Sony Four Legged Robot League at RoboCup 2002

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Abstract. We report research activities in the Sony Four Legged Robot League at RoboCup 2002. 19 teams including 3 new teams participated in the league. We revised some rules and setup specifications such as a larger field and 4 robots for each team. In addition wireless LAN system were employed for inter-robot communication. These revisions encouraged the participants to develop team play behaviors.

1 Introduction

We started the Sony Four Legged Robot League at RoboCup-98 in Paris [Fujita00] as an exhibition match with three teams, which were from Carnegie Mellon University (USA), Laboratory of Robotics of Paris (France), and Osaka University (Japan). Since then, we have been increasing the number of teams, and in 2002 we have the Four Legged Robot league by 19 teams from 18 countries.

The significant features of this league are:

- All teams must use the same robot platform (Figure 1) without any modification. This means that it is a software competition but participants have to use physical robots, unlike Simulation League.
- The robot platform is a legged robot, which needs to walk. The robot sometimes falls down accidentally, and need to recover. This feature is unique to the Four Legged Robot League expect for the Humanoid League, which started at RoboCup-02 as an exhibition match.
- There is no global vision sensor. This is the same situation as in the Middle Size Robot League.

Especially, the same robot platform allows to reuse software among participants. Therefore, accumulation of technologies has been done in this league, and the technology level has become rapidly very high In this article, we focus on the description of research activities in the Four Legged Robot League at RoboCup-02.

2 Revised Rule and Field

From 1998 to 2001, the field size was about 2 by 3 meters and the number of players of each team was 3 including a goalie. This size and the number of players

G.A. Kaminka, P.U. Lima, and R. Rojas (Eds.): RoboCup 2002, LNAI 2752, pp. 469–476, 2003.

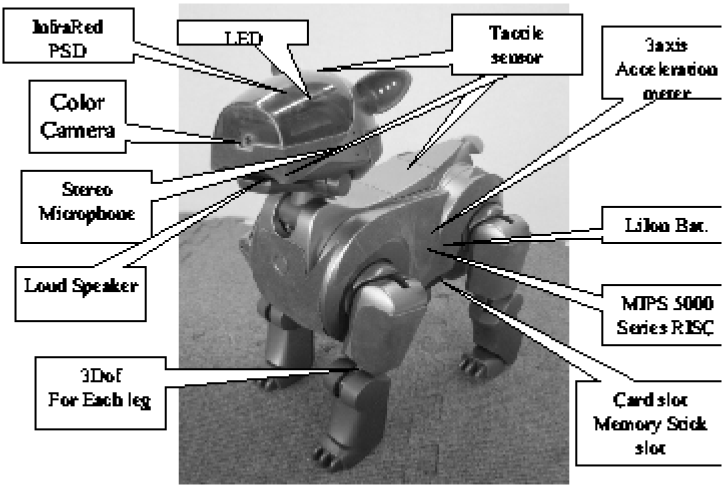

Fig. 1. The robot platform used in RoboCup-02 (ERS-210)

were a good balance for the robot platform and the average level of technologies of the participants. However, we felt, the field was so small that many robots gathered around the ball, which caused a game to become stack quite often. In addition, we felt that the number of players, 3, was also so small such that it is difficult to develop team play with two robots excluding the goalie. Therefore, we decided to enlarge the size of the field and the number of robots for RoboCup-02. The size of the field is now about 3 by 4 meters, and the number of robots is 4 for each team including the goalie. The color specification of the field is the same as before. Figure2 shows the field used in RoboCup-02.

In order to encourage teams to develop team play, we introduced a wireless LAN system (IEEE 812.11b), which allows robots to communicate between each other. The robot can send its position and its perception results such as a position of the ball and goals. This cooperative perception capability is very important because the resolution of the on-board vision system of robot does not allow to recognize the ball from a far distance. In addition, in order to pass the ball to other robots, the position information of the players are crucial. Color stickers are attached to the body of the robots, which allow to estimate the position of an other robot, however, it is difficult to detect the team and opponent team robots by the color detector. Furthermore, it is difficult to estimate the position of the other robots. Thus, the wireless LAN system helps sharing the self localization results among the team robots.

Communication is achieved through a host PC. Namely we assign an IP address to each robot, and each robot send the information to the host PC, which then forward the information to the other robots. We decided that the PC should not be used for remote computation but only for the purpose of communication.

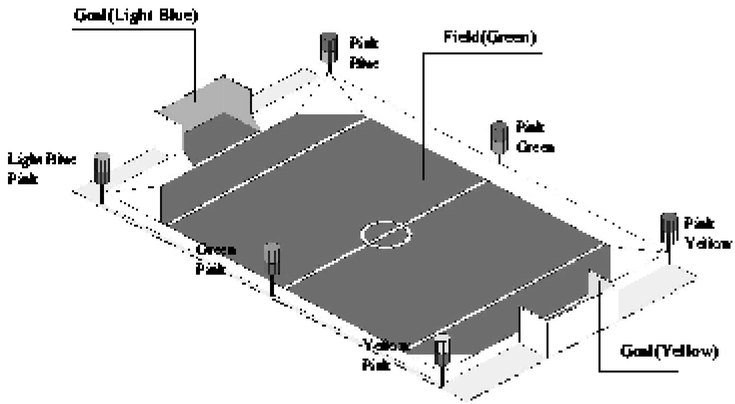

Fig. 2. The field used in RoboCup-02

In addition to the communication purpose among the robots, the wireless LAN system is used to control the game by the referee. A game controller software running on the host PC sends some pre-defined commands at proper timings by the referee. For example, a game start signal is sent to all robots such that the robots can start the game without human intereference. When a goal is scored, a message can be sent to all robots such that the scoring team can display some happy behaviors.

Regarding the details of the rule and the setup, please refer to [Rules].

3 Result of Championship Tournament

We divided the all teams into 4 groups (A,B,C,D group), each of which is formed by 5 teams except for the D group. The semifinalists of RoboCup-01 are allocated in different groups, and new participants, which were Georgia Institute of Technology (USA), University of Newcastle (Australia), and Tecnologico de Monterrey (Mexico), were allocated in different groups. The result of the round robin is shown in Figure 3.

The top two teams from each group can participate in a championship tournament. The result of the tournament is shown in Figure 4. The champion of RoboCup-02 is Carnegie Mellon University (CMU, USA), the second place is University of New South Wales (UNSW, Australia), and the third place is University of Newcastle (UNC, Australia). The final game was a very exciting one. First, CMU scored 2 goals, and then UNSW made 2 goals to be the even score. Then, UNSW made a goal to lead 3 by 2, but CMU finally made a goal to be even. Finally, a penalty kick (PK) match was carried out, and CMU won and became the champion. The semifinal also ended in a draw and a PK was carried out, which UNC won for recording the third prize. It should be noted here that 3

LRV		0 - 0	0 - 1	1 - 1	0 - 5	2	1	7	3
OSAKA	0 - 0		0 - 2	1 - 1	1 - 8	2	2	11	5
SWEDEN	1 - 0	2 - 0		3 - 0	0 - 3	9	6	3	2
McGill	1 - 1	1 - 1	0 - 3		0 - 4	2	2	9	4
Newcastle	5 - 0	8 - 1	3 - 0	4 - 0		12	20	1	1
C	UPENN	Melbourne	ESSEX	USTC	Monterrey	Point	Goal	Lost	Place
UPENN		0 - 1	5 - 0	1 - 3	8 - 0	6	14	4	3
Melbourne	1 - 0		6 - 0	4 - 1	11 - 1	12	22	2	1
ESSEX	0 - 5	0 - 6		1 - 2	1 - 0	3	2	13	4
USTC	3 - 1	1 - 4	2 - 1		4 - 0	9	10	6	2
Monterrey	0 - 8	1 - 11	0 - 1	0 - 4		0	1	24	5
D	UNSW	KYUSHU	Washington	BALKAN		Point	Goal	Lost	Place
UNSW		7 - 0	10 - 0	16 - 0		9	33	0	1
KYUSHU	0 - 7		2 - 0	5 - 0		6	7	7	2
Washington	0 - 10	0 - 2		1 - 0		3	1	12	3
BALKAN	0 - 16	0 - 5	0 - 1			0	0	22	4

Fig. 3. The result of the round robin

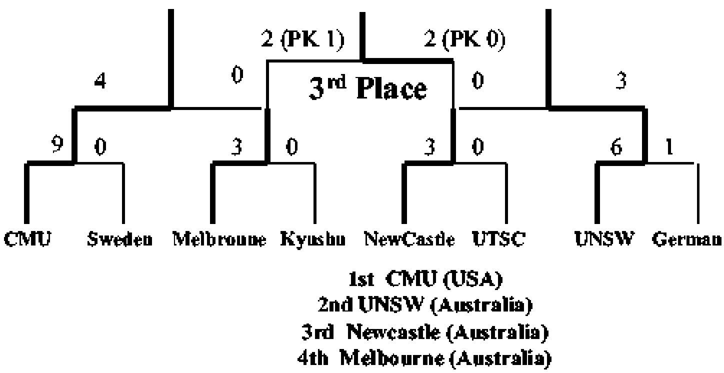

Fig. 4. The result of the championship tournament

of the top 4 teams are from Australia, including the new participant, University of Newcastle. The photos of a game in this league is shownin Figure 5.

4 Summary of Advanced Technologies

As we described in the previous section, some teams utilize a strategy of assigning robots to regional positions, such as a left winger, a right winger, a sweeper, and a goalie. Each robot computes its position by a localization algorithm employing for example a probabilistic approach (Monte-Carlo localization or Grid-based Markov localization), and tries to act in the pre-assigned area during a game. In addition, the robots share their position information using the wireless LAN system, and avoid the situation of no robot going to the ball. There are two ways for roll assignment, a static roll assignment and a dynamic roll assignment. CMU, the champion team of RoboCup-02, utilizes a dynamic roll assignment, by which efficient team formation is achieved depending on the current situations.

Fig. 5. Exciting Game in ihe Four Legged Robot League

Cooperative perception is achieved in the team formation strategy. Namely, the ball position and the robots' position are shared among the robots, therefore even if the ball is too far from some robots to perceive, if one robot perceives the ball position with its vision system, the position information is shared among all teammates.

In order to achieve a cooperative play as described above, many basic skills for each robot have to be implemented. Vision, walking, and ball manipulation system are examples. World modeling and behavior selection are also necessary. These basic skills have been developed in the Four Legged Robot League since 1998. The technology accumulation and sharing have been efficiently done in this league, such that many teams could benefit from the results of other teams in the previous years and performed very well at RoboCup-02.

5 RoboCup Challenges

The aim of RoboCup is not just to win a game. The scientific approaches are encouraged in order to develop an autonomous robot functioning in the realworld and in realtime. Therefore, we have been defining some technical routines, named RoboCup Challenges, every year. In RoboCup-02 we defined three RoboCup challenges, which were a Pattern Analysis Challenge, a Collaboration Challenge (version 2002), and a Ball Collection Challenge.

5.1 Pattern Analysis Challenge

One of the important challenges in RoboCup is not to use color information. Since 1998 we have been using color information to identify important items in the soccer domain such as the ball and the goals. However, we need to spend a lot of time to tune color parameters for the identification, and need to keep constant lighting conditions around field during the whole event as much as possible. An aim of the Pattern Analysis Challenge is to replace color painted items by black-and-white pattern items, so that we can carry out RoboCup in a more natural environment.

We selected 5 different shapes with black-and-white cross stripes. Two examples are shown in Figure 6. There are different sizes for each pattern. We selected 3 patterns among them and put them in random rotation at three positions; two corners of the field and the top of the goal. The participants had not known the selected patterns, the sizes, and the rotation angles before the challenge started. After submitting their programs with memory media (Memory Stick), we announced the selected patterns and the sizes and the rotation angles. Then, within 3 minutes, a robot had to visit the positions and generates sounds corresponding to the patterns.

Any teams could not identify all three patterns within 3 minutes at RoboCup 2002. However, three teams, CMU, UNSW, and University of Washington, could identify two of the three patterns.

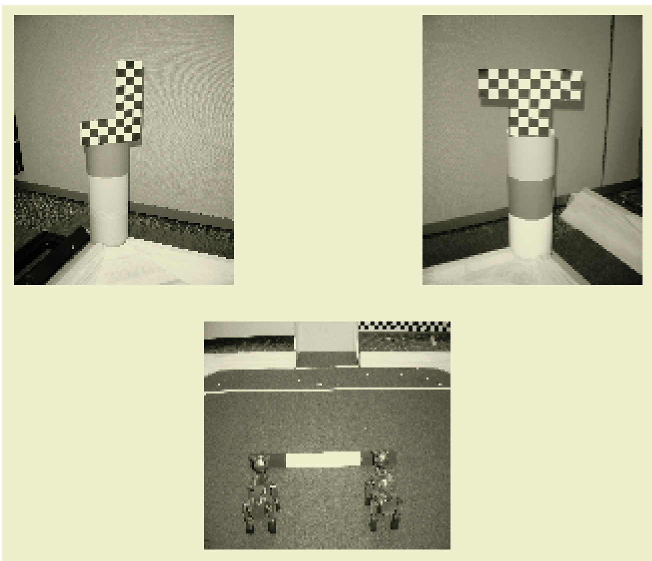

Fig. 6. Top two: Patterns used in Pattern Analysis Challenge. Bottom: Collaboration Challenge 2002

5.2 Collaboration Challenge 2002

The second challenge is to move a bar by two robots in a collaborative way. First, the two robots have to rotate the bar, and second, they have to push the bar in the same direction, for placing it into the penalty area. Thus, two robots have to share information about timing; when to rotate and when to push. Figure.6 shows the bar used in this challenge.

Three teams, UNSW, CMU, and UTSC, were able to complete the collaboration task within 3 minutes.

5.3 Ball Collection Challenge

The third challenge is to confirm basic skills, to search for a ball, to go close to it, and push it into one of the goals. However, in this challenge, 10 balls and two robots are in the field. Therefore, it is better to handle different balls by each robot. Only one team, UNSW, was able to score all 10 goals in this challenge. It should be noted here that the top 4 teams, UNSW, CMU, University of New castle, and University of Melbourne, are also the top 4 teams in this challenge.

6 Future of the Four Legged Robot League

There will be significant changes in the Four Legged Robot League in RoboCup-03. First, Sony released the OPEN-R SDK [OPEN-R SDK], by which any user can program the AIBO ERS-210(A). This means that in RoboCup-03, this league will become open entry league. Then, we hope that many new teams will join the league to accelerate the activity of the accumulation of technologies. Second, the Four Legged Robot League is going to be operated by selected committees from the universities. Until RoboCup-02, the operation was done by members of Sony Digital Creatures Laboratory, however, we have already selected technical committees and organizing committees, defining the rules and challenges for RoboCup-03 as of writing this article.

Technically, our targets is to remove well defined environment conditions, such as a uniform and consistent lighting conditions, and the existence of field walls surrounding the field. We define proper challenges so that we can perform feasibility studies to achieve our technical target. We hope that within 5 years, we will be able to enjoy watching RoboCup Four Legged Robot League in every country without any need of special setups.

7 Summary

In this article, we reported technical aspects of the RoboCup Four Legged Robot League in 2002. The wider field and the increase of the number of robots resulted in the development of team play behaviors. The wireless LAN system plays an important role to achieve good team behaviors. Now, the technology levels of the participants go up, and we can enjoy watching exciting soccer games. The next target is to have local competitions in the world, and to increase the sharing information in order to accumulate the developed technologies.

The following tables conveniently summarize the various teams and the outcome of the competition:

Table 1. Qualified Four-Legged Teams

rUNSWift	University of New South Wales	Australia
CM-Pack'02	Carnegie Mellon University	USA
UPennalizers	University of Pennsylvania	USA
Les 3 Mousquetaires	Laboratoire de Robotique de Versailles	France
Baby Tigers	Osaka University	Japan
SPQR	University of Rome	Italy
ASURA	Kyushu Institute of Technology, Fukuoka Institute of Technology	Japan
Wright Eagle 2002	University of Science and Technology of China	China
German Team	HU Berlin, University of Bremen, TU Darmstadt, University of Dortmund	Germany
ARAIBO	University of Tokyo	Japan
McGill Red Dogs	McGill University	Canada
Essex Rovers	University of Eseex	UK
UW Huskies	University of Washington	USA
Team Sweden	Orebro University	Sweden
Cerberus	Bogazici University, Technical University of Sofia	Bulgaria
RoboMutts++	University of Melbourne	Australia
NUBots	University of Newcastle	UK
Borregos Salvajes	TEC de Monterrey	Mexico
Yellow Jackets	Georgia Tech	USA

Table 2. Results: Four-Legged Robot League

1	CM Pack'02	Carnegie Mellon University	USA
2	rUNSWift	University of New South Wales	Australia
3	NUbot	The University of Newcastle	Australia

Acknowledgement

We thank all participants of the Four Legged Robot League in RoboCup-02. In addition, we also thank Sony ERC for their sponsoring our league, and members of Sony Digital Creatures Laboratory for their technical and operational support.

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