Ball-Receiving Skill Dependent on Centering in Soccer Simulation Games

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Abstract. This paper describes an effective ball-receiving skill. When soccer games are played in real life, players generally must make consecutive actions in one play, for example, running, receiving, and shooting a ball. We believe that the same is true in the case of simulation soccer games. Therefore, we designed an experiment to check how changing ball-receiving methods which is dependent on the centering patterns influence scoring goals. The experiment shows that one ball-receiving method is more effective than the others. The result is embedded into our soccer team, Kasugai-bito II, and the effectiveness is discussed in games.

1 Introduction

In the last few years, many researchers have devoted their efforts toward RoboCup (The World Cup Robot Soccer)[2, 3, 4]. In RoboCup, robots or agents play a soccer game under given constraints. RoboCup was proposed as a standard problem to promote AI and intelligent robotics research. It consists of three competition tracks: Simulator League, Real Robot Small Size League, and Real Robot Middle Size Leage[1]. We have investigated only Simulator League.

RoboCup has features different from typical traditional AI problems such as computer chess. Features of computer chess are static and non-real-time. A computer with powerful and large parallel processors, enormous knowledge, and sophisticated software, can find the most effective move in a few minutes, and it defeated the world chess champion [6].

For RoboCup, however, situations change dynamically and in real-time. Therefore, we cannot apply the traditional techniques to RoboCup. To develop a high level robot soccer game, we must investigate intelligence (e.g. learning) for individual agents and teams.

The purpose of this paper is to confirm the effectiveness in changing the soccer agents' action dependent on situations. At this time, much of the work about intelligent agents is in the planning phase. However, it is important to confirm the effectiveness before we implement our intelligent agents. Our current soccer agents, Kasuga-bito II, do not have intelligent ability, but are hand-coded to change ball-receiving methods which are dependent on centering. After this confirmation of effectiveness, we will implement the new intelligent agents. If

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new intelligent agents are the same level as our hand-coded agents, they will be regarded as having good skill.

In section 2, we define centering patterns and ball-receiving methods. In section 3, we explain the outline of our experiment and evaluate the effectiveness for the changing of receiving methods. In section 4, we describe the results of the match games where we applied our skill. Finally, we summarize the paper.

2 Centering Patterns and Receiving Methods

2.1 Real Soccer Games

From the experience of playing soccer games in real life, players generally must make consecutive actions in one play, for example, running, receiving, and shooting a ball. In the consecutive actions, they must receive the ball by the most effective methods. That is, we should select one method to receive the ball. For example, when the centering ball moves toward the goal, we usually turn toward the goal and receive the ball, then shoot it. Another example is when the centering ball lands outside the goal. In this case, we usually turn back against the goal and receive the ball, then shoot it. Generally speaking, we decide the next action by considering current situations.

When human players shoot the ball toward the goal, it is said that as the number of times the ball is touched increases, the shooting success rate decreases[5]. Moreover, it is said that direct or one-trapping shots occupy 70–80% of the successful shoots. This points out the need for real-time processing for the soccer agents. To satisfy this need, the agents should shoot the ball toward the goal as soon as they receive it in the penalty area.

2.2 Classification of Centering Patterns

We can classify centering as the point of relationship between the player and the ball. We call this the centering patterns.

We introduce 4 centering patterns such as depicted in Figure 1. The patterns have different features relative to the position of the player (the "shooter") and the direction of the ball.

Our classification is as follows:

1. When the X-position of the ball is the same as the X-position of the shooter, the Y-position of the ball is
   - positive to the Y-position of the shooter (1 and 3 in Figure 1), or
   - negative to the Y-position of the shooter (2 and 4 in Figure 1).
2. The gradient of the ball-trajectory is
   - positive (3 and 4 in Figure 1), or
   - negative (1 and 2 in Figure 1).

These combinations make 4 centering patterns. To simplify our discussion, we will call the patterns Centering-1, Centering-2, Centering-3, and Centering-4.

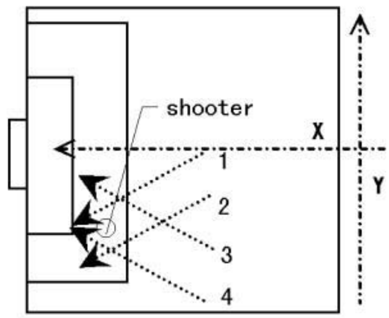

Fig. 1. Centering Patterns

2.3 Prediction and Receiving Methods

Prediction of the Ball Position: For receiving the ball, we need to design a prediction of ball movement by using see-information from the soccer server. We will describe our prediction in this section.

When we know the current ball position $\mathbf{B}(t)$ at time t, we can calculate the predicted ball position $\mathbf{B}(t + 100ms)$ at $100ms$ later below:

1. Calculate the distance, $\Delta(t)$, of the ball movement by using changes of relative distance and angle between the ball and the player.

$$\Delta(t) = \mathbf{B}(t) - \mathbf{B}(t - 100ms)$$

2. Multiply $\Delta(t)$ by the default Ball-Decay 0.96 and add the current position $\mathbf{B}(t)$ to it.

$$\mathbf{B}(t + 100ms) = \mathbf{B}(t) + 0.96\ \Delta(t)$$

When we predict the ball position at more than $100ms$ later, we can obtain it by repeating the above calculation.

Receiving Methods: From the experience of soccer games in real life, we have found some receiving methods from the point of relationship between the player and the ball. This naturally led us to introduce 3 methods for receiving the ball. The methods are different based on the relative position between the shooter and the ball such as depicted in Figure 2.

At the time t, we describe the shooter position as $\mathbf{S}(t)$ and the ball position as $\mathbf{B}(t)$. Moreover, we describe $t1$ as the moment when the shooter reaches on the ball-trajectory (maybe the predicted ball-trajectory), and $t2$ as the moment when the shooter receives the ball. This implies $\mathbf{S}(t2) = \mathbf{B}(t2)$. To simplify our discussion, we give the name to each method below:

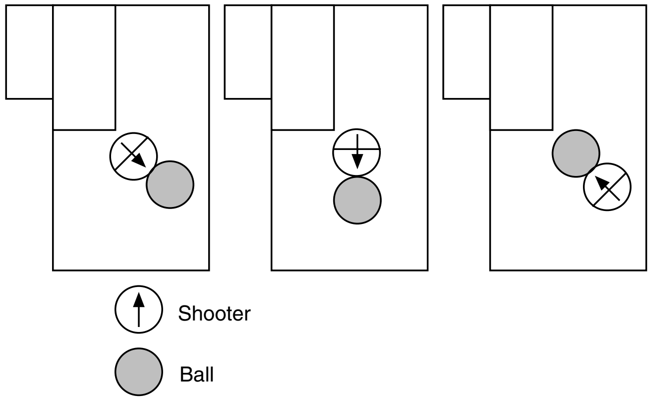

Fig. 2. Backward-Receiving, Simultaneous-Receiving, and Forward-Receiving

Backward-Receiving This method is used when the shooter reaches the predicted ball position in advance of the ball. The feature is

$$\begin{aligned} \mathbf{S}(t1) &= \mathbf{B}(t2) \\ t2 &= t1 + 300ms \end{aligned}$$

That is, the shooter waits for the ball before receiving it. Therefore, he can modify his position for the unpredictable ball movement. This method, however, has a drawback in that there is a delay in waiting for the ball.

Simultaneous-Receiving This method is used when the shooter receives the ball as soon as he reaches the predicted ball position. The feature is

$$t2 = t1$$

This method is the fastest among three methods. However, the shooter usually turns his back against the goal to receive the ball. Therefore, this method has a drawback in that he cannot see the situation around the goal.

Forward-Receiving This method is used when the shooter runs after the ball and receives it. The feature is

$$\mathbf{S}(t1) = \mathbf{B}(t1 - 100ms)$$

The shooter can easily see the situation around the goal (especially the goalkeeper). He utilizes his see-information around the goal and can shoot the ball effectively. This method, however, has a drawback of sometimes having to wait before receiving the ball.

These receiving methods make one action in consecutive actions to score. The next action is to shoot the ball. From the experience of soccer games in real life, our agents shoot the ball toward the goal as soon as they receive it[5].

3 An Experiment on Receiving and Shooting

We believe that soccer agent's skill of their shooting is related to their scoring ability. Therefore, we designed a skill experiment and examined the scores to evaluate our agents. If our well-designed agents improve their ability to score, we can conclude that the skill of our agents has improved.

We made an experiment to try 3 receiving methods from 4 centering patterns respectively. Figure 3 depicts an overview of the experiment. We describe here the experiment and the result.

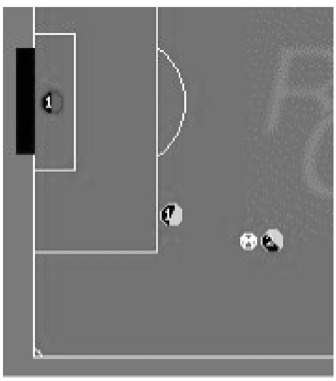

Fig. 3. An Overview of the Experiment

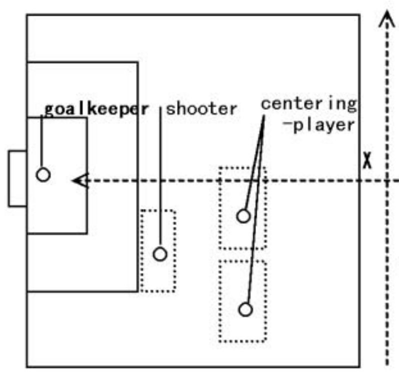

Fig. 4. Positions of the Players

3.1 The Condition of the Experiment

We designed the experiment with the following conditions:

- We prepared two players for offense. One kicked a ball according to a centering pattern. We called him the centering-player. The other was the shooter. We also prepared one goalkeeper for defense.
- We made the experiment in the coaching mode on the soccer server (version 3.17) to position the players and the ball.
- The shooter was positioned at random within a range of
  X-position: $33 \sim 37$ and
  Y-position: $-20 \sim -10$.
  The centering-player was positioned at the place where the direction from the shooter was
  150 degrees for Centering-1 and Centering-2, and
  -150 degrees for Centering-3 and Centering-4.
  Moreover, the distance between the centering-player and the shooter had a range of ± 3 around 17.5. The goalkeeper was positioned at 2.5 away from the goal. Figure 4 depicts the positions of players.

- The beginning position of the ball was at the centering-player's feet.
- The centering-player kicked the ball to the shooter by kick-power 100 toward the relative direction of
  $5 \sim 20$ degrees for Centering-1 and Centering-3, and
  $-5 \sim -20$ degrees for Centering-2 and Centering-4.
- The shooter shot the ball as soon as he received it.
- If it took less than 6 seconds to score the goal after the centering-player kicked the ball, the trial was regarded as success. Otherwise, the trial was regarded as a failure.

The number of trials was as follows:

- The centering-player kicked the ball to the shooter 300 times for each centering pattern. There were 4 centering patterns. Therefore, he kicked the ball 1200 times.
- The shooter received the ball 100 times by using each method for each centering pattern.

We adopted the goalkeeper of AT-Humboldt team (Germany) which won the championship at the 1st RoboCup Worldcup Simulation League held on 1997.

3.2 Experiment Result

The results of the experiment are shown in Table 1. The table shows the success rates of shooting the ball to 4 centering patterns by 3 receiving methods. The underlined rates are the most effective receiving methods for each centering pattern. We consider here the result for each centering pattern.

Table 1. Success Rate of Each Receiving Method (%)

	1	2	3	4
Backward-Receiving	42	40	39	<u>62</u>
Simultaneous-Receiving	<u>63</u>	46	<u>66</u>	50
Forward-Receiving	33	<u>53</u>	48	28

First, the table shows that the Simultaneous-Receiving is the most effective method for Centering-1. By comparing this with soccer games in real life, it is easily understood.

Secondly, the table shows that Forward-Receiving is the most effective method for Centering-2. In a real soccer game, however, we may find that Backward-Receiving is the most effective method. This is mainly because the shooter, when Forward-Receiving, can see the situation around the goal.

Thirdly, the table shows that Simultaneous-Receiving is the most effective method for Centering-3. In a real soccer game, however, we may find that

Forward-Receiving is the most effective method. This is mainly because it is likely that the goalkeeper will catch the ball if the shooter uses Forward-Receiving.

Finally, the table shows that Backward-Receiving is the most effective method for Centering-4. In a real soccer game, however, we may find that Forward-Receiving is the most effective method. This reason is the same as one given for Centering-3.

3.3 Statistical Testing

To examine the experiment results statistically, we tried hypothesis-testing. At first, we set a hypothesis:

> The receiving methods are not dependent on the success rate to score the goal.

Next, we made a 2×3 contingency table, where $\{$ *shoot success, failure* $\} \times \{$ *Backward-Receiving, Simultaneous-Receiving, Forward-Receiving* $\}$. Then we tested it, where the significance level is 1% and the rejection region is more than 9.28. Table 2 shows that our hypothesis was rejected to Centering-1, Centering-3, and Centering-4. That is, the receiving methods are dependent on the centering patterns except in the case of Centering-2.

Table 2. Result of Statistical Testing

	1	2	3	4
testing	reject 19.08	accept 2.79	reject 23.89	reject 15.13

4 Application to a Soccer Game

As mentioned above, changing the receiving methods which is dependent on centering patterns is usually effective to score the goal. We will confirm here the effectiveness in a soccer simulation match game.

First, we prepared two teams for comparison:

Rand All players select one of three receiving methods at random.
Advc All players select the most effective method dependent on the centering patterns.

For both teams, the receiving methods are only used for the players which are positioned within 30 meters from the center of the goal (52.5, 0) such as depicted in Figure 5.

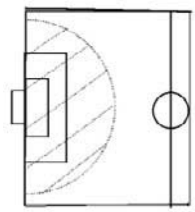

Fig. 5. Region to Change the Receiving Methods

We selected two opposing teams. One was AT-Humboldt team. The other was Andhill team (Tokyo Institute of Technology, Japan). Andhill won the second prize in the 1st RoboCup Worldcup Simulation League. The combinations were 4 match games. We tried each match game for 100 minutes[1].

The differences in the scores are presented in Table 3. When we changed teams from Rand to Advc, the difference in the scores was changed for both AT-Humboldt and Andhill. These results show the effectiveness of our changing methods in a soccer simulation match game.

Table 3. The Differences in the Scores

	Kasuga-bito II	AT-Humboldt	Difference	Kasuga-bito II	Andhill	Difference
Rand	31	33	-2	28	37	-9
Advc	36	31	+5	33	35	-2

5 Conclusion

The purpose of this paper was to examine the effectiveness of changing the ball-receiving methods in RoboCup simulation soccer game. For that purpose, we made an experiment to discover the most effective receiving methods which are dependent on the centering patterns. As a result, we found effective receiving methods except in the case of one centering pattern.

Acknowledgements

We wish to thank developers of AT-Humboldt and Andhill for freely distributing their soccer clients. We also thank the anonymous reviewers for some suggestions.

[1] We manipulated the length of games using the configuration file of soccer-server

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Appendix: Team Description

Our team, Kasugabito-II, was runner-up in the Japan Open 98 Simulation League. The most important feature of Kasugabito-II is, we mentioned it in this paper, changing ball-receiving methods which is dependent on the centering patterns. We describe other features here.

Formation and Roles

Kasugabito-II is composed of 3 Defenders (DFs), 5 Midfielders (MFs), 2 Forwards (FWs) and 1 Goalkeeper (GK) such as depicted in Fig.6.

DFs defend away a little bit from their goal to trap in off-side. MF*s in Fig.6 sometimes participate in an attack by dribbling. FWs stand nearby the penalty area and wait for centering from a MF.

In Kasugabito-II, each player has the same algorithm for predicting the ball position (see section 2.3). About the movement, however, each player's action is dependent on the position. For instance, a GK and DFs wait for the ball until the ball enters within a distance, and players move to receive it. This is because they should receive the ball safely by using more reliable prediction of the ball position. MFs and FWs move earlier toward the ball to rival opposite players to receive the ball.

Implementation

Kasugabito-II is written in C and it consists of about 3,000 lines. We are developing it on multiple SPARCstations which are running under Solaris 2.5.

We were using two workstations (SPARCstation 5/110, memory 64M bytes) in the early development. In the recent development, we are using five workstations;

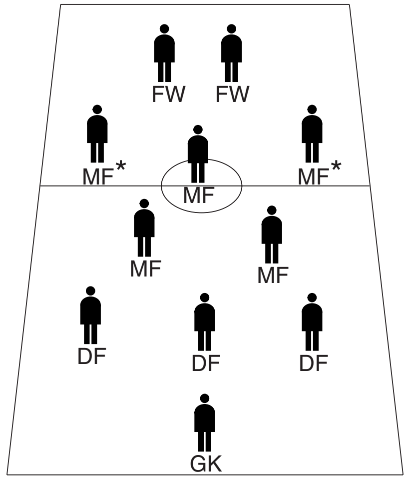

Fig. 6. Formation

- One Sun Ultra 1/140 (Memory 96M bytes)[2]
- Four Sun Ultra 1/170 (Memory 128M bytes)[3]

We would like to thank people for lending these workstations to us.

[2] This machine is supported by Nippon Steel, Inc. and Nissho Electronics, Inc.
[3] These machines are supported by Nihon Sun Microsystems, Inc.