RoboCup 2004 Overview

Pedro Lima and Luis Custódio

Institute for Systems and Robotics, Instituto Superior Técnico,
Av. Rovisco Pais, 1049-001 Lisboa, Portugal
{pal, lmmc}@isr.ist.utl.pt

1 Introduction

RoboCup is an international initiative with the main goals of fostering research and education in Artificial Intelligence and Robotics, as well as of promoting Science and Technology to world citizens. The idea is to provide a standard problem where a wide range of technologies can be integrated and examined, as well as being used for project-oriented education, and to organize annual events open to the general public, where different solutions to the problem are compared.

Fig. 1. A view of some of the RoboCup2004 participants, at the entrance of the venue

The RoboCup Federation stated the ultimate goal of the RoboCup initiative as follows: "By 2050, a team of fully autonomous humanoid robot soccer players shall win a soccer game, complying with the official FIFA rules, against the winner of the most recent World Cup of Human Soccer." [1]. This main challenge lead robotic Soccer matches to be the main part of RoboCup events, from 1997 to 2000. However, since 2000, the competitions include Search and

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Rescue robots as well, so as to show the application of Cooperative Robotics and Multi-Agent Systems to problems of social relevance [2]. Also in 2000 was introduced RoboCup Junior, now a large part of any RoboCup event, aiming at introducing Robotics to children attending primary and secondary schools and including undergraduates who do not have the resources yet to take part in RoboCup senior leagues [3].

RoboCup2004 was held in Lisbon, Portugal, from 27 June to 5 July. As in past years, RoboCup2004 consisted of the 8th Symposium and of the Competitions. The competitions took place at the Pavilion 4 of Lisbon International Fair (FIL), an exhibition hall of approximately 10 000 m^2, located at the former site of Lisbon EXPO98 world exhibition. The Symposium was held at the Congress Center of the Instituto Superior Técnico (IST), Lisbon Technical University. Together with the competitions, two regular demonstrations took place on a daily basis: SegWay soccer, by a team from Carnegie-Mellon University, and SONY QRIO robot, by a team from SONY Japan.

Portugal was chosen as the host of the 2004 edition due to its significant representation in RoboCup committees, competitions and conferences, as a result of the effort of the country in recent years to attract young people to Science and Technology and also because EURO2004^{TM}, the 2004 European Soccer Cup, took place in Portugal, therefore improving the chances to bring the media to cover the event.

RoboCup2004 was locally organized by a Portuguese committee composed of 15 researchers and university professors from several Universities, therefore underlining the national nature of the event organization. This committee worked closely with the international organizing and technical committees to set up an event with the record number of 1627 participants from 37 countries, and an estimated number of 500 robots, split by 346 teams. Twenty technicians from FIL were involved in the preparation of the competition site, and 40 student volunteers supported the event realization. The event was hosted by the Institute for Systems and Robotics, a research institute located in the campus of IST.

In the following sections we will briefly overview the main research progresses this year, the technical challenges and the competition results by league, with a brief report on the Symposium, whose accepted papers are the core of this book. More details on competitions, photos, short video clips and other related information can be found in the official web page of the event at www.robocup2004.pt.

2 Soccer Middle-Size Robot League

In this league, two teams of 4-6 mid-sized robots with all sensors on-board play soccer on a field. Relevant objects are distinguished by colours. Communication among robots (if any) is supported on wireless communications. No external intervention by humans is allowed, except to insert or remove robots in/from the field. There were 24 teams in Lisbon selected by the league technical committee from the 34 teams that submitted the qualification material.

2.1 Research Issues

The 2004 rules introduced a set of changes in the games:

1. the field was enlarged to 8m × 12m;
2. the number of players is now flexible and determined by the area occupied by the whole team, even though it can only range from 4 to 6 robots per team;
3. the light used was the artificial light of the exhibition hall, *i.e.*, no special overhead illumination as in past events, therefore with possible non-uniformity and less strong illumination;
4. a referee box was used, but only to start and stop the games for now.

The purpose of 1 and 2 was mainly to improve teamwork, as larger fields tend to encourage passing the ball among robots, as well as cooperative localization of the ball and cooperative navigation among teammates, since relevant objects and landmarks are less often seen during the game. Change 3 was common to almost all the leagues and intended to be a step towards vision under natural illumination in RoboCup. Finally, the introduction of a referee box, already existing in the Small Size and 4-Legged leagues, brings further autonomy and requires further intelligence and team-play to the robots.

After the usual initial adaptation phase, most teams handled the new rules quite well. This year, most teams had their robots running well from the beginning of the tournament, without so many technical problems as in the past, except those concerning wireless communications, which is the main unsolved technical problem in RoboCup events so far.

2.2 Technical Challenges

Every year, the league technical committee (TC) prepares technical challenge competitions where teams show specific skills and technical achievements. There were two technical challenges this year:

- *Ball Control and Planning*,
- *Free Demonstration* of scientific or engineering achievements.

In the *Ball Control and Planning Challenge*, several obstacles are arbitrarily positioned in the field, and the robot must take the ball from one goal to the other with minimum or no contact with the obstacles and within a limited time.

In the *Free Challenge*, teams are free to pick their most relevant technical and/or scientific recent achievement and demonstrate it. The demonstration is evaluated by the members of the TC.

2.3 Results

The 24 teams were organized in 4 groups of 6 teams each, which played a round-robin tournament. Then, the 4 best teams in each group, in a total of 16, were grouped in 4 groups of 4 teams each, for another round-robin tournament. Finally, the first and second place teams from each group were qualified for the

Table 1. Soccer Middle-Size League top three teams

rank	team
1	EIGEN (Keio University, Japan)
2	WinKIT (Kanazawa Institute of Technology, Japan)
3	CoPS Stuttgart (University of Stuttgart, Germany)

Table 2. Overall rank for Soccer Middle-Size League technical challenges

rank	team
1	Persia (Isfahan University of Technology, Iran)
2	AllemaniACs (Technical University of Aachen, Germany)
3	Clockwork Orange (Delft University of Technology, The Netherlands)

playoff phase, which consisted of quarter-finals, semi-finals and final (as well as third-fourth place game). The top three teams of the soccer competition are listed in Table 1.

The winners of the technical challenges were:

– *Ball Control and Planning* challenge: Persia (Isfahan University of Technology, Iran)
– *Free Demonstration* challenge: Persia (Isfahan University of Technology, Iran)

The overall rank for the Middle-Size League technical challenges is shown in Table 2.

3 Soccer Small-Size Robot League

Two teams of 5 small robots without on-board sensors play soccer on a field with an overhead camera which provides feedback to an external computer of the game state (e.g., ball, own and opponent player locations). Relevant objects are distinguished by colour and coloured coded markers on the top of the robots. Commands are sent by the external computer to the robots using wireless communications. No external intervention by humans is allowed, except to insert or remove robots in/from the field. There were 21 teams in Lisbon selected by the league technical committee from the 39 teams that submitted the qualification material.

3.1 Research Issues

The main research challenges for 2004 resulted from three main changes in the rules:

1. the light used was the artificial light of the exhibition hall, i.e., no special overhead illumination as in past events. In this league, this is a particularly troublesome issue, due to the shadow cast by the camera mounting structure on the field;

Table 3. Soccer Small-Size League top three teams

rank	team
1	FU Fighters (Freie Universität Berlin, Germany)
2	Roboroos (University of Queensland, Australia)
3	LuckyStar (Ngee Ann Polytechnic, Singapore)

2. the field was almost doubled to 4×5.5 m;
3. the field boundary walls were removed.

The purpose was, similarly to what happened in the Middle-Size League, to encourage more cooperation among robot teammates (especially passes) and to move towards a closer-to-reality perception scenario. The illumination issue was particularly effective in this league, as some teams were relying on their good quality top cameras and had not invested on advanced vision algorithms, required to overcome non-uniform light conditions and low-light illumination. On the other hand, the improvement in teamwork, with many passes and robot formations, was visible as expected, and interesting to follow. The need for better ball control was also noticeable, both for pass reception improvement and to avoid the ball going out of the field most of the time. Some teams in this league show very interesting kicking devices, including some which are capable to raise the ball above the ground.

3.2 Results

In the round-robin phase, the teams were split in 4 groups. The top 2 teams from each group proceeded to the playoff phase. The top three teams are listed in Table 3.

4 Soccer 4-Legged Robot League

Two teams of up to 4 four-legged robots (SONY's specially programmed AIBO robots), with all sensors on-board, play soccer on a field. Relevant objects are distinguished by colours. Communication among robots (if any) is supported on wireless communications. No external intervention by humans is allowed, except to insert or remove robots in/from the field. There were 23 teams in Lisbon selected by the league technical committee from the 32 teams that submitted the qualification material.

4.1 Research Issues

This is the real robot league with the most standardized hardware, as all the platforms are SONY's specially programmed AIBOs. Consequently, teams share their code every year and the advances in software are considerably faster than for other real robot leagues. Nevertheless, this year there were two types of robots: the new ERS-7 AIBOs and the old ERS-210 AIBOs. The former are significantly faster robots, and this made a difference in terms of competition, as only one team with ERS-210 robots made it to the quarter-finals.

The 4-Legged League was the only real robot league which could not use yet the natural light of the hall, still requiring strong local illumination from projectors located around the fields. This is mainly due to the low sensitivity to light of the AIBOs cameras.

The AIBO's 3-degree-of-freedom single camera forces the teams to work on selective directed vision problems, leading to research advances in active vision (e.g., where to look), cooperative world modelling and navigation. Also, some of the rule changes for 2004 fostered the introduction of cooperative localization algorithms, as a consequence of removing the two central beacons of the field, therefore reducing the frequency of landmarks visibility by the robots.

Another rule change concerned obstacle avoidance, less enforced in the past in this league. Gait optimization was also a hot topic among teams, so as to speed up the robots, including the utilization of learning techniques. The fastest gait speed increased from 27 cm/s in 2003 to 41 cm/s this year.

4.2 Technical Challenges

Three technical challenges were held in the 2004 edition of the Four-Legged League:

- The *Open Challenge*, similar to the free challenge in the Soccer Middle-Size League, where free demonstrations were assessed by the other teams. The demonstrations included robot collaboration, ball handling, object recognition, and tracking by vision or sound.
- The *Almost SLAM Challenge*, where a landmark-based self-localization problem involving learning initially unknown landmark colours was the goal.
- The *Variable Lighting Challenge* involved light changing conditions over a 3-minutes time interval, during which a robot had to score as many goals as possible. This was surely hard for 4-Legged teams, and the winner only scored twice.

4.3 Results

In the round-robin phase, the teams were split in 4 groups. The top 2 teams from each group proceeded to the playoff phase. The top three teams are listed in Table 4.

Regarding the technical challenges, the winners were:

- *Open Challenge*: GermanTeam, demonstrating four robots moving a large wagon.
- *Almost SLAM Challenge*: rUNSWift (University of New South Wales, Australia).
- *Variable Lighting Challenge*: ASURA (Kyushu Institute of Technology, Japan).

The top three teams from the overall result for technical challenges are listed in Table 5.

Table 4. Soccer 4-Legged League top three teams

rank	team
1	GermanTeam (HU Berlin, U. Bremen, TU Darmstadt, U. Dortmund, Germany)
2	UTS Unleashed! (University of Technology, Sydney, Australia)
3	NUBots (University of Newcastle, Australia)

Table 5. Soccer 4-Legged League top three teams in the overall technical challenge

rank	team
1	UTS Unleashed! (University of Technology, Sydney, Australia)
2	ARAIBO (University of Tokyo, Chuo University, Japan)
3	ASURA (Kyushu Institute of Technology, Japan)

5 Soccer Humanoid Robot League

Humanoid robots show basic skills of soccer players, such as shooting a ball, or defending a goal. Relevant objects are distinguished by colours. So far, no games took place, penalty kicks being the closest situation to a 1-on-1 soccer game. There were 13 teams in Lisbon selected by the league technical committee from the 20 teams that submitted the qualification material.

5.1 Research Issues

This league made its debut in RoboCup2002, and its main research challenge is to maintain the dynamic stability of robots while walking, running, kicking and performing other tasks. Moreover, perception must be carefully coordinated with biped locomotion to succeed.

This year, significant advances were observed in the humanoids, namely on the technological side. Some teams showed progresses on features such as the more ergonomic mechanical design and the materials used, the ability to walk on uneven terrain, the walking speed, the ability to kick towards directions depending on sensing (e.g., the goal region not covered by the goalie), body coordination, cooperation among robots (a pass was demonstrated by Osaka University) and omnidirectional vision (used by Team Osaka ViSion robot). Also relevant is the fact that most robots came equipped with an internal power supply and wireless communications, thus improving autonomy. Tele-operation of the robots was not allowed this year.

5.2 Technical Challenges

In the humanoid league, since no games are played yet, the main events are the technical challenges: *Humanoid Walk, Penalty Kick* and *Free Style*. This year, humanoid walk included walking around obstacles and balancing walk on a slope. In the free style challenge, a pass between two robots and robot gymnastics could be observed, among other interesting demonstrations. Next year,

Table 6. Soccer Humanoid Robot League technical challenges

Soccer Humanoid Walk technical challenge

rank	**team**
1	Team Osaka (Systec Akazawa Co., Japan)
2	Robo-Midget (Singapore Polytechnic, Singapore)
3	Senchans (Osaka University, Japan)

Soccer Humanoid Free Style technical challenge

rank	**team**
1	Team Osaka (Systec Akazawa Co., Japan)
2	Robo-Erectus (Singapore Polytechnic, Singapore)
3	NimbRo (U. of Freiburg, Germany)

Soccer Humanoid Penalty Kick H80 technical challenge

rank	**team**
1	Senchans (Osaka University, Japan)
2	Robo-Erectus 80 (Singapore Polytechnic, Singapore)

Soccer Humanoid Penalty Kick H40 technical challenge

rank	**team**
1	Team Osaka (Systec Akazawa Co., Japan)
2	Robo-Erectus 40 (Singapore Polytechnic, Singapore)

challenges will attempt to promote the current weakest points in the humanoid league, by improving battery autonomy, onboard computing, locomotion and real-time perception.

5.3 Results

The winner of the Best Humanoid Award was Team Osaka ViSion humanoid, from Systec Akazawa Co., Japan. The results for the other technical challenges are listed in Table 6.

6 Soccer Simulation League

In this league, two teams of eleven virtual agents each play with each other, based on a computer simulator that provides a realistic simulation of soccer robot sensors and actions. Each agent is a separate process that sends to the simulation server motion commands regarding the player it represents, and receives back information about its state, including the (noisy and partial) sensor observations of the surrounding environment. There were 60 teams in Lisbon selected by the league technical committee from the 196 teams that submitted the qualification material.

6.1 Research Issues

The main novelty in the Soccer Simulation League in 2004 was the introduction of the 3D soccer simulator, where players are spheres in a three-dimensional environment with a full physical model. Besides that, two other competitions already running in past tournaments were present: the 2D and the Coach competitions.

The best teams from the past 2D competitions were able to quickly adapt their code to face the new challenges of the 3D competition quite well. Those challenges included the possibility to move in 3 directions, the motion inertia and delayed effects of motor commands. In the 2D competition, remote participation through Internet was possible for the first time. Participants in the Coach competition must provide a coach agent that can supervise players from a team using a standard coach language. Coaches are evaluated by playing matches with a given team against a fixed opponent.

The main research topics in the league are reinforcement learning, and different approaches to select hard-coded behaviours, such as evolutionary methods or rule based systems.

6.2 Results

The top three teams in the three competitions are listed in Tables 7-9.

Table 7. Soccer Simulation League top three teams in the 3D competition

rank	**team**
1	Aria (Amirkabir University of Technology, Iran)
2	AT-Humboldt (Humboldt University Berlin, Germany)
3	UTUtd 2004 (University of Tehran, Iran)

Table 8. Soccer Simulation League top three teams in the 2D competition

rank	**team**
1	STEP (ElectroPult Plant Company, Russia)
2	Brainstormers (University of Osnabrück, Germany)
3	Mersad (Allameh Helli High School, Iran)

Table 9. Soccer Simulation League top three teams in the Coach competition

rank	**team**
1	MRL (Azad University of Qazvin, Iran)
2	FC Portugal (Universities of Porto and Aveiro, Portugal)
3	Caspian (Iran University of Science and Technology, Iran)

7 Rescue Real Robot League

The RoboCupRescue Real Robot League competition acts as an international evaluation conference for the RoboCupRescue Robotics and Infrastructure Project research. The RoboCupRescue Robotics and Infrastructure Project studies future standards for robotic infrastructure built to support human welfare. The U.S. National Institute of Standards and Technology (NIST) Urban Search and Rescue (USAR) arena has been used in several RoboCupRescue and AIAA competitions and was used in Portugal as well. A team of multiple (autonomous or teleoperated) robots moves inside this arena, divided in 3 regions of increasing difficulty levels, searching for victims and building a map of the surrounding environment, to be transmitted and/or brought back by the robot(s) to the human operators. There were 20 teams in Lisbon selected by the league technical committee from the 37 teams that submitted the qualification material.

7.1 Research Issues

The competition requires robots to demonstrate capabilities in mobility, sensory perception, planning, mapping, and practical operator interfaces, while searching for simulated victims in unstructured environments. The actual challenges posed by the NIST USAR arena include physical obstacles (variable flooring, overturned furniture, and problematic rubble) to disrupt mobility, sensory obstacles to confuse robot sensors and perception algorithms, as well as a maze of walls, doors, and elevated floors to challenge robot navigation and mapping capabilities. All combined, these elements encourage development of innovative platforms, robust sensory fusion algorithms, and intuitive operator interfaces to reliably negotiate the arena and locate victims.

Each simulated victim is a clothed mannequin emitting body heat and other signs of life including motion (shifting or waving), sound (moaning, yelling, or tapping), and carbon dioxide to simulate breathing. They are placed in specific rescue situations (surface, lightly trapped, void, or entombed) and distributed throughout the arenas in roughly the same percentages found in actual earthquake statistics.

This year, two new league initiatives were introduced:

1. a high fidelity arena/robot simulation environment to provide a development tool for robot programming in realistic rescue situations;
2. a common robot platform for teams to use if they choose, based on a standard kit of components, modular control architecture, and support for the simulation mentioned above.

7.2 Results

The competition rules and scoring metric focus on the basic USAR tasks of identifying live victims, assessing their condition based on perceived signs of life, determining accurate victim locations, and producing human readable maps to enable victim extraction by rescue workers — all without damaging the environment or making false positive identifications.

After several rounds of competitive missions, the scoring metric produced three awardees that demonstrated best-in-class approaches in each of three critical capabilities:

1. Toin Pelicans team (University of Toin, Japan) for their multi-tracked mobility platform with independent front and rear flippers, as well as an innovative camera perspective mounted above and behind the robot that significantly improved the situational awareness by the operator.
2. Kurt3D team (Fraunhofer Institute for Artificial Intelligence Systems, Germany) for their application of state-of-the-art 3D mapping techniques using a tilting line scan lidar.
3. ALCOR team (University of Rome "La Sapienza", Italy) for their intelligent perception algorithms for victim identification and mapping.

8 Rescue Simulation League

The main purpose of the RoboCupRescue Simulation League is to provide emergency decision support by integration of disaster information, prediction, planning, and human interface. A generic urban disaster simulation environment was constructed based on a computer network. Heterogeneous intelligent agents such as fire fighters, commanders, victims, volunteers, etc. conduct search and rescue activities in this virtual disaster world. There were 17 teams in Lisbon selected by the league technical committee from the 34 teams that submitted the qualification material.

8.1 Research Issues

The main research objective of this league is the introduction of advanced and interdisciplinary research themes, such as behaviour strategy (e.g. multi-agent planning, real-time/anytime planning, heterogeneity of agents, robust planning, mixed-initiative planning) for AI/Robotics researchers or the development of practical comprehensive simulators for Disaster Simulation researchers.

In 2004, the league was split in two competitions:

– **Agent Competition**, where a team has a certain number of fire fighters, police, and ambulance agents and central stations that coordinate each agent type. The agents are assumed to be situated in a city in which a simulated earthquake has just happened, as a result of which, some buildings have collapsed, some roads have been blocked, some fires have started and some people have been trapped and/or injured under the collapsed buildings. The goal of each team is to coordinate and use its agents to minimize human casualties and the damage to the buildings.
– **Infrastructure Competition**, where the performance of the simulator components developed by the teams is tested. The awarded team is requested

to provide the component for the next year's competition. For this reason teams are expected to accept the open source policy before entering the competition.

8.2 Results

In the Agent competition, the preliminaries consisted of two stages. In the first stage, the teams competed on six maps with different configurations. The first 6 teams went to the semi-final. The remaining 11 teams competed in the second stage which was designed to test the robustness of the teams under varying perception conditions. The latter stage top 2 teams went to the semi-finals too. The top 4 teams of the semi-finals competed in the final.

The final standings were:

1. ResQ (University of Freiburg, Germany), with platoon agents that have reactive and cooperative behaviours which can be overridden by deliberative high-level decisions of the central station agents.
2. DAMAS-Rescue (Laval University, Canada), with a special agent programming language. Using this language, their Fire Brigade agents choose the best fire to extinguish based on the knowledge they have learned with a selective perception learning method.
3. Caspian (Iran University of Science and Technology, Iran).

In the Infrastructure competition, only the ResQ Freiburg team competed, presenting a 3D-viewer and a Fire Simulator. The 3D-viewer is capable of visualizing the rescue simulation both online and offline. The Fire Simulator is based on a realistic physical model of heat development and heat transport in urban fires. Three different ways of heat transport (radiation, convection, direct transport) and the influence of wind can be simulated as well as the protective effects of spraying water on buildings without fire.

9 RoboCup Junior

RoboCupJunior is a project-oriented educational initiative that sponsors local, regional and international robotic events for young students. It is designed to introduce RoboCup to primary and secondary school children.

RoboCupJunior offers several challenges, each emphasizing both cooperative and competitive aspects. In contrast to the one-child-one-computer scenario typically seen today, RoboCupJunior provides a unique opportunity for participants with a variety of interests and strengths to work together as a team to achieve a common goal. Several challenges have been developed: dance, soccer and rescue.

By participating in RoboCupJunior, students especially improve their individual and social skills (building self-confidence, developing a goal-oriented, systematic work style, improving their presentation and communication abilities, exercising teamwork, resolving conflicts among team members). RoboCupJunior has spread in more than 20 countries around the world. We estimate that this

Fig. 2. The RoboCup2004 Junior area

year more than 2000 teams world-wide adopted the RoboCupJunior challenges and prepared for participation in RoboCup in local, regional, or national competitions. The largest RoboCupJunior communities are China (approximately 1000 teams), Australia (approximately 500 teams), Germany, Japan, and Portugal (over 100 teams each).

Lisbon hosted the largest RoboCup Junior event so far, with 163 teams from 17 countries, 677 participants, and about 300 robots.

9.1 Competitions

The Lisbon RoboCupJunior event featured competitions in eight leagues, covering four different challenges: RoboDance, RoboRescue, RoboSoccer 1-on-1, and RoboSoccer 2-on-2 - and in each challenge two age groups - Primary for students aged under 15, and Secondary for students aged 15 and elder. The teams qualifying for the playoffs were interviewed in order to scrutinize their ability to explain their robot designs and programs.

The RoboRescue challenge is performed in an environment mimicking an urban search and rescue site. Robots have to follow a curved path, marked by a black line, through several rooms with obstacles and varying lighting conditions. The task is to find two kinds of victims on the path, marked by green and silver icons. Points are awarded for successful navigation of rooms and for detecting and signalling victims, and the time for executing the task is recorded when it is completed. Perhaps surprisingly, the vast majority of teams demonstrated perfect runs and quickly navigated through the environment while finding and signalling all victims, so that the timing was the decisive factor for making it to the finals and winning.

The RoboSoccer challenge play soccer on a pitch which is covered by a large grayscale floor and surrounded by a black wall. The only difference is that the 1-on-1 field is smaller. Goals can be detected by their walls coloured gray, and the well-known infrared-emitting ball is used for play. In both 1-on-1 and 2-on-2 Primary leagues, teams were split by three groups and played a single round of round-robin games. Teams placed first and second after round-robin directly qualified for the playoffs, and the remaining two playoff spots were determined among the three teams placed third. In 2-on-2 Secondary, we had 6 groups in round-robin and teams placed first and second advanced to the second round. On playoff day, four groups of three teams each played a second round of round-robin games, and the best team from each group advanced directly to the semifinals. Even seasoned RoboCupJunior organizers were stunned by sophisticated robots and the spectacular level of play the teams demonstrated across all of the four Junior soccer leagues.

The RoboDance challenge asks students to design some kind of stage performance which involves robots. Students may engage themselves as part of the per-

Table 10. Junior Leagues top three teams

	RoboDance Primary		**RoboDance Secondary**
1	Coronation Quebec 1 (Canada)	1	Kao Yip Dancing Team (China)
2	The Rock (Germany)	2	Mokas Team (Portugal)
3	Peace of the World (Japan)	3	Gipsies (Israel)
	RoboRescue Primary		**RoboRescue Secondary**
1	Chongqing Nanan Shanh (China)	1	Dunks Team Revolution (Portugal)
2	Dragon Rescue 100% (Japan)	2	Ren Min (China)
3	Chongqing Nanan Yifen (China)	3	Across (USA)
	RoboSoccer 1-on-1 Primary		**RoboSoccer 1-on-1 Secondary**
1	Shanghai Road of Tianjin (China)	1	Liuzhou Kejiguang (China)
2	Shenzhen Haitao (China)	2	I Vendicatori (Italy)
3	Wuhan Yucai (China)	3	TianJin Xin Hua (China)
	RoboSoccer 2-on-2 Primary		**RoboSoccer 2-on-2 Secondary**
1	NYPSTC1 (Singapore)	1	Kao Yip 1 (China)
2	Ultimate (Japan)	2	Espandana Juniors (Iran)
3	Red and Blue (South Korea)	3	Kitakyushu A.I. (Japan)

Table 11. Junior Dance League award winners

Category	**RoboDance Primary**	**RoboDance Secondary**
Programming	ChaCha (Japan)	Godzillas (Portugal)
Construction	The Rock (Germany)	Pyramidical Dragon (Portugal)
Costume	Turtles (Portugal)	Hunan Changsha Yali (China)
Choreography	Crocks Rock (Australia)	Joaninhas (Portugal)
Creativity	Hong Kong Primary Dancing Team (China)	Bejing No. 2 Middle School (China)
Originality	Ridgment Pearl (UK)	Mokas Team (Portugal)
Entertainment Value	RoCCI Girls (Germany)	The Rocking Robot (UK)

formance, or give a narrative to the audience while the robots perform on stage. There is a two minute time limit for the performance, and an international judge committee assesses the performance in seven categories. RoboDance is without doubt the RoboCupJunior activity allowing most flexibility in the design and programming of the robots, and challenges students' inspiration and creativity. All teams of the same age group performed on stage on one the preliminaries, and the best three teams advanced to the finals.

9.2 Results

The top three teams for the different Junior leagues, as well as the winners of the Dance League awards are listed in Tables 10 and 11, respectively.

10 Symposium

The 8th RoboCup International Symposium was held immediately after the RoboCup2004 Competitions as the core meeting for the presentation of scientific contributions in areas of relevance to RoboCup. Its scope encompassed, but was not restricted to, the fields of Artificial Intelligence, Robotics, and Education.

The IFAC/EURON 5th Symposium on Intelligent Autonomous Vehicles (IAV04) took also place at Instituto Superior Técnico, Lisbon from 5 to 7 July 2004. IAV2004 brought together researchers and practitioners from the fields of land, air and marine robotics to discuss common theoretical and practical problems, describe scientific and commercial applications and discuss avenues for future research.

On July 5, the IAV04 Symposium ran in parallel with the RoboCup Symposium and both events shared two plenary sessions:

– James Albus, NIST, USA, "RCS: a Cognitive Architecture for Intelligent Multi-agent Systems".
– Shigeo Hirose, Tokyo Institute of Technology, Japan, "Development of Rescue Robots in Tokyo Institute of Technology".

The other two plenary sessions specific to the RoboCup2004 Symposium were:

– Hugh Durrant-Whyte, U. Sydney, Australia, "Autonomous Navigation in Unstructured Environments".
– Luigia Carlucci Aiello, Universitá di Roma "La Sapienza", Italy, "Seven Years of RoboCup: time to look ahead".

118 papers were submitted to the RoboCup2004 Symposium. Among those, 68 were accepted and are published in this book: 30 as regular papers, 38 as shorter poster papers.

This year, the awarded papers were:

Scientific Challenge Award: "Map-based Multi Model Tracking of a Moving Object", Cody Kwok and Dieter Fox.

Engineering Challenge Award: "UCHILSIM: A Dinamically and Visually Realistic Simulator for the RoboCup Four Legged League", Juan Cristóbal Zagal Montealegre and Javier Ruiz-del-Solar.

11 Conclusion

Overall, RoboCup2004 was a successful event, from a scientific standpoint. The main technical challenge of holding the competitions under a reduced artificial light of the exhibition hall, instead of having special illumination per field as in the past, was overcome by most teams without significant problems, thus showing the evolution on perception robustness within the RoboCup community. Another noticeable improvement is the increase in teamwork across most real robot soccer leagues, from passes to dynamic behaviour switching, including formation control and cooperative localization. Even in the humanoid league a pass between biped robots was demonstrated by one of the teams.

On the educational side, RoboCup Junior was a tremendous success, despite the increased organizational difficulties brought by the fact that the number of participants almost doubled that of 2003.

The next RoboCup will take place in Osaka, Japan, in July 2005.

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