

# A Proposal of Bridging Activities between RoboCupJunior and Senior Leagues

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**Abstract.** We propose new bridging activities between RoboCupJunior (RCJ) and RoboCup senior leagues. Many of RCJ graduates cannot find a suitable way to progress to the senior leagues. Therefore, they often retire from the RoboCup at this stage. A major problem is the technical gap between RCJ and senior leagues. However, if some top-level RCJ teams are provided with sufficient technical advice, they can join senior leagues in a short time. Our proposal aims to achieve this. Since authors have managed RCJ Soccer Secondary class (RCJSS) and RoboCup Soccer Small-Size League (SSL) in RoboCup national competition and know them well, the bridging activities for them are proposed. The first-level activities include the following. (1) RCJSS members visit an SSL competition, watch the game, and understand its rules, and vice versa. (2) We have realized an inter-league game using only the current field and robots in RoboCup National Open 2007. (3) A greater level of interaction is required. When the RCJSS teams require technical assistance or advice, if they are friendly with the members of any SSL team, they can freely seek assistance. The second-level is to form a bridge league between RCJSS and SSL. (1) Rules are introduced from SSL since this league aims to be a stepping-stone to full SSL. The field size is reduced to half the current size of an SSL field. The number of robots is reduced from five to three in order to reduce the parts cost. (2) We prepare development kits for transition. RCJSS teams can develop their robot systems rapidly by utilizing these kits for transition.

## 1 Introduction

We would like to ask the following question to RoboCup senior league researchers. Do you know any of the teams that participate in the RoboCupJunior (RCJ)? In fact, we actually asked many senior league teams this question during the RoboCup JapanOpen 2007. We also asked many RCJ teams whether they were aware of any senior league team. From our questions, we found that 8% (3/39) of the teams in the senior league were aware of RCJ teams, while 18%

(2/11) of RCJ teams knew senior league teams. Overall, only 10% (5/50) of the teams were aware of teams belonging to another league. This clearly shows that the interaction between the teams belonging to the RCJ and senior leagues is insufficient.

The objective of RCJ is described in its official website [1]. According to the league representatives, the RCJ is a project-oriented educational initiative, which is designed to introduce the RoboCup competition to primary and secondary school children, and its focus is on education. From the viewpoint of such an ongoing educational aim, the lack of interaction between the RCJ and senior leagues is not desirable. We believe that interaction and cooperation between the two leagues should be meaningful and effective to improve the current situation. Some activities that will bridge the gap between the two leagues are necessary for this.

We propose new bridging activities between the RCJ and senior leagues. The present authors have been managing RCJ (particularly RCJ soccer) and RoboCup Soccer Small-Size League (SSL) in RoboCup national competitions, and therefore, we are aware of the potential difficulties as well as the possibilities. Hence, we propose an intermediate league between RCJ Soccer Secondary class (RCJSS) and SSL as a specific application of the proposed bridging activities.

Guided by similar desires and motivations, Anderson et al. have proposed the “ULeague”, which is meant for undergraduate students [2]. ULeague is designed as an entry-level league for SSL. Since both ULeague and our proposed league have identical objectives – that is, the formation of an entry-level senior league for RCJ graduates or undergraduate students and focus on SSL – they have identical features in many respects. However, they also have several differences. This is discussed in a later section in greater detail.

Our proposal consists of activities divided into three levels. The first level refers to the initiation of immediate actions, which will be effective in making the interactions between the RCJ and senior leagues more active. The second is the establishment of a bridge league between RCJSS and SSL and providing software- and hardware-development kits for RCJSS teams in order to ease their transition from RCJ to our bridge league or even to the full SSL. The third-level activities would consist of other kinds of assistance.

In Sect. 2, we survey the current status of science education by referring to the PISA report. In Sect. 3, we describe the problems associated with RCJ and senior leagues. In Sect. 4, the details of our proposal are presented. In Sect. 5, we describe the difference between our proposal and previous studies, for example, that on ULeague by Anderson et al. [2]. In Sect. 6, the conclusions from this paper are given.

## 2 Science Education and RoboCupJunior

The OECD Programme for International Student Assessment (PISA) [3] periodically assesses young students’ knowledge and skills. In the latest report titled “PISA 2006 Science Competencies for Tomorrow’s World” [3], the relationship

between students and science is investigated. The chapter titled “Attitudes to science : A profile of student engagement in science” provide an executive summary as well as a more comprehensive analysis of knowledge and skills. In this chapter, for the question, “Do students support scientific enquiry?” the answer is as follows. “In general, students showed a strong support for scientific enquiry. For example, 93% said that science was important for understanding the natural world.” However, for the question “Are students interested in science?” the majority of students reported that they were motivated to learn science, but only a minority reported taking a close interest.

From the viewpoint of science education, the current RCJ activities have achieved success and have made major contributions. Today, there are many branches for managing local RCJ competitions in many countries. Only the winner from these competitions can advance to the next stage, that is, the national championships. Subsequently, only the winner from the national championships can advance to the next stage – the world championships. Thus, the RCJ is established in many countries, and they have become the largest league in terms of the number of participants [1], [4]–[6].

RCJ focuses on introducing students to science and technology and their education, while the senior leagues focus on research and development of robotics and AI. The proposed bridge league will play the role of closing the gap between them. It focuses on higher education in science and technology, and training in conducting scientific experiments, manufacturing devices, and technological advances.

### 3 Problems with RoboCupJunior and Senior Leagues

#### 3.1 RoboCupJunior

The RCJ mainly focuses on education. In addition, the league plays a role in finding potential future robotic researchers and providing them with encouragement and motivation. However, with respect to encouraging young students, the current activities are not sufficient. Hence, many of the RCJ graduates cannot find the right path to the senior leagues. Moreover, these students often retire from the RoboCup. Some go to a university, but it is unclear whether they return to RoboCup. This implies that after we discover the next generation of RoboCup researchers, we lose them at the end of RCJ secondary class activities. Hence, it is important that we maintain the interest of the students in RoboCup (and in the world of science and technology) from the viewpoint of continuing their education as well as keeping the RoboCup active.

This tendency of students was indicated by Anderson [2]. One of the authors of the present paper, who is currently managing an RCJ, also strongly agrees with Anderson’s thoughts on the subject. Why do not or cannot many of RCJ graduates advance to the senior leagues?

The major problem is the considerable technical gap between the RCJ and senior leagues. During the early years of the RoboCup, a new team was able to join one of the senior leagues without too much difficulty, since the technical level

was not so high then. However, nowadays, the rules have become more difficult and the required robot specifications have increased. These changes are made in order to keep with the technical advancements, but this has made joining each league to become more and more difficult.

On the other hand, with respect to the technical skills of the RCJSS teams, some of the top-level teams already have good skills to the best of our knowledge. Those teams can build original robots for an RCJSS competition on their own. This robot-building procedure includes mechanical processing, assembling parts, and making control circuits. Moreover, certain advanced students even begin to write a simple computer program after several months of training. If such students are given adequate technical guidance, they can join a senior league within a short time. This is the objective of our bridging activities.

### **3.2 Senior Leagues, Soccer Small-Size League**

The technology of all RoboCup leagues is advancing every year. Hence, the level of competition increases to a great extent. This is true for SSL as well. The movement of the robots has become very smooth, fast, and accurate. Most robots have a powerful kicking device. The field size has been increasing every two or three years. These technical advancements are keeping in line with the objectives of the RoboCup. However, as described above, such advancements become a technical barrier for new teams.

For example, if a certain team wants to compete in SSL, they must have an understanding of a wide range of technical fields such as mechanical engineering, electronic engineering, control, wireless communication, computer programming, image processing, and AI. Moreover, they have to combine these techniques into the building of an actual working robot system. The total performance of the system depends on the technical field in which they are weakest. Even if only one element of the abovementioned technical fields is weak, the robots will not work correctly. Therefore if a laboratory belonging to faculty of engineering in a university attempts to develop the SSL robot system, it is not easy to cover all of above technical fields with higher level. Another drawback is the total cost of the parts. Expensive parts are required to build competitive robots. This problem of cost was also pointed out by Anderson [2].

Therefore, there must be some support for new teams. However, at present, there is no such effective support system. Hence, we believe that our proposed bridging activities are effective for not only RCJSS graduates but also the new teams in SSL, and it is effective to expand the teams and make SSL more active.

## **4 Bridging Activities between RoboCupJunior and Senior Leagues**

As mentioned above, both RCJ and senior leagues have their own drawbacks. We can solve them by preparing and showing a next step or a method for transitioning from RCJ to senior leagues by mutual cooperation.

As an example, we use the gaps between RCJSS and SSL and propose the following three levels of activities for bridging it.

#### 4.1 First-Level Activities: Immediate Actions

First-level activities are the immediate actions we can perform. They consist of the following three activities.

**(1) Understanding Partner League.** We must understand the partner league first of all. RCJSS members must visit the SSL field and watch SSL games during the competition, and vice versa; We must understand the rules and regulations of RCJSS and SSL each other.

**(2) Realizing Inter-League Games.** We can realize an inter-league game by using the current field and robots. RCJSS robots require a special ball that radiates infrared rays. Further, RCJSS needs a field with white to black gradations. Therefore, SSL teams will have to adjust their ball, field surface, and vision settings to those of the RCJSS. On the other hand, SSL teams require a camera above the field. Further, the SSL vision system requires an orange-colored ball and a color marker on the robot to indicate blue or yellow in order to distinguish the two teams. Therefore, the ball should be painted orange. The team's respective color marker is placed on the RCJSS robot. Thus, an inter-league game between RCJSS and SSL teams can be realized.

The advantage of this style is that there is no need for a serious modification of both the RCJSS and SSL robot systems, except a minor change in the vision system setting of the SSL team. The objectives of this game are (a) realizing interaction, and (b) motivating the RCJSS members by showing them how the SSL robots run fast and precisely, and sophisticated strategy of SSL system.

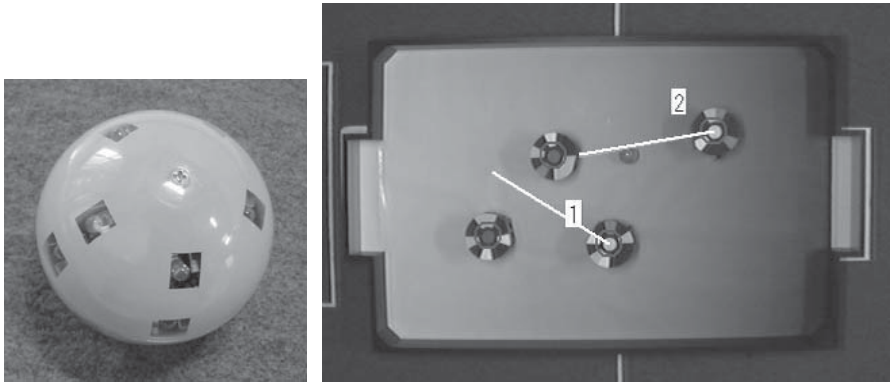
**(3) Communicating as Much as Possible.** We need to make an effort to know and talk to each other. When the RCJSS teams develop new robots for the SSL competition, they may sometimes require technical assistance or advice. In such cases, if they have a knowledgeable and approachable SSL team working with them, they can easily sort out their problems.

**Achievement for Year 2007.** As one of the activities, the authors participated in a RoboCupJunior Japan Soccer Summer Camp 2007, and gave a lecture on the SSL robot design, its specifications, and the difference between RCJ soccer and SSL. Figure 1 shows a scene from the lecture. Subsequently, the participating students enquired about the mechanical construction and electronic circuit design displaying considerable enthusiasm. Although the allotted time was limited, we had a lively and thorough discussion.

We prepared a ball painted with orange color for the inter-league game. Figure 2 (left-hand side) shows the ball. A ball used in the RCJ soccer is originally covered with transparent plastic. We painted the inner part of the ball with the same color as that of the SSL ball, barring the front part of the radiator,



**Fig. 1.** Lecture at RoboCupJunior Japan Soccer Summer Camp 2007

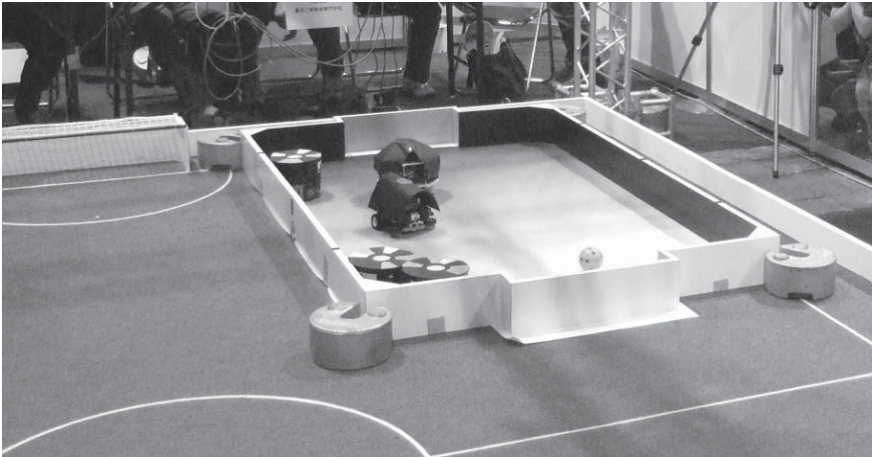


**Fig. 2.** Painted RCJ soccer ball (lefthand side), and checking of SSL vision system using RCJ soccer field (righthand side)

which is meant for infrared rays. This ball can be detected on the field by both RCJSS and SSL robots.

Figure 2 (right-hand side) shows a screen image of our vision system for SSL. We tested whether the vision system functions correctly on the RCJ soccer field. It can be seen that the ball position and the blue and yellow markers (indicating robots' positions) including the direction are correctly detected even on the RCJ soccer field, which has black to white gradation. Thus, we verified that the gradation of the RCJ soccer field does not affect the SSL vision system.

The inter-league game between the RCJSS and SSL teams was actually conducted during the RoboCup JapanOpen 2007. Figure 3 shows the field for the inter-league game when it was in progress. The RCJ soccer field was placed at the corner of the SSL field. The goal of the SSL field can be seen at the left-hand side of the RCJ soccer field. The SSL teams were able to use their cameras directly with a minor change in the settings. The RCJ soccer robots were covered with black paper because the SSL vision system is sensitive to various colors



**Fig. 3.** Inter-league game during RoboCup JapanOpen 2007

present in the body of the RCJ soccer robots. The RCJ soccer robots also have their blue team markers at the top.

Three games were conducted and successfully completed. We have confirmed that the proposed inter-league game is possible. The participants from RCJSS must understand that they can actually compete with the SSL teams.

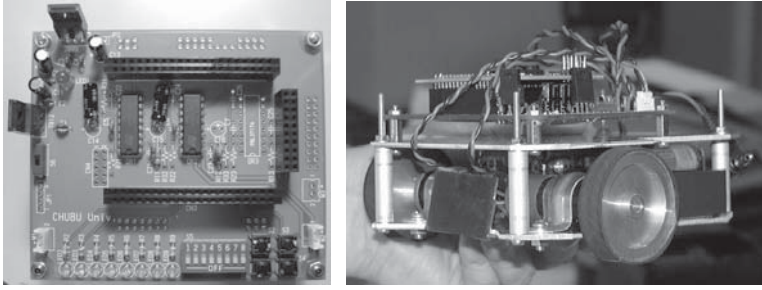
## 4.2 Second-Level Activities: Forming a Bridge League

Second-level activities include the formation of a bridge league between RCJSS and SSL and various related supporting activities. This forms the main activities of this proposal. The league is positioned as a freshmen league or a novice league of SSL.

**(1) Forming a Bridge League.** The basic rules are derived from SSL since this league aims to be a path toward promotion to a complete SSL league. The main difference is the size of the field and the number of robots in one team.

The size of the current (Year 2008) SSL field is  $6100 \times 4200$  mm. A field of this size results in many advantages to top-level SSL teams; however, new teams will have several problems. For example, two or more cameras will be required to cover the entire field. Moreover, it will be difficult to prepare such a large space, which will also have to include 4000-mm high frames for cameras. Hence, the size of the fields for the bridge league should be reduced to a smaller size. We determined the field size to be  $3200 \times 1800$  mm, but the actual dimensions is not that important. Since the field size is not large, new teams will be able to have the field in their working space.

Another change is the decrease in the number of robots from five to three. This is to reduce the cost of the parts of the robots and to reduce overcrowding on the field.



**Fig. 4.** Main board used in the engineering freshman course (lefthand side) and an example of robots (righthand side)

**(2) Development Kit for Transition.** We are preparing a software-development kit for image processing and wireless communications. These two fields are not required for RCJSS. However, they are indispensable for the SSL robot control system. Hence, RCJSS teams who intend to progress to SSL must need these techniques. By preparing and offering these kits, the RCJSS teams can rapidly develop a working robot system for the bridge league.

We also have a plan to develop kits for other technical areas such as mechanical design, manufacturing control boards, and microcomputer programming. For such kits, the authors already have a resource, which is currently used as the course for an engineering freshman major [7]; we will utilize this resource for this purpose. Figure 4 (lefthand side) shows the main board used in abovementioned course. Figure 4 (righthand side) shows an example of robots built by freshman.

**(3) Technical Subjects for Transition.** For the abovementioned development kits, we defined certain technical subjects, which must be understood first and cleared to build robots. If RCJSS graduates have already become familiar with SSL teams through the first-level activities, they can consult such SSL teams for determining solutions to their problems. The following lists the seven main technical fields for building the SSL robots.

1. Design of the robot, Mechanical processing
2. Microcomputer programming
3. Electronic circuit, Control board
4. Assembling the robot
5. Wireless communication
6. Image processing
7. AI, Team strategy

Each technical field has several subjects. Table 1 shows those subjects.

For the advanced RCJSS graduates who are able to complete all subjects, we defined next advanced subjects. Table 2 shows those subjects.

Completing the subjects of the technical field one to four, beginner teams can build a moving robot following the direction described as the program of



**Table 1.** Technical subjects to be cleared for building the SSL robots

Technical field	Subjects
1. Design, Mechanical processing	Designing the robot body. Preparing material. Preparing tools. Processing. Assembling. Checking functions.
2. Microcomputer programming	Preparing microcomputer. Preparing software development tools. Programming practice. Writing an easy program. Executing it. Understanding hardware functions, I/O etc.
3. Electronic circuit, Control board	Preparing tools. Designing the power supply circuit. Designing the motor driver circuit. Designing the wiring diagram. Preparing the electronic parts. Developing the circuit board by etching. Soldering. Testing the functions.
4. Assembling robot body	Assembling robot body. Writing the motor speed control program. Writing the robot motion control program. Testing the functions.
5. Wireless communication	Preparing the device. Making the interface circuit. Writing a program that sends and receives signals. Designing the protocol. Sending the robot motion commands. Checking the transmission speed.
6. Image processing	Preparing a camera and an image capture board. Writing a program which captures color images. Writing a program which discriminate colors. Writing a program which estimate the robot and ball positions. Checking the image processing speed.
7. AI, Team strategy	Recognizing the teammates and enemy positions. Calculating the moving path. Robots move following the path. Robots kick a ball after moving. Planning the next action of each robot. Realizing the combination of robots. Making a team strategy.

microcomputer. Further, completing the one to five, they can direct a robot by wireless communication. Moreover, completing the one to seven, they can compete in the bridge league. If they have sufficient vision system to cover an entire SSL field, they can compete even in full SSL. Finally, completing all subjects, they can compete in full SSL against top teams of the world.

**Table 2.** Advanced technical subjects

Technical field	Subjects
8. Advanced subjects	Realizing robust image processing against the change of illumination or shades on the field. Planning the moving path using smooth curves. Using rotary encoder to detect the rotation precisely. Realizing the feedback control such as PID method for accurate control. Writing a robot simulator. Realizing pass of ball between teammate robots.

### 4.3 Third Level Activities: Other Supports

Third level activities include several supports for RCJSS students from outside of RoboCup competition. They includes;

**(1) Internship in Senior League Team.** RCJ students temporally belong to the senior league team as an intern. There, they can take charge of some development under the senior league members coaching. They can experience the work of senior leagues.

**(2) Evaluating the Career of RCJ in AO Entrance Examination.** We request universities which have the AO (Admissions Office) entrance examination to consider the career and the result of competition of RCJ and RoboCup as one of the standard of selection. This aims to make a certain path to a university to continue RoboCup activities there.

## 5 Comparison with Previous Work, ULeague

ULeague is the entry level league of SSL proposed by Anderson [2] by similar motivation as ours. We compared our proposal and ULeague. In this section, we show the similar points and differences.

### 5.1 Similarity

- Motivation. That is to give the RCJSS graduates a next step or adequate path to SSL.
- Focusing on SSL. Proposed league is positioned as an entry level league of SSL.
- Equipments. Field size, material of surface, orange colored golf ball.
- Main object of the proposal. From high school students to undergraduates.

## 5.2 Differences

- In our proposal, it is mainly taken into account that already existing SSL team can participate in the new league with as little change as possible. In other words, we want to realize the game by both RCJSS and SSL teams as many as possible. For RCJSS graduates teams, they can play with existing SSL team in the same field, even the world champion team, by actual play. We expect RCJSS graduates teams to have confidence and to be motivated. We then strongly recommend the participation of existing SSL teams.
- Regulation of robots is identical to SSL. Because of using same regulation, existing SSL team can participate easily. Further, for RCJSS graduates teams, if they could develop the image processing system for full SSL field size, they can participate in full SSL immediately.
- We have a plan to provide sample implementation of image processing system (including ULeague video server, if possible) and image processing server computer in competition. However, we also recommend to develop their own image processing system to RCJSS graduates teams. This is for their future entry to full SSL, and for advance of their developing skills.
- Our proposal includes not only the proposal of new entry level league, but also many side activities. As immediate actions, there are inter-league game, encouragement of interchange and communication, and encouragement of consultation to familiar SSL teams. As second level activities, there are proposal of bridge league, providing hardware- and software-development kits, and technical subjects to build fully functional robot system.

## 5.3 Others

These are the specific points to our proposal. We cannot confirm whether these points are same or not between ULeague and our proposal from the paper [2].

- If others than undergraduates participate in the new league, they are welcome for us. Even a laboratory of an university, master course students, or a company, they are welcome.
- If the participants became strong, we recommend to progress to full SSL.
- In our proposal, number of robots is three. This aims for reduction of total parts cost and to dissolve the overcrowding of robots in the field.

## 6 Conclusion

The bridging activities between RCJ and the senior leagues, particularly between RCJSS and SSL, were described in this paper.

We believe most participants of RoboCup can understand the necessity of such bridging activities between RCJ and senior leagues. However, actual activities are not fixed in past. Though the ULeague was once demonstrated in RoboCup world championships, it was not fixed after demonstration. Our proposal is the second challenge of bridging activities between RCJ and the senior leagues. We hope

that our proposal become one trial to spread RoboCup senior league activities to RCJSS graduates and beginners.

We have conducted first level activities this year. The results of those activities were reported. On the other hand, our second and third level activities need much time. Actually we cannot release the development kits yet. However, we continue to prepare those kits with patience, because they are indispensable to realize the bridge league.

Our proposal is for only RCJSS and SSL now, but similar activities must be needed to other leagues. After investigating the effectiveness of our trial, we want to apply our proposal to other leagues.

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