Overview of RoboCup 2003 Competition and Conferences

Enrico Pagello, Emanuele Menegatti*, Ansgar Bredenfeld, Paulo Costa, Thomas Christaller, Adam Jacoff, Jeffrey Johnson, Martin Riedmiller, Alessandro Saffiotti, and Takashi Tomoichi

Intelligent Autonomous Systems Laboratory (IAS-Lab)
Department of Information Engineering, Faculty of Engineering
University of Padua, Padova, Italy
emg@dei.unipd.it

1 Introduction

RoboCup 2003, the seventh RoboCup Competition and Conference, took place between July the 2nd and July the 11th 2003 in Padua (Italy). The teams had three full days to setup their robots. The competitions were held in the new pavilion n°7 of the Fair of Padua (Fig. 1). Several scientific events in the field of Robotics and Artificial Intelligence were held in parallel to the competitions. The RoboCup Symposium was held in the last two days. The opening talks took place in the historical Main Hall of the University of Padua and the three parallel Symposium sections in the conference rooms of the Fair of Padua.

Fig. 1. The entrance of the RoboCup-2003 Competition Site.

* Corresponding author.

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Fig. 2. The ancien Main Hall of The University of Padua where the opening talks of the RoboCup-2003 Symposium took place.

RoboCup was born with the goal of "*building by 2050, a team of fully autonomous humanoid robot to beat the human winning team of the FIFA Soccer World Cup*". This is a long term goal that someone saw as utopian or with a limited scientific appeal, but in the mind of the promoters of RoboCup, this is a mean to foster Robotics and AI research among the scientists, the students, and the general public. RoboCup already produced the result of disseminating interest and knowledge about Robotics and Artificial Intelligence. This is witnessed by the ever increasing number of people and institutions that get involved in RoboCup and by the offspring of new initiatives within the RoboCup community. RoboCup is no longer only the Soccer World Cup for autonomous robots, but it is a container for different robotics event: Soccer Robotics, Rescue Robotics, Educational Robotics and a Scientific Symposium on Robotics.

RoboCup 2003 was a new record milestone in the history of robotic events. We had 243 teams for a total of 1244 registered participants coming from more than 30 countries from four of the five Continents, the only missing was Africa. Fig. 3 gives a clear understanding of the tremendous growth of the number of participants along the years. During RoboCup 2003, a small industrial exhibit took place, where some international companies showed their commercial and research products. Among the others, we had the presence of COMAU one of the few "total" suppliers for the automotive industry of automation systems. COMAU has a long tradition in the robotics and automation industry. Another important exhibitor was "Polo Robotico di Genova" a research and technological Consortium of Genoa (Italy).

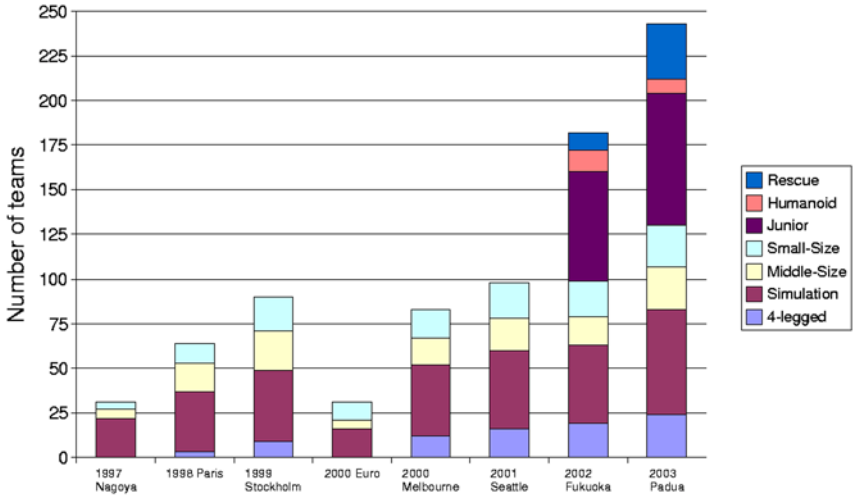

Fig. 3. The trend in the number of participating teams in the RoboCup Competitions.

2 RoboCup Symposium and Correlated Scientific Events

The RoboCup 2003 Symposium opened up in the ancient Main Hall of The University of Padua. This is the hall where Galileo Galilei tought and Manuela Veloso gave her invited talk on the evolution and achievements of seven years of RoboCup, under the family crests of the ancient students of the University of Padua. The organisers wanted a female researcher to open the Symposium to commemorate Elena Lucrezia Cornaro Piscopia, the first graduated woman in the world, that graduated in Philosophy at the University of Padua in 1678.

The second invited talk was from Masahiro Fujita who gave an overview of humanoid robots developed in Japan with an impressive demonstration of the new prototype of companion humanoid robot of Sony.

The other two invited talk where held in the Conference Center of the Fair of Padua and were given by Ulrich Nehmzow, on the use of chaos theory in the study of the interactions between the robot and its environment, and by Paolo Dario, a President of the Robotics and Automation Society of IEEE, on the use of robotics in medicine and other application fields. The invited talks were completed by Maja Mataric talking about multi-robot cooperation, unfortunately this was just a video contribution, because she could not attend the Symposium.

For the first time in the history of RoboCup, the number of papers selected for oral presentation and the number of Symposium attendants were so high, the organisers decided to split the Symposium on three parallel tracks.

The Symposium was closed by the RoboCup roadmap discussion. The roadmap discussion is aimed to identify the intermediate milestone to be reached in the next five, ten or twenty years in order to achieve the final goal of 2050. The roadmap discussion was only started in Padua and it continued by e-mail after

Padua and was finalised in Blaubeuren (Germany) in October 2003 (as detailed in the Roadmap Discussion contribution in this book).

Several parallel scientific events took place during RoboCup2003. The mostly articulated event was the Japan-Italy bilateral seminar organised by JSPS (Japanese Society for the Promotion of Science) and CNR (National Research Council of Italy). This seminar was chaired by Minoru Asada and Enrico Pagello and lasted three days. The schedule of the seminar was dense of talks and panel discussion. One of the results of the bilateral seminar was the participants pinpointed a set of "*hot*" and promising topics in which to start joined project between Italian and Japanese research centers. The most promising topics were identified as Rescue Robotics and standardised Simulation Environment for Mobile Robots.

We had also two one-day Conferences: one on *Multi-robot systems: trends and industrial applications* organized by SIRI (the Italian Association for Robotics and Automation) and chaired by Giuseppina Gini and Rezia Molfino and another one on *Synthetic Simulation and Robotics to Mitigate Earthquake Disaster* chaired by Daniele Nardi.

3 Results of Competitions

As we said in the introduction, nowadays the RoboCup competitions are divided in three main branches: RoboCup Soccer, RoboCup Rescue and RoboCup Junior.

3.1 RoboCup Soccer

Soccer Simulation: This year, the games of Soccer Simulation league showed a big advance in the performances of the teams. For the first time in the history of the Simulation League, all games were started automatically. This resulted in the possibility to have a very tight time schedule with the possibility to play more games during the tournament. The automatic start of the game forced the developers to provide more autonomy to their teams (e.g. by effectively using the 'coach'). From 56 teams that were qualified, 46 teams participated in the tournament. In the first round, 8 groups of 5 to 6 teams participated, from which the first 3 teams of each group advanced. All participating teams showed a good level of individual skills. The teams that advanced to the second round additionally showed a good level on team play abilities. In the second round, 4 groups of 6 teams played, from which again the first 3 advanced. For the first time, a 3rd round was also played in groups. The level of play of the last 12 teams this year was very mature and close to each other. Unlike in previous years, games often were not decided until the end. Most of the games where decided just by one or two goals. Exciting games happened among the teams. In Fig. 4 are reported the results of the final stage of the tournament. The winning teams of the soccer tournament were: first place: UVA Trilearn (Netherlands), second place: Tsinghuaelous (China), third place: Brainstormers (Germany). The

winners of the online coach competition were: UT Austin Villa (USA) first place, and FC Portugal (Portugal), second place. The winner of game presentation and analysis competition was the team Caspian (IRAN).

In the word of the organising chair of the Soccer Simulation league "the top teams showed mature capabilities in team play, in stamina management, in active vision, in the use of heterogeneous players and communication. The main reason for the successfulness of the winning teams is a highly elaborated software design that considers all of the above issues"[1].

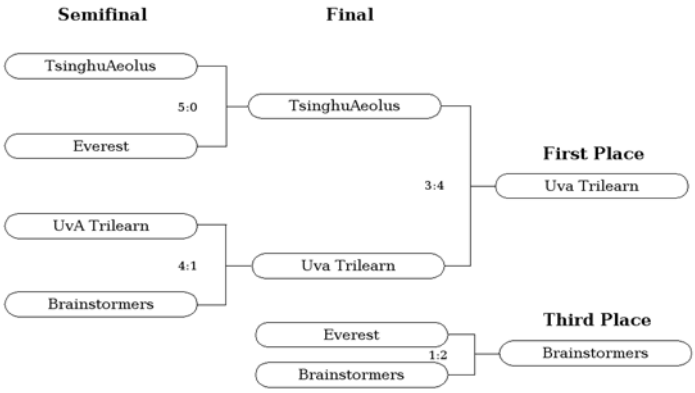

Fig. 4. The results of the games of the final phase of the **Soccer Simulation League** tournament.

Four-Legged League: The RoboCup four-legged league began in 1998, and it was managed by Sony until 2002. In 2003, the management of the league was taken over by the RoboCup Federation for the first time. The transition went rather smoothly, thanks to the kind help received from Sony. In RoboCup 2003, 24 teams from 15 countries participated in the Four Legged League. Teams were evenly distributed across continents, except Africa: 8 coming from Europe, 7 from the USA, 5 from Asia, and 4 from Australia. The teams were divided into 4 pools of 6 teams each. The games were organized in a preliminary round robin phase, followed by a single elimination championship tournament. The winning team was rUNSWift (Australia). This team was already champion in 2000 and 2001, and 2nd place in 2002. UPennalizers (USA) placed second, and NUbots (Australia) third. This year the Sony Prize was awarded to rUNSWift (Australia). The winners of the technical challenge competition are first place German Team (Germany), second place rUNSWift (Australia), third place Araibo (Japan).

In the four-legged league, two different philosophies of robot programming are measuring them-self, i.e. learned behaviours and controls vs. hand-coded

[1] E. Pagello, E. Menegatti, D. Polani, A. Bredenfel, P. Costa, T. Christaller, A. Jacoff, M. Riedmiller, A. Saffiotti, E. Sklar, and T. Tomoichi. Robocup 2003: New scientific and technical advancements. *AI Magazine*, (to appear), 2004.

Fig. 5. A phase of a game of the **Four-Legged League** tournament.

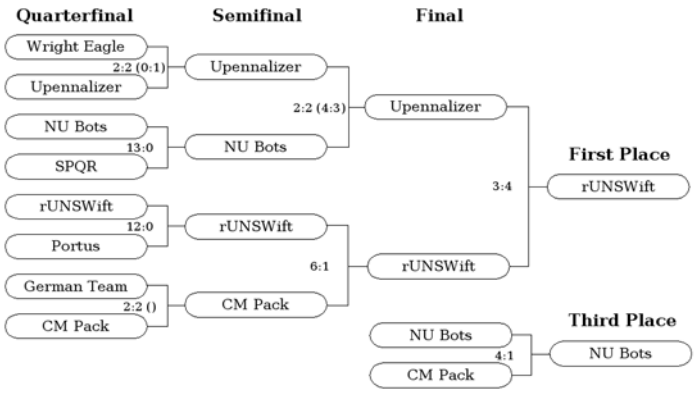

Fig. 6. The results of the games of the final phase of the **Four-Legged League** tournament.

robot programs. In the Four-Legged League the research focus is shifting from lower-level functionalities to higher level skills like planning, coordination, and adaptation. Most teams in 2003 used some form of multi-robot cooperation, including dynamic role assignment and information sharing. In fact, most teams showed fast and stable walking, accurate ball control, reliable ball perception, and good self-localization. This is derived also from the code sharing policy adopted by the league. “A drawback of this policy is a potential reduction in diversity, since many teams prefer to improve on existing successful techniques rather than try to invent radically new ones” as written by the organising chair

of the Four-Legged League[2]. Code sharing is possible because, all teams uses a common platform: the Sony AIBO robot. This year there was three technical challenges: 1) to score with a black and white soccer ball in an empty field; 2) to visit 5 points defined by their (x, y) coordinates with the colored landmarks removed; 3) to traverse the field while avoiding collisions with 7 static robots. The result of the first challenge was rather deceiving. Only 9 teams out of the 20 who tried the challenge managed to perceive the ball and to make contact with it. The second challenge showed that localization without colored landmarks can be achieved, and several teams managed to get around the target points. The third challenge was much more successful, showing that the league is ready to get more serious about collision avoidance. Of the 20 teams who tried this challenge, none collided with more than 3 obstacles.

Small-Size League: This year competition saw 20 teams from all over the world. The results of the final stage of the tournament is reported in Fig. 8. This year there was no quarter finals because there was a second round robin with four groups of three teams. The winners of each group progressed to the semifinals. This was to maximize the games for each team while minimizing field changes. In Small Size League field changes are hard because the teams have to unmount, mount and recalibrate their cameras.

Fig. 7. A phase of a game of the **Small Size League** tournament.

The winners were: first place, BigRed'03 from Cornell University U.S.A., second place RoboRoos from The University of Queensland, Australia and third place FU Fighters Freie Universität Berlin, Germany.

[2] ibidem.

This year a "referee box" was introduced, i.e. all commands which the referee can communicate to the teams, were sent directly to the software controlling each robot team from a laptop operated by the assistant referee. The result was that there was no human intervention during the game and the game flow was greatly improved. All teams used one or two cameras, placed 3m above the field to extract the position of the ball and of the robots.

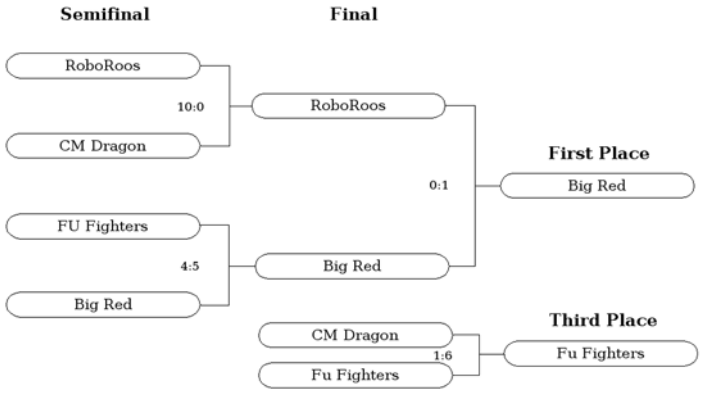

Fig. 8. The results of the games of the final phase of the **Small Size League** tournament.

This year there was a certain convergence on the robot design as most teams adopted an optimized solution. Almost all teams used omnidirectional wheels with three or four of those wheels per robot. The additional maneuverability of this solution made the two-wheel configuration almost obsolete on this league. Most top teams focused on having an efficient dribbler and kicker. A dribbler is a set of rotating rubber cylinders that transmits a backspin to the ball keeping it almost glued to robot even when it is travelling on the field. It was a general concern that this feature was overused and some kind of limitation should be imposed for next years' competitions.

Middle-Size League: The Middle-Size tournaments saw 24 teams from 11 countries participating in 2003. Although 32 teams qualified for the games, finally 8 teams could unfortunately not take part. The main reason was lack of financial resources or not-finished robots. Only a few teams did not take part due to missing student resources. The tournament was played on four fields, thus opening the opportunity to play four games in parallel using one hour time slots. The organizing committee decided to play two round robins in order to maximize the number of games for each team. The results of the final section of the tournament are reported in Fig. 10

As pre-condition for qualification, each team had to submit a team description paper. These papers concentrate on the research focus of the team. All

Fig. 9. A picture of the match between the AIS-Musashi team and the AllemaniACs team in the **Middle-Size League**.

hardware and software details of the robots - which had been included in the team description paper in the last years - were collected systematically by a newly introduced Team Questionnaire. The intention of the Questionnaire is to support information exchange between existing teams and to lower the entrance barrier for new teams that want to join the Middle-Size-League. In addition, the material collected in the Questionnaire provides a concise overview of the methods and technologies used by the teams. The questionnaires of all participating teams are contained on the CD-ROM of this book.

A larger field of play (i.e. $10 \times 8m$) and removed poles around the field were the major rule changes for 2003. Nearly all participating teams did not have problems with this changed field set-up. The security bar around the field turned out to be suitable and sufficient to prevent robots from leaving the field.

The challenge competition consisted of two challenges. Challenge 1 was performed as described in the Middle-Size-League rules of 2003. The team leaders decided during the tournament to perform the second part of the challenge competition as free challenge. The free challenge was a five minutes oral presentation and a short demonstration of innovative results each team wanted to demonstrate. A jury consisting of all team leaders voted on the performance of this challenge and awarded points from 0 to 6 to each presentation. Some teams demonstrated challenges like proposed in the rules, i.e., co-operative behavior or the ability to play with a standard FIFA ball. Other teams gave an insight into ongoing research, new robot developments or special behaviour capabilities of their robots. This includes for example studies on new ball stopping mechanisms, robots playing continuously passes or soccer playing behaviors that had been evolved in a physical robot simulator. The winner was the team Attempto! Tübingen from Germany.

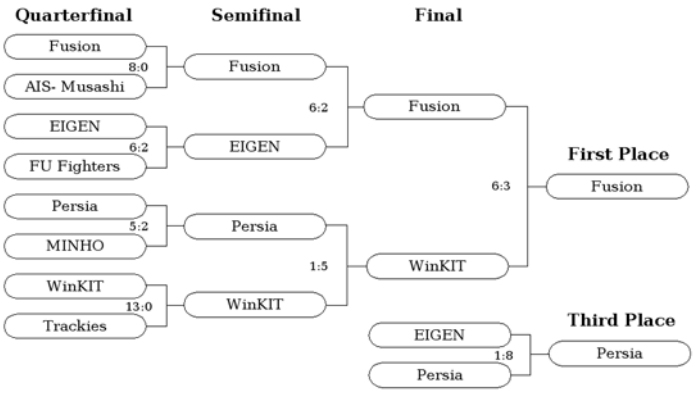

Fig. 10. The results of the games of the final phase of the **Middle Size League** tournament.

Playing the challenge competition at the end of the tournament turned out to be problematic, since not all teams were able to participate. The main reason was broken robots. In future, it should be considered to have the challenges before the start of the round robin and to use their results at least as an additional criterion for the assignment of teams to groups for the first round robin.

Humanoid League: Started in the previous year, the Humanoid League is still rapidly developing. The Humanoid league has different research issue to face with respect to the other leagues. The main difference is that the dynamic stability of robots needs to be well maintained while the robots are walking, running, kicking and performing other tasks. Furthermore, the humanoid soccer robot will have to coordinate perceptions and biped locomotion, and be robust enough to deal with challenges from other players. Test-games could be performed. However, the competition consisted of four non-game disciplines, namely standing on one leg, walking, penalty kick and free style. A number of excellent robots were presented in the competition.

After a good competition with tight results the team HITS-Dream of the Honda International Technical School's received the Best Humanoid Award. In the Walk Competition HITS-Dream (Japan) won the first place, Senchans (Japan) the second place, and Foot-Prints (Japan) the third place. In the Penalty-Kick Competition, Foot-Prints (Japan) ranked first in the class of the robot shorter than 40cm and Senchans (Japan)ranked first in the class of the robot under the 80cm. In the Free Performance Competition the winner was Robo Erectus (Singapore), the second place was of Isaac (Italy) and the third place of Tao Pie Pie (Canada).

Humanoid soccer robots are complex machines, which should have advanced abilities from very different fields of technology, namely materials, locomotion, manipulation, power, communication, perception and intelligence.

Fig. 11. A picture of the five minutes talk allowed to the teams for explaining the free performance their are about to demonstrate in the **Middle-Size League**.

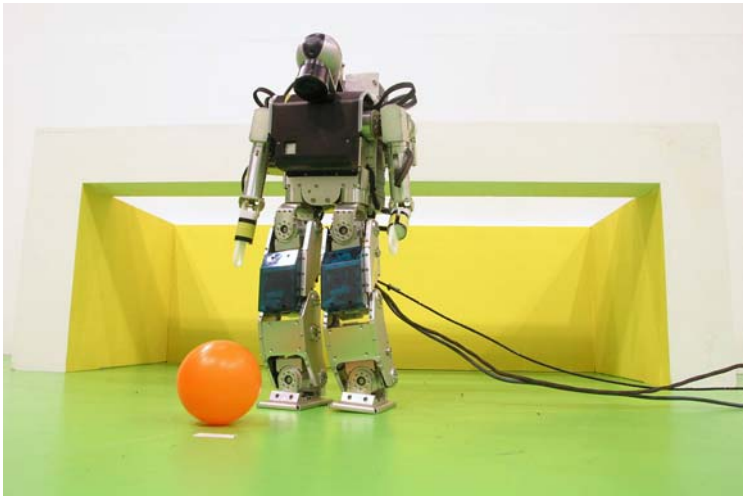

Fig. 12. A picture of a game in **Humanoid League** Soccer Competition.

3.2 RoboCup Junior

RoboCup Junior 2003 involved 74 teams (258 participants) from 16 countries world-wide. In Padua, teams could enter four different challenges: one-on-one soccer, two-on-two soccer, dance and rescue. Three different age groups were

Fig. 13. A picture of a game in **RoboCup Junior Soccer Competition**.

represented: primary (up to age 12), secondary (age 12-18, or end of high school) and undergraduates. The biggest changes in the event from 2002 were the introduction of a newly designed rescue challenge and the development of a new entry-level soccer league for undergraduates, called the *ULeague*. Note that some teams entered more than one challenge within their age group.

At RoboCup Junior 2003, soccer remained the most popular challenge, engaging 67% of teams overall. Some of the secondary students took advantage of state-of-the-art technological improvements and used, for example, magnetic sensors for direction and ultrasonics for collision avoidance. LEGO Mindstorms continues to be the most popular medium for robot construction but many teams, particularly in Asia, use the Elekit SoccerRobo. More advanced teams, most notably from Australia and Germany, even constructed their hardware completely from scratch.

RoboCup Junior has seen strong growth in the number of female participants, particularly in the dance challenge, which provides a unique outlet for creativity. While RCJ attracts in total an average of 15% female students overall (increased from 10% in 2000), the dance challenge at RCJ-2003 had 31% female participation.

3.3 RoboCup Rescue

Real Robot League: RoboCup 2003 hosted the third Rescue Robot League competition, which included 12 teams from 8 countries. The winning teams were: first place ROBRNO team from the Czech Republic, second place CEDRA from Iran, and third place was IUT-MICROROBOT from Iran. Only one team demonstrated autonomous mapping during the competition, but did not

Fig. 14. The blimp used by the UVA -Zeppelin team of the University of Amsterdam in the **Real Robot Rescue League** tournament.

contribute quite enough points to earn a place award. There were other interesting approaches: fully autonomous robots, a robot almost directly from the Middle-Size League, and even a blimp. Although two teams demonstrated fully autonomous robots capable of navigating parts of the yellow arena, they didn't produce maps showing victim identifications so did not score well. Meanwhile, the remotely tele-operated teams showed very few autonomous behaviors to assist their efforts, although several teams were working toward such capabilities.

To evaluate the performances of the teams, the metric of Fig. 15 was used. This takes into account the quality of the output map, the quality of the robot sensing and the motion skill of the robot.

$$\text{ARENA WEIGHTING} \left(\frac{\text{MAP QUALITY} + \text{VICTIM LOCATION} + \text{VICTIM TAG} + \text{VICTIM SITUATION} + \text{VICTIM STATE} - \text{ARENA BUMPING} - \text{VICTIM BUMPING}}{\left[1 + \text{NUMBER OF OPERATORS} \right]^2} \right)$$

Fig. 15. The metric used to calculate the performances in the **Real Robot Rescue League** tournament.

Simulated League: In the RoboCup-2003 Rescue Simulation League tournament, 17 teams participated. Many teams were here competing for the first time. In fact, after RoboCup-2002, useful tools like Java based agent developing kits, JGISEdit, and a Multi-platform map editor with the map of the city of Foligno (Italy) were provided and this helped new comers to join rescue community.

This year the map of Foligno was adopted as an official map at competition. This map was chosen in order to easily convey the importance of RoboCup Rescue to the general audience, especially the Italian audience. In fact, Foligno is an Italian city that was seriously damaged by an earthquake. The Foligno map is bigger twice than the two traditionally used maps, Kobe and Virtual City. The adoption of the Foligno map was a challenge for the teams competing in RoboCup-2003. In the preliminary games, all team did rescue operations at two disaster situations per three different maps. The winners of Simulated Rescue competition were: first place ARIAN team, Sharif University of Technology, IRAN, second place YOWAI, University of Electro-Communications, JAPAN, and third S.O.S, University of Technology, IRAN.

With respect to the games played in RoboCup-2002, the teams showed increased abilities both in the single autonomous agents (fire fighter, police agent, and ambulance) and in the cooperation abilities among the agents. In order to improve the capability of their agents the teams used on-line learning methods for rescue formation, clustering methods or agents group formation mechanism.

4 Special Content of the CD-ROM

Due to the always increasing number of participating teams in the competitions, it is no longer possible to include the Team Description Paper in the RoboCup book. Nevertheless, the teams are the engine that move the RoboCup event and the innovations introduced by the teams are the real thrust that moves forward research. In order not to disperse the knowledge and the innovations proposed by the teams during the RoboCup 2003 competition, we proposed to include with this book a CD-ROM containing the Team Description Papers of the teams that participated in Padua. The Team Description Papers have been edited and revised after the competitions in Padua. We expressly asked the teams to critically analyse the performances of their robots during the competition by discussing which solutions and techniques proved to be effective (or proved not to be effective at all).

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