 + (y - y_i)^2}}}{a_i}, \qquad i = 1, 2 \qquad (2)$$

The dominant region can be generalized to multiple teammates and opponents. It is calculated by considering all pairs of teammates and opponents, and for each point on the field the robot with minimal arrival time gains the point as its dominant region.

Pass play and dominant region

First, we discuss a direct play based on the dominant region method. The direct play is the cooperation between two robots. See [1] for detail. Figure 8 is a typical case of such a situation. Robot A passes the ball toward robot B, and robot B kicks the ball toward the goal immediately after catching the ball.

Robot B has an open line from robot A, as well as an open line to the goal. Robot A can thus pass the ball to robot B. The dominant region of the figure 8 is given by the figure 9. In the figure, each solid curve shows a dominant boundary between one of the teammate robots and one of the opponent robots. Shaded area is the dominant region for the teammate robots. It is clear from the figure 9 that the opponent can easily intercept the ball if robot A kicks the ball to the robot B.

On the other hand, as shown in figure 10, three teammate robots make a dominant region which can pass around in the teammate's dominant region.

The dominant region method is useful as a criterion for whether a pass should be done or not. In a real game, we might weaken this criterion slightly. However,

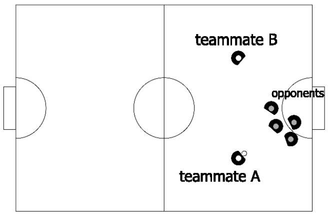


Fig. 8. Typical attack positioning

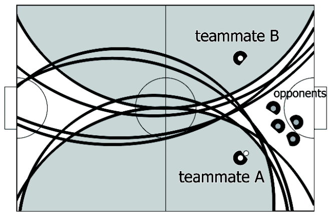


Fig. 9. Dominant region of figure 8

we think it is still a good criterion for judging whether a direct play should be done or not.

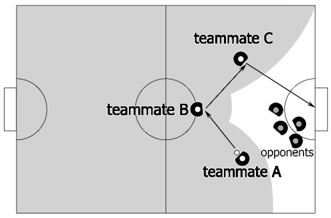


Fig. 10. Example of cooperation among 3 robots

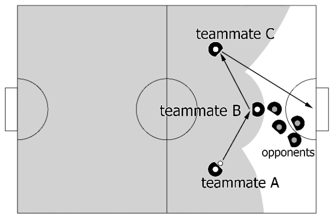


Fig. 11. 1-2-3 shoot position

Algorithm for the 1-2-3 shoot

When should we play a 1-2-3 shoot? The following is a basic procedure to select the 1-2-3 shoot play.

[Selection procedure of action]

Let A be a robot holding ball, and let B and C be the cooperating robots.

```
if (Robot A have a shoot line)
 { Robot A shoots.} else {
  Search open space which is able to make a shooting line.
  Robot C moves to the open space.
  Calculate a dominant region.
  if (Pass line is in the dominant region of the teammate)
    {Direct play between robots A and C.} else {
      Robot B moves to the appropriate position.
      1-2-3 shoot play among robots A, B and C.
    }
  }
```

When the 1-2-3 shoot play is selected, the following algorithm is executed.

[1-2-3 Shoot algorithm]
Let A be a robot holding the ball, and B and C be the cooperating robots. Assume that the initial positions of the robots are as shown in figure 10.

Step 1 The robot C moves to the open space that has a shooting line to the goal.

Step 2 If the pass line crosses the opponent dominant region, the robot B moves to the vertex of the near equilateral triangle as shown in figure 11. As a result, a pass line is made in the teammate dominant region. (If this is not the case, a re-schedule should be done.) The robot B turns to the robot C.

Step 3 The robot A kicks the ball to the robot B, then the robot B kicks it to the robot C according to the direct play algorithm.

Step 4 The robot C kicks the ball toward the goal mouth.

6 Conclusion

This paper gave a brief overview of both robot hardware and software on the host computer of the RoboDragons 2008 system and then gave the distinctive techniques that we have developed. Continuing improvement of the software modules makes the RoboDragons system be flexible and robust.

By the enlargement of the field size this year, it will become harder to recognize the ball in the field since the camera should cover the larger area of the field when we use the same number of cameras as the last year. Our vision system employing techniques of the camera layout and the occlusion extraction will take an important role in the competition.

We realized the 1-2-3 shoot. It enables to make a goal even if the goal area is defended by multiple opponent robots.

References

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