

Progress in RoboCup Soccer Research in 2000

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Abstract: In addition to researchers in AI and robotics, RoboCup attracts ordinary people, especially kids, high school and university students. Over 3000 people from 35 nations around the world have participated in RoboCup since the great success of the First Robot World Cup Soccer Games and Conferences, RoboCup-97 [1] held in conjunction with the Fifteenth International Joint Conference on Artificial Intelligence (IJCAI-97). Every year, the number of participating teams is increasing about 50%, that is, 35 teams in RoboCup-97, 64 teams in RoboCup-98 [2], and 90 teams in RoboCup-99 [3], and almost same number of teams in RoboCup-2000. Attendance in 2000 was impacted by the application of a new qualification process, difficulties for some of the European teams to travel to Australia, and by the addition of a European RoboCup competition, EURO-2000. This paper focuses on a discussion of the challenging research problems present in RoboCup and how they have been concretely addressed in RoboCup competitions in 2000.

1 Introduction

Robocup is a research challenge encourages investigation in the fields of robotics and artificial intelligence, with a particular focus on developing cooperation between autonomous agents in a dynamic multiagent environment [4]. By provid-

ing a well defined problem, RoboCup enables many research groups to cooperate and compete with each other over many years in the pursuit of a grand challenge.

RoboCup-2000 was held between August 27th and September 3rd, 2000, at the Melbourne Exhibition Center in Melbourne, Australia. 83 teams, including a total of about 500 people attended RoboCup-2000. In RoboCup-2000, much improvement in all completion leagues (F180, F2000, Legged, Simulation) were obtained, and new activities (RoboCup Jr. and RoboCup Rescue) were demonstrated with many attendants. In the RoboCup workshop, four papers were nominated for a Challenge Award; one was awarded the RoboCup Engineering Challenge Award, another the RoboCup Scientific Challenge Award.

In the remainder of this article, we summarize each league and their activities.

2 F180

In the F-180 league, 16 teams from nine different nations competed this year. The usage of on-board vision by three teams is among the most interesting achievements of this year. The ViperRoos from the University of Queensland, Australia, the CIIPS Glory team from the University of Western Australia, and the 4 Stooges from the University of Auckland, New Zealand managed to integrate an on-board camera and on-board vision into the severe size-limits of the F-180 league, namely maximum 18 cm diameter and maximum 180 cm² floor area for a robot. The ViperRoos even managed to win 2:0 against a team with global vision.

The Big Red team from Cornell University, USA, repeated their last year's success and won the tournament. Instead of well controlled power, which was their road to success last year, they focused on skillful play. On the hardware side, they came up with two mechanical novelties in the F-180 league: omnidirectional drive and a dribbling-device. Building an omni-directional drive within the size limitation of F-180 is challenging and Big Red seems to have come up with a novel mechanical solution to it. Especially the goalie could profit from this feature as it can defend the sidelines of the goal as well as the space ahead of the goal equally well. The second mechanical novelty from Big Red, the dribbling device, consists of a rotating bar in front of each robot. It imparts a backspin on the ball which therefore tends to "stick" to the robot. This device was impressively used by individual robots for dribbling as well as for team-behaviors by receiving passes. The second place team, FU Fighters from the Freie Universität Berlin, Germany, also were finalists in the previous year. They mainly impressed by a strong kicking mechanism which allows very fast shots towards the goal. The third place went to LuckStar II from Ngee Ann Polytechnic, Singapore.

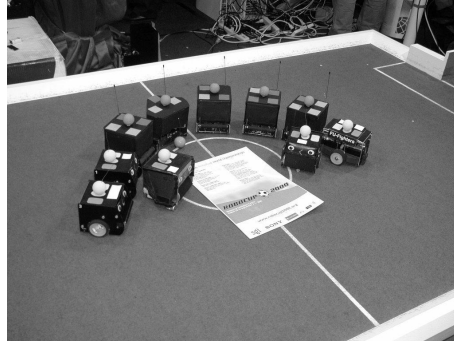


Figure 1: Players from Big Red and Fu-fighters after the final

3 F2000

F-2000 League Competition this year included 15 teams from eight different countries all around the world. The games showed a great improvement both in the technologies applied, and in the scientific achievements from all teams. The winner was CS Freiburg, from Germany, who earned an F-2000 First Place for the second time. The runner-up the Golem Team, a surprising new entry from a group of young students, supported by Elpro Innotek, an Italian small industrial automation company. The third place was obtained by Sharif CE, from Iran, the 1999 winner. Both the finals for the first place, and for the third place, ended with penalty kicks, since the difference in skill between the teams was quite small. This added great excitement to the games. Several other teams, in addition to the winners of the 3 cups, showed very good playing capabilities based on excellent research, like for example, among all, the Trackies (the fourth place), from Japan, that had a very flexible control capabilities of the ball without any kicking devices while top other three teams have them, and RMIT, from Australia, that were very fast and flexible in their motions.

The games affirmed the superiority of the planning system implemented by the University of Freiburg, that uses a positioning system based on laser range finders. They successfully demonstrated ball passing, opponents dribbling, etc., through a good estimation of the position and velocity of the other players. With the simple improvements given by introducing new motors, and adding a powerful kicker, CS Freiburg succeeded to overcome some mechanical limitations of the original commercial platforms used for their players. However, the most interesting players were the new mobile robot designed by the Golem Team. This omnidirectional platform proved to be extremely powerful. The 360 degree vision system complemented very well the mechanical design, allowing to exploit the maximum of flexibility during the play (see Figure 2(a)). Golem Team's planning system was mainly based on a reactive approach, since their robots do not localize globally, like CS Freiburg, but use only relative positioning with respect to the opponent goal, and rely on a set of very well designed basic

behaviors able to show emergent cooperative abilities.

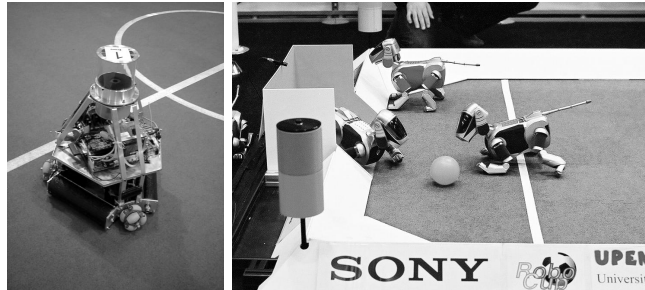


Figure 2: Distinguished Players from the F-2000 and Legged Leagues. Left: An F-2000 player of Golem Team, Italy. Right: Legged player of UNSW United approaches a goal.

4 Legged

The selected twelve teams came to Melbourne to participate in the Legged Robot League. In this league, all participants use the same robot platform, the Sony four legged robot. Therefore, this is a software competition in the real world. We had an elimination round with 4 groups (3 teams/group), the top two teams of each group went to the quarter finals. This year, UNSW United from University of New South Wales, Australia was the champion of the league. The second place was awarded to Les 3 Mousquesaires from Laboratoire de Robotique de Paris, France, and the 3rd place was CM-Pack00 from Carnegie Mellon University, USA.

In the Legged Robot League, we have an additional RoboCup Challenge competition. Three different technical challenges were devised: Challenge-1 (Striker Challenge), Challenge-2 (Collaboration Challenge), and Challenge-3 (Collision Avoidance Challenge). These are not game type competitions, but qualification of basic behaviors such as finding a ball and goal, self-localization, passing, detection of other robots and so on. The 1st place of these 3 challenges is UNSW United, the 2nd is Baby Tigers from Osaka University, Japan, and the 3rd is CM-Pack00.

One of the most significant progress in this year is UNSW's behavior of creeping flat on the ground by two front legs (See Figure 2(b)), which enabled more stable walking and much more accurate ball control such as passing or shooting. In addition, they invented fast self-localization and collision avoidance with the team mates by exchanging audio signals. Besides them, almost all teams implemented "heading" (kicking the ball with the head) so that ball passing can be a better strategy than ball dribbling by a single player.

5 Simulation

In the simulation league, 40 teams from 15 countries all around the world joined the competition. We can summarize this year's competition as the game of real team strategies. The final winner was FC Portugal, which was also the champion of Euro-2000 and a new comer of this year. The runner-up was Karlsruhe Brainstormers from Germany. The third place was ATT-CMUnited2000 from USA, whose previous program, CMUnited-99, was the champion of RoboCup-99 and finished at the fourth place in this year. Final games were very sophisticated and exciting. Most of teams in final tournaments have good tactics to handle the ball and strategies to pass the ball smoothly. Some of games needed extended time. Especially, a game of Magma Freiburg and Sharif Arvand ended up with draw and the winner was decided by a coin toss. These happened because most of teams has the similar level of basic skills.

Offensive teamwork was an important factor this year. Because goal blocking techniques of goalies have been improved very much, it becomes very difficult for a single attacker to dribble and get a goal against such a skillful goalie. As a result, dynamic combination plays in the offending situation is necessary to get goals. For example, FC Portugal is very good at side attack strategy; A side player carries the ball and kick to the goal area, and an attacker rushes into the goal area to shoot the ball. These strategies require methods to assign roles and to synchronize actions among multiple players. In order to realize these methods, FC Portugal used situation based strategic positioning and dynamic positioning and role exchange, which enables dynamic role assignment without communication in the offending situation. On the other hand, defensive strategies have not improved so much in this year. Some teams uses man-to-man marking in the defensive strategy, which was used the last year's champion team, CMUnited-99. Although this was effective in the last year, it can be broken by dynamic combination plays like the centering strategy of FC Portugal. To oppose such offense, defending strategies, especially expectation of opponents strategies will become an important factor in the next few years.

6 RoboCup Jr.

RoboCup Jr. is one of the activities putting much more emphasis on educational and entertainment aspects of RoboCup. Education researchers from the world's leading universities met at Robocup 2000 to discuss methods of using Robocup Junior as part of a school's curriculum. Robofesta 2001 (www.robofesta.com) to be held in 4 major cities in Japan, is using the Australian Robocup Jr as a pilot project for their competition. Plans are already afoot for each state in Australia to conduct eliminations, followed by an Australian Championship to find a representative for World Robocup in Seattle next year.

The soccer competition along with a Line Tracking-Sumo and a Parade/Dance competition attracted entries from interstate and overseas. With the number of entries over 40, it was one of the larger leagues of Robocup 2000.

Students from 55 visiting schools had a chance to perfect their skills in virtual robot soccer competitions, not only planned to be fun, but having educational elements integrated into them. Who would have thought that evolution could be taught with a robot soccer game. These simulations were presented by their designers who have travelled from U.S.A. and Europe, in the interest of promoting the concept that “education can be fun.”

7 RoboCup-Rescue

The RoboCup-Rescue Project was newly launched by the RoboCup Federation in 1999. Its objective is as follows.

1. Development and application of advanced technologies of intelligent robotics and artificial intelligence for emergency response and disaster mitigation for the safer social system.
2. New practical problems with social importance are introduced as a challenge of robotics and AI indicating a valuable direction of research.
3. Proposal of future infrastructural systems based on advanced robotics and AI.
4. Acceleration of rescue research and development by the RoboCup competition mechanism.

A simulation project is running at present, and a robotics and infrastructure project will soon start.

In Melbourne, a simulator prototype targeting earthquake disasters was open to the public to start international cooperative research. Distributed simulation technology combines the following heterogeneous systems to make a virtual disaster field.

1. Disaster Simulators:
Collapse of buildings, blockage of streets, fire spread, and traffic flow are simulated considering mutual effects.
2. Autonomous Agents:
Civilians, fire brigades, policemen, and rescue parties make autonomous action in the virtual disaster.
3. Simulation Kernel:
Manages state values and networking of/between the systems.
4. Geographical Information System:
Gives a spatial information to the whole system.
5. Simulation Viewers:
Show 2D/3D image of simulation results in real time as shown in Fig. 3.

RoboCup-Rescue competition will begin in 2001. Details are described in papers and a book [7, 8, 9, 10, 11, 14]. The simulator prototype can be downloaded from the links at <http://robomec.cs.kobe-u.ac.jp/robocup-rescue/>.

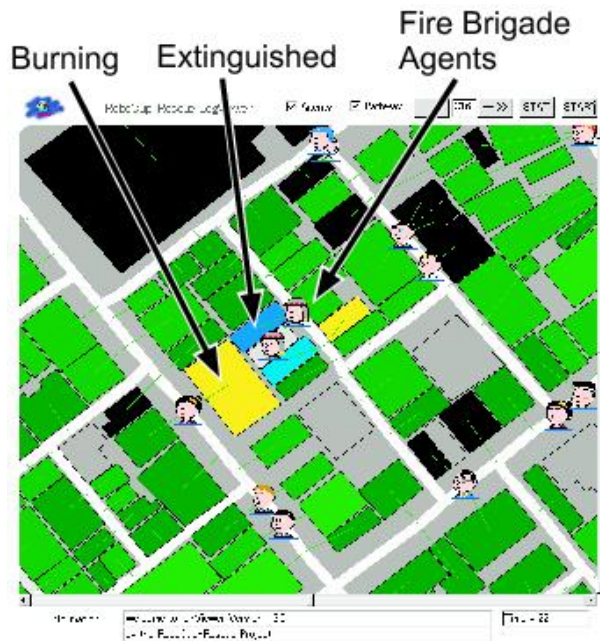


Figure 3: 2D viewer image of RoboCup-Rescue prototype simulator.

8 Humanoid Demonstration

The humanoid league will start from 2002 towards the final goal of RoboCup, that is, to beat the human world cup champion team by a team of eleven humanoid robots by 2050. This league is much much more challenging than the existing ones because dynamic stability of robot walking and running must be addressed.

The main steps of such development will be:

1. building an autonomous biped able to walk alone on the field,
2. locomotion of this biped on straight line, curve, turn on itself,
3. identification of the ball, the teammates, and the opponents,
4. kicking, passing, shooting, intercepting, and throwing the ball,
5. acquisition of cooperative behavior (coordination of basic behaviors such as passing and shooting), and
6. acquisition of team strategy.

Although the items 3, 4, 5, and 6 have been already attacked in the existing leagues, the humanoid league has its own difficulty to handle the ball by foot and hands.

At RoboCup-2000, the humanoid demonstration was held with four characteristic humanoids. Figure 4 shows these four humanoids, in which the number corresponds to the order from the left.

1. Mark-V: Prof Tomiyama group, Aoyama Gakuin University, Japan. Mark-V showed his walking and kicking a ball into the goal.
2. PINO: Kitano Symbiotic Project, Japan. PINO showed his walking and waving his hand to say “Good Bye!”
3. Adam: LRP, France.
4. Jack Daniel: Western Australia University. Jack showed his walking in the air.

These humanoids are still under development, and we expect to see more humanoids with higher capability of walking, running and more in next year.



Figure 4: Four humanoids brought in RoboCup-2000

9 Workshop and Challenge Awards

The RoboCup-2000 workshop was co-chaired by Peter Stone, Tucker Balch, and Gerhard Kraetzschmar. From among more than 60 submissions, 20 papers were selected for oral presentation and an additional 20 were selected for poster presentation. Topics covered included research advances in all of the leagues as well as RoboCup rescue and RoboCup education initiatives.

Four workshop papers were selected as finalists for the RoboCup-2000 Scientific and Engineering Challenge Awards, are distinctions given annually to the RoboCup-related research that shows the most potential to advance their respective fields.

The RoboCup-2000 Scientific Challenge Award went to [5] for its contribution of a method for using Self-Organizing Maps to cluster spatio-temporal data. A novel vector representation is used as the inputs to the Self-Organizing Maps to capture relative player motions and player-ball interactions in the RoboCup simulator.

The RoboCup-2000 Engineering Challenge Award went to [6] for its novel localization method employed by robots that compete in the middle-size league. This method works with images captured from an omni-directional vision system consisting of a specially engineered mirror designed to obtain the bird's eye-view of the soccer field, with no need for software image transformations after image acquisition. It matches landmarks in the image, such as goals and field lines, using a priori knowledge regarding the geometry of the playing field.

10 Conclusion

Several RoboCup competitions and workshops have been already held, namely in 1997 in Nagoya, Japan, in 1998 in Paris, France, in 1999 in Stockholm, Sweden, and in 2000 in Melbourne, Australia. The participation and attendance of these events has been increasing every year, with about 500 participants and more than 5,000 visitors at RoboCup-2000.

RoboCup-2001 is going to be held in the United States for the first time, in Seattle, colocated with the International Joint Conference of Artificial Intelligence. RoboCup-2001 will include a 2-day research forum with presentations of technical papers, all competition leagues: soccer simulator competition, RoboCup simulation rescue competition (for the first time - details TBA), the small-size robot competition (F180), the middle-size robot competition (F2000), Four-Legged competition, the RoboCup robot rescue competition in conjunction with the AAAI robot competition (for the first time - details TBA), the RoboCup Jr. symposium including soccer 1 on 1 robot and robot dancing competitions, and other educational events for middle-school and high-school children, and an exhibition of humanoid robots.

For more information, please visit:

<http://www.robocup.org>

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