RoboCup Mixed Reality Competition

Irina Gulakov[1], Marco A. C. Simões[2], and Ramin Fathzadeh[3]

[1] Ostfalia Hochschule für angewandte Wissenschaften, University of applied Science, Wolfenbüttel, Germany
i.gulakov@ostfalia.de
[2] Bahia State University, Computer Architecture and Operating Systems Research Group (ACSO/UNEB), Salvador,BA,Brazil
msimoes@uneb.br
[3] Mechatronics Research Laboratory, Department of Computer Engineering, Islamic Azad University, Qazvin Branch, Qazvin, Iran
fathzadeh@qazviniau.ac.ir

Abstract. This paper describes the most recent RoboCup competition: Mixed Reality. This competition was part of RoboCup 2007 in the Simulation League and its evolution is described here. Many teams from almost all parts in the world had participated in previous Mixed Reality editions. An overview of the competition hardware and software infrastructure is described and a road map for the future of this competition in RoboCup is presented.

1 Introduction

RoboCup is an international research and education initiative, which maintains the Mixed Reality competition. We want to introduce this fascinating challenge in the first official paper to you. But why is the Mixed Reality so interesting?

Our answer about that would be following: it brings the virtual life and real life together. It is neither simulation, nor completely real. It is both of them.

The idea of this project was developed about two years ago while we were thinking how to mix up the two already fixed leagues. Sometimes good artificial intelligence (AI) strategies are validated in Simulation competitions, but when researchers try to evaluate them using physical robots (like small size league or medium size league for example) they do not work or need to be partially re-invented to work. Mixed Reality can fill this gap between Simulation and Physical Robots Leagues. The idea in the future is to run Simulation agents with no changes using real micro-robots. It is clear that these algorithms validated in a Mixed

Reality environment has more chances to work fine in physical robots leagues.

Other important gap filled by Mixed Reality are the one between RoboCup Junior and Senior Leagues. Many young guys who participate in RoboCup Junior experience some difficulty when they try to be initiated in Simulation or Small Size leagues, for example. Mixed Reality is aimed to provide an easy programming interface for agents so undergraduate students in the first years can learn how to program these micro-robots in few time. We have some successful experiences using our micro-robots for educational purposes [1, 2].

Flexibility is another requirement present in Mixed Reality System. At this moment the main focus is soccer challenge. But, it is easy to replace soccer by other challenge like rescue, autonomous urban vehicles or any other scientific or educational application. To do this, it is only necessary to replace the Soccer Server by another Application Server. This way, Mixed Reality can be in a short future an important testbed for artificial intelligence and mobile autonomous robotics.

The first idea was really small-sized. A mini display and four micro-robots. The server had to be constructed, the clients invented and much more to do. With handling the server, it was possible to play the first game 2 vs. 2 as you can see in figure 1.

Micro-robots autonomous playing made us proud, but we wanted more. The second idea was to play 5 vs.5. So we needed a bigger display, more robots, better server etc. At this time, more teams wanted to join us. Teams from all over the world started to get interested in this project.

Now there was a competition about the best client and artificial intelligence. The time was ready for first real games. So we started to play on the RoboCup Open games. Like German Open, Iran Open, Brazil Open, Japan Open and Latin American Open. We received a good feedback of all teams, which took part in our challenge. They approved the current system and thought that this project was a good invention.

At the moment there are some other increments planning. For example we want to start up an 11x11 competition in 2011. How to realize this we are not sure yet, but we have some relevant ideas. With enough support this is feasible until 2011.

On the following sections we explain which other projects are planned and how we want to handle them. Section 2 describes Mixed Reality short

history in RoboCup. Section 3 contains a brief description of hardware and software infrastructure. Section 4 presents the current road map discussed by teams and refined by current Organization Committee.

2 Mixed Reality Competiton in RoboCup

The use of miniature robots in RoboCup competitions with benefits to the global RoboCup goal was presented in previous works[3–7]. The Mixed Reality System not only brings RoboCup closer to its goals, it also fills an important gap between RoboCup Junior and Senior leagues. Undergraduate students can develop their own teams in a limited time even with few knowledge about multi-agent systems and artificial intelligence. With an easier starting point, people from RoboCup Junior challenges can participate and contribute to senior leagues in a more natural and progressive manner. This section describes Mixed Reality competitions in RoboCup since 2007. There are some videos of official and test matches available on YouTube[1].

2.1 RoboCup 2007

In 2007, Mixed Reality was presented as an official RoboCup event for the first time. It was named **Physical Visualization Sub-league** (PV) and was part of **Soccer Simulation League**. It shared the same Organization Committee with Simulation League.

The qualification process to RoboCup 2007 required candidate teams to submit a research proposal using PV Sub-league robots and infrastructure. Three reviewers were randomly assigned to review each proposal according to a set of objective and subjective criteria. Out of 27 applications only 12 teams with the highest scored reviews were qualified.

Table 1 lists qualified teams for RoboCup 2007. Except teams Austin Vila and FEUP-5DPO, the other 10 teams were present in Atlanta for RoboCup competition. PV Sub-league was divided into three competitions[5]:

i. electronics & firmware competition;
ii. educational games competition;

[1] See playlist RoboCup MR in `http://www.youtube.com/view_play_list?p=9E1B0D33C6668457` to watch videos.

Team	Institution	Country
Brazil-PV1	Bahia State University (UNEB)	Brazil
Brazil-PV2	FURG / NAUTEC	Brazil
Brazil-PV3	UFRN / LAR	Brazil
UManitoba	University of Manitoba	Canada
WF Wolves	Univ.A.Sc. Wolfenbuettel Comp. Science	Germany
UI-AI	University of Isfahan	Iran
SOCIO	Osaka Prefecture University	Japan
HELENA	Osaka University / Asada Laboratory	Japan
FEUP-5DPO	Faculty of Engineering / Univ. Porto	Portugal
FC-Portugal	University of Aveiro / Univ. of Porto	Portugal
City United	AIS group / City University	United Kingdom
UT Austin Villa	The University of Texas at Austin	USA

Table 1. Teams qualified for RoboCup 2007 PV Sub-league

iii. undergrad team development competition.

In the first competition, teams had the opportunity to contribute with new ideas for the electronic aspects of the system as well as robot's firmware. Also infrastructure software, such as vision system, soccer application server and others, were included in this competition. Later, this competition was renamed to technical development competition.

In the second competition, teams came up with different game ideas using the system in which they teach concepts related to common subjects ranging from basic computer programming to very specialized topics related to multi-agent systems and artificial intelligence.

The last competition allowed undergraduate students to develop complete teams of their own within the typically limited time window of their courses. The teams were based on a simplified soccer game framework allowing easy development that required only a very limited amount of knowledge. All contestants had an equally limited amount of time for the development of their teams, thus giving similar advantages to teams with limited time to spare. Game rules and supporting software was officially released just a predefined amount of months before the games. In Atlanta we had 2 vs. 2 matches lasting 1 time of 10 minutes. Figure 1 shows one of the matches during RoboCup 2007.

Although all these three competitions were held in Atlanta, most teams had no or few contributions to competitions **i** and **ii**. Most teams presented only proposals, but no developed solutions or prototypes. The exception was team HELENA who developed all the infrastructure for

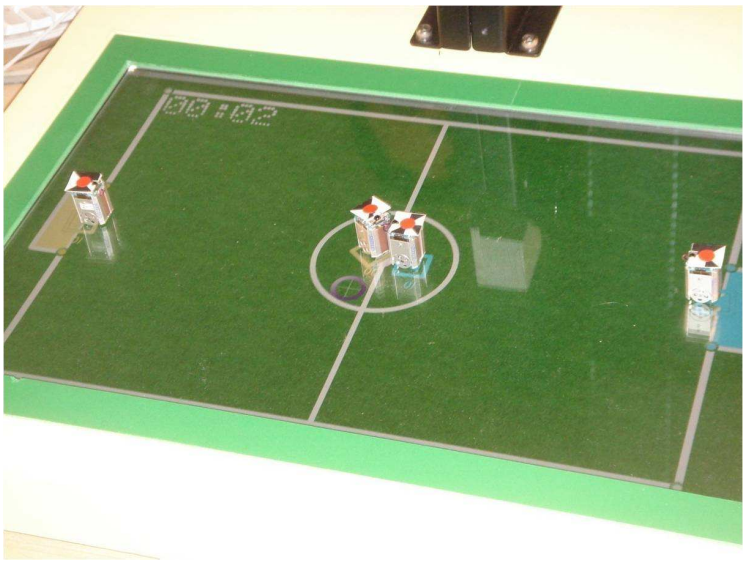

Fig. 1. 2 vs. 2 matches during RoboCup 2007 in Atlanta.

soccer tournament in Atlanta including vision system, infrared communication protocol, soccer application server and robot's design and firmware. This way, team HELENA was the champion of both competitions.

Competition **iii** - soccer tournament - was very exciting. All 10 teams developed their strategies during a limited amount of time. Teams were divided into two groups. A round robin schedule was defined within each group. Two teams qualified from each group for semifinals. Teams SOCIO and Brazil-PV1 qualified from group A and teams FC-Portugal and UI-AI qualified from group B. Semifinals and finals scores are listed on table 2. FC-Portugal was the champion after penalties shot tie-break.

Each competition had the same weight on the global Sub-league ranking. The champion of each competition received 5 points to the global ranking, runner-ups received 3 points and 3^{rd} places received 2 points. All participating teams received 1 point for each competition. Team HELENA - champion of competitions **i** and **ii** - was the first PV Sub-league champion.

2.2 RoboCup 2008

In 2008, Physical Visualization was renamed to **Mixed Reality** (MR) and gained the status of official competition in simulation league. This

Semifinals		
Brazil-PV1	0 x 1	FC-Portugal
SOCIO	1 x 2	UI-AI
3^{rd} **Place Match**		
Brazil-PV1	0 x 2	SOCIO
Final		
FC-Portugal	1 x 1	UI-AI

Table 2. Semifinals and Finals matches in RoboCup 2007.

year, many technical improvements were tested during official competition. The major improvement was the new robot model, with similar dimensions and better robustness. Figure 2 shows both versions.

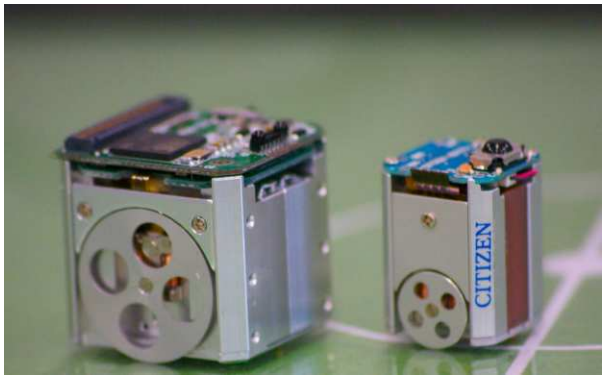

Fig. 2. Two versions of micro-robots: the left one is the 2008 version and the other is 2007 version.

Other important improvement was the new software architecture to support soccer matches during RoboCup. In Atlanta, the software was based on a monolithic architecture developed as a prototype to run competitions in 2007. At the end of RoboCup 2007, many teams agreed to develop applications capable of supporting this new Mixed Reality System. Figure 3 shows the new software architecture for Mixed Reality. The development was performed in a distributed way. Each team was responsible for one specific module.

Vision Tracking and **Graphics** were developed by team MR Koblenz (a new team who joined MR in RoboCup 2008). **Robot Control** was de-

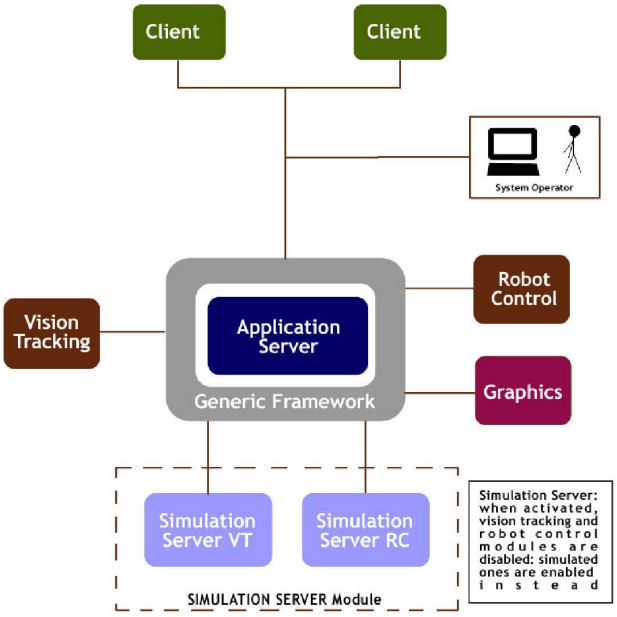

Fig. 3. New software architecture developed for RoboCup 2008.

veloped by team WF Wolves in partnership with Technical Committee (TC). The Soccer Application Server was developed by team BahiaMR (renamed from team Brazil-PV1 in RoboCup 2007).

TC was responsible to provide integration of all modules. An XML specification was developed and improved by the teams in order to have a standard protocol released a few months before competitions. As the teams did not reach an agreement over the final protocol specification on the required time, the schedule was impaired and the integration tests were only performed during RoboCup 2008.

The qualification process was based on TDP submission. Thirteen teams (see table 3) were qualified but only nine teams were present in Suzhou. This year, there were three competitions again. Competition **i** was renamed to Technical Development Competition. Its scope is the same described in section 2.1. Competition **ii** was renamed to Application Development Competition. This competition was expanded to include any kind of application, not only educational ones. Any scientific or educational application could be presented on this competition. Competition **iii** was renamed to Soccer Tournament. The idea was the same

as in Atlanta. The intention was to get 4 vs. 4 or at least 3 vs. 3 matches, but this year we saw again 2 vs. 2 matches lasting 2 times of 5 minutes using the new micro-robots.

Team	Institution	Country
BahiaMR	Bahia State University (UNEB)	Brazil
FURGBOL PV	FURG / NAUTEC	Brazil
Keystone MR	University of Manitoba	Canada
MR Koblenz	Univ. of Koblenz	Germany
WF Wolves	Univ.A.Sc. Wolfenbuettel Comp. Science	Germany
Kshitij	International Institute of Information Technology	India
UI-AI	University of Isfahan	Iran
SOCIO	Osaka Prefecture University	Japan
Tatsuno Otoshigo	Meijo University	Japan
Tecnorregos	Tecnológico de Monterrey	Mexico
5DPO	Faculty of Engineering / Univ. Porto	Portugal
FC-Portugal	University of Aveiro / Univ. of Porto	Portugal
UT Austin Villa	The University of Texas at Austin	USA

Table 3. Teams qualified for RoboCup 2008 Mixed Reality Competition.

The integration testing and debugging task was too time consuming during RoboCup so soccer tournament had its schedule affected. When teams and TC got a working system, there were only two days left for soccer competition. The system was based on new micro-robots and robot control, but using the old soccer application server, old vision system and old graphics monitor. This setup was used because there was not enough time to integrate all new modules in a stable system.

The soccer tournament was held in a partial round robin schedule. There was a draw to divide teams into three groups of three teams. Each team played two matches against the teams in the same group. After that the teams who scored more points in this phase qualified to a final match. The final match was WF Wolves vs. UI-AI and WF-Wolves was the champion of soccer tournament competition.

The other two competitions were based on presentations made by each team and an election where each team had one vote using an evaluation form provided by organization committee (OC). Team MR Koblenz was the champion of the Application Development Competition and team WF Wolves was the champion of the Technical Development Competi-

tion. With these results, team WF Wolves was the general champion of the Mixed Reality Competition in RoboCup 2008.

2.3 RoboCup 2009

Some people who was elected for OC and TC in Simulation League to deal with Mixed Reality issues resigned from these committees. This way there was no time to organize the competition again as an official competition of Simulation League in 2009.

People from team WF Wolves decided to take the organization of Mixed Reality as a Demo Competition in RoboCup 2009. The main goal of this demo event was to show that it is possible to run autonomous 5 vs. 5 soccer matches in the new stable Mixed Reality system. For this reason the competition only had the soccer tournament in Graz. Seven teams registered to Mixed Reality competition as can be seen in table 4.

Team	Institution	Country
BahiaMR	Bahia State University (UNEB)	Brazil
WF Wolves	Univ.A.Sc. Wolfenbuettel Comp. Science	Germany
RT Lions	Reutlingen University	Germany
Northern Stars	University of Applied Sciences Kiel	Germany
Osna-Be!	University of Osnabrueck	Germany
MRL	Qazvin Islamic Azad University	Iran
Fukui-United	Fukui National University of Technology	Japan

Table 4. Teams registered for RoboCup 2009 Mixed Reality Competition.

The whole system developed in 2008 was integrated and worked in a stable way. The soccer tournament has now rules based on other RoboCup leagues. For example, when a team is losing the game by ten goals, it can ask for a break-out, ending the match. Now the games are more autonomous because the new MR-SoccerServer[8] provides an automatic referee who defines goals, goal kicks and corner kicks during match. It also controls time and timeouts. This way there were only few human interferences during matches. It was only necessary to pause the game and reposition robots when they were stuck for any reason.

During RoboCup 2009 we had very stable 5 vs. 5 matches, with many competitive and balanced games. Figure 4 shows an image of a match in Graz. The schedule was a round robin tournament where the

Fig. 4. 5 vs. 5 match during RoboCup 2009 in Graz.

best four teams qualified for semifinals and finals matches. Teams BahiaMR, Osna-Be!, RT Lions and MRL were qualified to semifinals.

Semifinals		
RT-Lions	3 x 2	BahiaMR
Osna-Be!	4 x 3	MRL
3^{rd} **Place Match**		
BahiaMR	3 x 0	MRL
Final		
RT-Lions	4 x 3	Osna-Be!

Table 5. Semifinals and Finals matches in RoboCup 2009.

Table 5 shows the scores in final matches. RT-Lions was the champion. During RoboCup 2009, there was also a pick-up competition where people were invited to develop a simple team for 2 vs. 2 matches. Many teams participated and became interested in joining Mixed Reality Competition in the next year. Also, many teams who participated in 2007 and 2008 competitions confirmed their interest in still participating on Mixed Reality in 2010.

The stability of the system added with the interest of general public and other teams in Graz is an important indication to organize Mixed Reality as an official competition again in RoboCup 2010. One important decision was the election of a TC and OC. TC is formed by José

Grimaldo Filho (Brazil), Sebastian Ott (Germany) and Vahid Mokhtari (Iran). OC is composed of Marco Simões (Brazil), Irina Gulakov (Germany) and Ramin Fathzadeh (Iran). These people are responsible for organization and technical issues of Mixed Reality Competition for RoboCup 2010.

2.4 National RoboCup Competitions

As part of the cooperative development of Mixed Reality infrastructure, many teams organized competitions in their countries during National Robocup events.

The first one was RoboCup Brazil Open 2007 in Florianópolis, Brazil. On this competition three Brazilian teams (BahiaMR, POTI and FURGBOL) competed with the same rules and system from Atlanta but using a larger screen as field. After a round robin tournament, BahiaMR and FURGBOL qualified for final match. The final score was BahiaMR 2x1 FURGBOL, and BahiaMR was the champion.

German Open 2008 in Hannover also had a Mixed Reality competition with three German teams and one Brazilian Team. MR-Koblenz from Germany and BahiaMR from Brazil were the finalists and MR-Koblenz was the champion. The rules and system was the same used in Atlanta, but some demonstrations on new software modules was presented. The same system was also used in Iran Open 2008 and Japan Open 2008.

In Latin American and Brazilian RoboCup Open 2008 in Salvador, Brazil, the new MR-SoccerServer was used for the first time. There was a competition with 2 vs. 2 matches using the old version robots and the new MR-SoccerServer. Teams BahiaMR and FURGBOL were the finalists and BahiaMR was the champion after penalty shots tie-break. The score in regular time was BahiaMR 1x1 FURGBOL.

The new system was used again, but now with the new robots in German Open 2008. At this time there were 4 vs. 4 matches. Four German teams competed and RT-Lions was the champion after the final match against Osna-Be!.

Iran Open 2009 used the same system but now with 3 vs. 3 matches. Two teams competed, one from Iran (team MRL) and other form Germany (team WF Wolves). MRL was the champion.

The last competition before RoboCup 2009 was Japan Open in Osaka. The Mixed Reality competition had three Japanese teams and one Brazilian team (BahiaMR). Teams BahiaMR and Tatsunootoshigo were the finalists and the Japanese team was the champion. On this competition, there were 5 vs. 5 matches with the entire new system being used. No bugs were reported about the new software.

These national competitions were very important to test the new system in a real competition environment. Problems and bugs detected were reported after each competition and the system was continuously improved to reach the stability presented in Graz.

3 The RoboCup Mixed Reality System

The structure of MR system is depicted in figure 5. This system is constructed of a set of micro-robots, a high resolution camera, an IR transmitter and a horizontally placed $42''$ screen that displays the simulated soccer field [7].

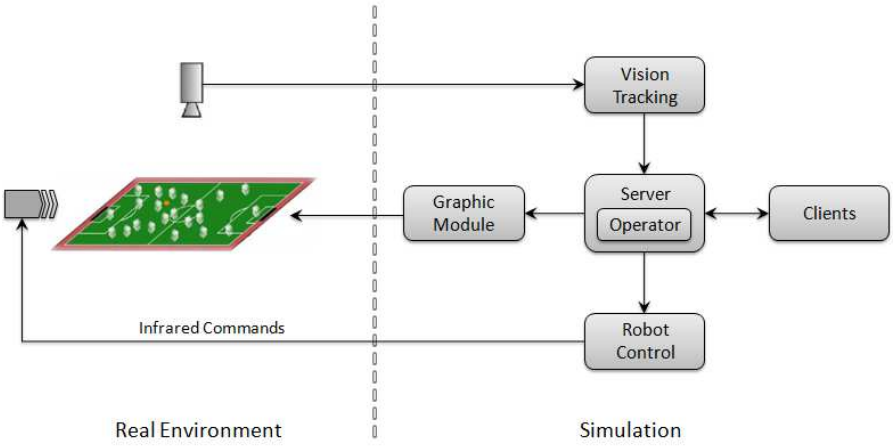

Fig. 5. The structure of Mixed Reality System.

The camera above the screen captures the field. By image processing, positions and directions of micro-robots are generated. In order to achieve this, a unique marker is placed on the head of each micro-robot.

The camera should have high resolution and good frame rate to distinguish these markers.

3.1 The Micro-robots

These micro-robots have been built in dimension of $2.5cm^3$ by CITIZEN Corporation. The body and control board are the main parts of the micro-robots. The body has two wheels and each wheel has a lithium ion battery and a step-motor.

The controlling board can be attached to the micro-robot through a standard connector. The board has a powerful ARM microcontroller and a AVR processor dedicated to control the step motors. This board also has an IrDA transceiver capable of up to 115kbps of data rate allowing bidirectional communication between the micro-robots. On the top of the board there is an 80 pin connector which gives access to all pins of the ARM controller and power supply allowing easy implementation of expansion boards [3]. The current robot model is being used since RoboCup 2008 and is illustrated in fig. 2.

One of the prospective issues in control board is replacing the Infrared module (IR). IR communication module has some limitations in which involve line-of-site drawback, disability to transmit data through obstacles, high intensity to fluorescent light, low distance range and some others. So designing a control board based on Radio Frequency (RF) or other communication technology is an important effort that is being evaluated by Technical Committee.

3.2 Simulation Architecture

The main role of MR system is Simulation. Referee, ball, field, etc are the samples of simulated objects in this system. Simulation can reduce the dependency to hardware devices, for example the micro-robots have a simulated kicker. Also the simulation can provide a standard platform to develop and implement AI algorithms. The different modules of simulation involve *Soccer Server*, *Soccer Operator*, *Graphic Module*, *Vision Tracking*, *Robot Control* and *Client* shown in the figure 5.

Soccer Server controls and manages the flow of information. All modules send data to the server and server process and parse data and send it again to the modules. Server processing includes the simulation

Fig. 6. Simulator is a useful tool to develop agents.

of the virtual portion of Mixed Reality world. For example, server simulate physics when a robot collides with a goal pole or the ball. Server also simulates a virtual kicker for robots turning the robots able to kick the virtual ball. An automatic referee is also included in *Soccer Server*.

Soccer Operator is a simple interface that allows a human referee to send commands such as pause, stop, and restart. *Graphic Module* renders the field and all simulated objects and displays these objects on the screen. *Vision Tracking* receives the captured images from camera and uses image processing to generate the position and orientation of micro-robots on the field. Sending IR signals to micro-robots is done by *Robot Control*. This module receives the agent commands from the server and converts them to low-level commands and sends them to micro-robots through IR.

Clients act like the brain of micro-robots. In each cycle, client receive data from server and send the commands to micro-robots after processing. In fact developing and carrying out the AI algorithms for game strategy and robots behaviors are done in this part of simulation. Clients are the part of simulation developed by teams to participate in soccer com-

petitions. Each robot is controlled by an independent client. No direct communication is allowed between clients in current rules.

Additionally MR system has a *Simulator* module which can simulate all hardware modules of MR system and helps teams to implement and test their AI algorithms. A screenshot of a 5 vs. 5 soccer match with no needs of any camera, real micro-robots and IR transmitter is shown in figure 6.

4 Mixed Reality Road map

During all RoboCup competitions, teams participating on Mixed Reality discussed goals for MR competition and a road map for MR so it can be useful for RoboCup main goal. In this section we will briefly describe current road map.

This road map is based on some long-term goals:

- consolidate a stable platform to support migration of high-level AI contributions from simulation league to physical robots league;
- provide an *entrance door* for guys coming from RoboCup Junior to RoboCup Senior Leagues;
- provide a stable educational platform for technical or undergraduation courses about introduction to robots' programming;
- provide a generic Mixed Reality framework for educational and research applications supporting other challenges besides robotic football.

To meet these goals, we have discussed a short-term planning that generated the following short-term goals listed by year:

2010:

- Mixed Reality back as a RoboCup official competition;
- new standard vision system providing more stable perceptions to agents;
- new or modified controller board for robots resulting in a more stable behavior during matches;
- Pick-Up competitions to attract more teams for this competition.

2011:

- full autonomous matches with no human interference at all;

– 11 vs. 11 matches;
– return of new Applications competition;
– new Robot Design proposal (may be a specific competition ?);
– more realistic football rules like goal kicks, corner kicks, offside, etc.

2012:

– New robot used in competitions with new communication system, other than infrared;
– provide an abstraction layer for clients with the same primitive actions used in 2D Simulation League. This way it will be possible to migrate 2D high-level strategies to Mixed Reality in an easier fashion.

TC is currently working hard to get all 2010 goals ready up to November, 30th, 2009. The idea is to provide a trustable system description for all teams interested in participate on Mixed Reality in Singapore as early as possible.

Maybe that a goal predicted to 2012 (new communication system) can be met before it. One of the candidate solutions for a new controller board for 2010 robots include a RF communication system. If this is the choice of TC for 2010 we can meet two goals with one solution.

We are sure that if we follow this road map, Mixed Reality can be an important competition to get RoboCup Simulation and Physical Robots' leagues closer helping to support the RoboCup main goal in 2050.

5 Conclusion

This paper described the RoboCup Mixed Reality competition. Mixed Reality is an innovative concept that lead to mixing real and virtual elements in the same environment. For RoboCup it is a good idea to mix the current successful Simulation league and Physical robots leagues. Mixed Reality is the solution to do this.

The reason to divide the Soccer challenge into many leagues is to deal with different variables and levels of abstraction of the problem. It is necessary that, sometime in the future, these leagues start to converge to an unique Humanoid 11 robots team which will face the 2050 RoboCup challenge. Mixed Reality can be a first step in this direction.

All teams who have experimented to migrate high-level strategies from Simulation League to a Physical robot team know that this is too

time consuming and demands many adaption. The MR competition is a first step to turn Simulation and real world closer and so begin the necessary convergence of RoboCup leagues.

Providing an easy programming interface, MR will also become an important attraction factor for undergraduation students and those coming from RoboCup Junior. Current students are the future RoboCuppers, so it is very important to attract more students for this initiative. This way we can have more confidence to meet RoboCup main goal.

Beyond RoboCup, MR competition can become a stable and flexible testbed for advanced research initiatives in RoboCup related themes. It is possible to change the application used, replacing soccer by other challenge in an easy fashion.

Teams from four continents have participated in RoboCup last year. In its first year, 27 teams were interested on this platform. During all competitions, general public was very interested in seeing so small robots playing soccer. Many teams with previous experience in other RoboCup leagues are interested and working hard to follow the described road map. It is clear that Mixed Reality has the RoboCup community support. We are sure that the conduct of Mixed Reality as an official RoboCup competition in Singapore is the right choice to start the leagues convergence and turn easier to meet the 2050 main goal.

References

1. da Silva Guerra, R., Boedecker, J., Mayer, N., Yanagimachi, S., Ishiguro, H., Asada, M.: A new minirobotics system for teaching and researching agent-based programming. In: Computers and Advanced Technology in Education, Beijing (2007)
2. da Silva Guerra, R., Boedecker, J., Ishiguro, H., Asada, M.: Successful teaching of agent-based programming to novice undergrads in a robotic soccer crash course. In: 24th SIG-CHALLENGE Workshop. (2007) 21–26
3. Guerra, R., Boedecker, J., Mayer, N., Yanagimachi, S., Hirosawa, Y., Namekawa, K.Y.M., Asada, M.: Citizen eco-be! league: bringing new flexibility for research and education to robocup. In: 23th SIG-CHALLENGE Workshop. (2006) 13–16
4. Guerra, R., Boedecker, J., Yamauchi, K., Maekawa, T., Asada, M., Hirosawa, Y., Namekawa, M., Yoshikawa, K., Yanagimachi, S., Masubuchi, S., Nishimura, K.: Citizen eco-be! and the robocup physical visualization league. In: Micromechatronics Lectures – The Horological Institute of Japan. (2006)
5. Guerra, R., Boedecker, J., Asada, M.: Physical visualization sub-league: A new platform for research and edutainment. In: 24th SIG-CHALLENGE Workshop. (2007) 15–20
6. Guerra, R., Boedecker, J., Yanagimachi, S., Asada, M.: Introducing a new minirobotics platform for research and edutainment. In: Symposium on Autonomous Minirobots for Research and Edutainment (AMIRE'07), Buenos Aires (2007)

7. Guerra, R., Boedecker, J., Mayer, N., Yanagimachi, S., Hirosawa, Y., Yoshikawa, K., Namekawa, M., Asada, M.: Introducing physical visualization sub-league. In: Lecture Notes in Computer Science. (2008)
8. Filho, J.G., Pimentel, F., Junior, A., Casaes, E., Reichow, J.: Mr-soccerserver: Um simulador de futebol de robôs usando realidade mista. In: IX Regional School of Computer Science Bahia, Alagoas and Sergipe (ERBASE 2009), Ilhéus, Bahia, Brazil, Brazilian Computer Society (SBC) (April 2009) (in Portuguese).