RoboSports: Autonomous Soccer-playing Robots (September 2010)

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Abstract: This paper considers the project´s third stage, which has consisted of consolidating the first Costa Rican league of autonomous soccer-playing robots. During the two first years, the principles for design and control of robots were analyzed and studied within the framework of the technological competitions of the RoboCup organization, with special emphasis on the international rules of the Robocup Soccer Junior competition. However, this year students and teachers have improved their robot design thanks to their participation in the 2009 Latin American Robotics Competition, held in Chile in October of 2009. The real competition showed that robotics competitions provided 'real' experiences for students, exposing them to fortuitous problems they might otherwise not encounter in controlled environments. These competitions engaged them to work together and stimulated student learning to solve any habitual problem in an optimistic fashion. Concerns included improvement of design and programming using flow diagrams.

Key words: **Robotics, RoboSports, autonomous robots, Robocup Soccer Junior.**

I. INTRODUCTION

The first Costa Rican autonomous soccer league is the result of a three-year research and development process. This includes investigation and hands-on practice involving new and specialized knowledge of robotics. This work has had educative aims and has been focused on participating technological competitions.

In order to create the National League, the group working on the project has learned by using the trial and error method. Observation, creativity, an original design, and the students' persistence have been essential towards attaining the main objectives of the competition.

Due to the educational activities experienced in 2008, it was possible for the six RoboSports team members to acquire the conceptual knowledge and skills to assemble mobile robots based on LEGO Mindstorms technology with the brick RCX.

Photo1. First RoboSports competition and presentation made to the students' parents (September 29th, 2008).

In 2009, the groups decided to start working with sturdier technology to create new robots with the NXT interface. At that moment, four different prototypes were designed. All creations were different and had peculiar programming behaviors in spite of the fact that the experience and challenges of the 2009 LARC competition in Chile had provided the teams with a unique opportunity to work together to achieve a common goal.

Fig 1. Official Robosports Team presentation to the media October, 2009.

In 2010, after an intense group performance analysis, a particular necessity to follow new ways to develop students' programming abilities emerged. This included the need for hands-on experience with software resources. In fact there was a special concern about improving the operation of these autonomous robots.

The idea of improving their robots' performance was mainly focused on introducing the algorithm[ii] approach as a problem-solving technique. This gives the students the tools to solve competition challenges in less time and more easily.

II. Process Description

First stage, 2008

1) Assembling structures and mechanisms for mobile robots with LEGO Mindstorms RCX

The fact that participants were used to constructing and programming structures and mechanisms using RCX technology facilitated the process of construction and programming robots since the earliest stages.

The latest concepts and skills learned were associated to the design of sturdy chassis for mobile robots. Their individual challenge was to design a sturdy but light prototype able to move in any direction and collect a tennis ball, which would then be thrown to a specific zone.

The building demand focused on the use of cross-brace mode. On the other hand, the programming claim was related to the control of a robot´s movements by means of two contact sensors. As a consequence, this experience gave them the opportunity to know and determine which the faster and more efficient strategies to obtain the ball were. Later, structural adjustments were made to fix the robots' dimensions, such as width and weight characteristics established by the RoboCup organization for the Soccer Junior category.

Light Sensor Technical Adjustment for IR Ball

The LEGO Education Mindstorms RCX kit does not have a reading infrared sensor that works under the specifications of the RoboCup Junior rules. In fact, the regulation 2.2 about interference declares that "the robot must not emit infrared light" (Soccer Junior rules 2010iii) because the emission of any red light can cause control problem to other robots in the competition. For this reason, the group researched and put into practice a modified light sensor as an alternative solution. This procedure implied technical transformations and tests for several prototypes in order not to break the competition´s rules and to find a substitute sensor. In fact, this learning issue provided real engineering experiences as each student realized the necessity to create a new device to control his robot.

2) Programming the first soccer-playing robots

The idea of the embarking upon the process of teaching programming to create soccer-playing robots without having enough experience or technological support was a little bit intimidating but not impossible. The research team spent a considerable amount of time looking for samples and resources on the web in order to learn about them and "tropicalize" this information to fit our educational context.

Altogether, the group got new issues on programming due to the practice they got. Their robots were getting physical modifications on the construction for the effective and appropriate positioning of the sensors, especially the light sensors that were modified to read infrared balls' values.

The sensor tests constantly failed because the data reading-process was not trustworthy or stable. This obstacle made it somehow frustrating for the team as they tried and failed to get positive results.

At the end of 2008, the Omar Dengo Foundation presented the first three intelligent mobile robot teams to the media. Six intelligent robots were able to play under the RoboCup Soccer competition system before a large audience, generating a lot of media attention.

By 2009, the group realized that they had learned more than they had expected. Nevertheless, there were many design and programming aspects to improve for the coming year in order to prepare for an international robotics competition.

In 2009, there were numerous design and programming aspects to improve according to the new curriculum goal. Among such aspects were outcomes and self-analysis of their last performance, such as to optimizing the location, retention, and expulsion of the IR ball.

Second Stage, 2009

1) Mobile robots with Mindstorms NXT

As a new challenge or solution for the previous design problems, the team decided to start constructing sturdier and faster robots using the latest LEGO Education Mindstorms NXT kits. It meant less time for the preparation schedule in order to participate in the Latin American Robotics Competition (October 2009, Chile). In fact, the four soccer-playing robots were done a week before this competition with complete adaptation to the new devices.

The new size of the devices, as well as the intense use of the pin and the beam allowed them to explore other areas of the assembly, in which creativity and observation were indispensable to complete the bodies of the robots.

Figure 2. Two students (Alejandro Quesada and Sebastian Rojas) working on the robots' chassis. The construction process was guided by the team construction specialist (Jorge Lopez). October 2009.

2) Incorporation of new sensors

At the moment, the team's main worry was related to which technology should to buy in order to solve previous obstacles encountered by their robots. It was not easy, although thanks to previous research conducted by the Robotics Department and educational experiences with robotics technology, the team thought that they needed to get additional benefits from this new acquisition. For instance, they needed to be able to include devices such as a position sensor, a rotation sensor, and IR-seeker sensors made by other companies. These sensors improve data collection for robots and consequently the robots' performance. As a result, a new perspective of programming sprang out for the curriculum, and the team got more intelligent conducts for their robots.

In fact, the team`s robots got an opportunity to compete in a real competition when they participated in the 2009 Latin American Robotics Competition, held in Chile in October 2009. Their performance was outstanding and they came in second against university-level teams with a much higher level of experience. Although this competition represented a great reward for the teams for their effort and perseverance, there was some concern based on their relative lack of experience.

Third Stage, 2010

1) Constructing original structures and mechanisms for soccer-playing robots

For most students in the educational system, Monday may seem like the most boring day of the week. For our participants, the contrary is true. For them, it is the beginning of joyful countless hours of after-school work to design robots that can become complex soccer players. The challenge issued this year by the team was the construction of four new robots, unlimited in terms of originality and complexity in accordance with their individual background and skills. The main assignment was to solve earlier problems encountered by previous models with regards to speed turns, heaviness, design, and ball kicking.

Each robotics team received a set of construction parts, some electronic devices, sensors, tools, and an engineering notebook, where they had to design and adapt their new robots.

Teams were allowed to use extra parts and even design custom components. Some parts, such as motor axes, chassis structures, and controllers might have had team approval but had to be checked against the official RoboCup Junior rules.

Figure3. 2010 III Generation soccer-playing robots

The shared robotics competition experience stimulated their learning motivation and intensified teamwork within our labs. In fact, team members have turned into better students more capable of adapting their systems for a new age and an innovative technological learning process.

2) Programming more intelligent soccer-playing robots

As part of a new list of programming improvements for the robots' conduct, they were required to have a nested complex structure like conditionals, validation of variables, containers, loop structures, subroutines, and multitasking.

This learning process was assisted by the intentional algorithm method, which let the team subdivide the challenge into smaller problems in order to solve them. Hence, they learned that the best solution to solve any kind of problem might be to subdivide the complete problem into smaller parts to analyze it from different perspectives.

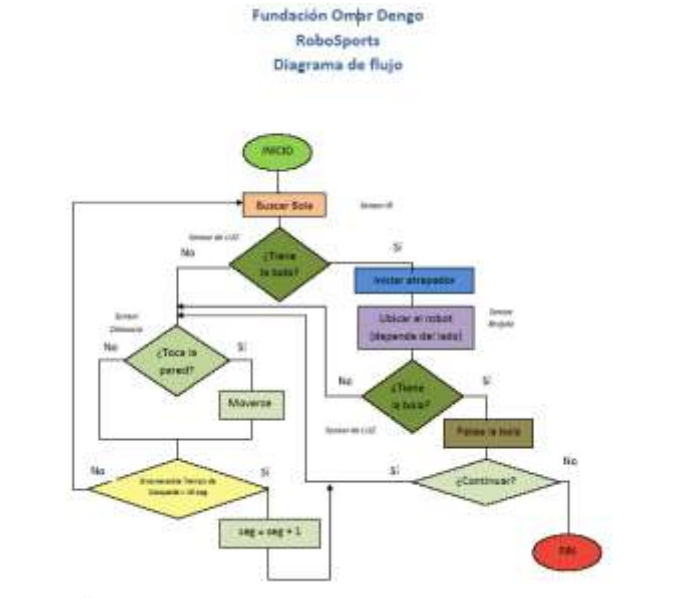

Figure 4. Programming diagram done by programming specialists (Christian Cordoba and Jorge Lopez) 2010.

III. OUTCOMES

1. *Remarkable lessons*

Based on the experience acquired through this project, we would like to highlight the following aspects:

It is fundamental to have the financial and administrative support from the educational organization.

It is necessary for each institution to construct al least four robots in order to conform or compete in a regional league.

The main pillars of this multidisciplinary labor are based on the robotics professional experience and knowledge of the specialists related to this academic area. For example, there was a moment in which the team got a vital programming doubt, and it cut off the path of programming development, nevertheless the contribution of the online robotics community helped us solve this problem.

Two weekly hours of after-school work is the minimum time required to obtain optimal results from the students. In fact, the teams required at least five hours per week.

As a registration requirement student must have experience and knowledge of construction and programming. This will allow students to focus and have a positive mental disposition and attitude for this kind of competition.

There must be room for social exchanges, and it is also important to give positive feedback by means of words and gestures to motivate students. Professors must remember that it is a fun learning process and not a competition.

The construction and programming team improvement has been attained through a process that requires patience and persistence by means of trial and error as well as observation.

2. *Future goals*

The students' main aspiration is to prepare to classify and participate in the next RoboCup. In addition, they would like to become mentors of the future national robotics league.

IV. CONCLUSION

The project has faced many challenges that were not anticipated and which have been successfully overcome based on the experience and the will to do our best. We thank the Omar Dengo Foundation for their kind support. We also thank our work partners and the students' parents, who gave us the mental power to continue in this arduous challenge.

In many occasions the team persistence was our beacon. especially in moments where we had to recognize the limitations of our sometimes technologically-deprived country. However, we are glad to be part of this project that will be recognized in the coming future as a pioneer for national robotics competitions.

Fig 5. RoboCup Soccer Junior Team. October 2009.

V. ENDNOTES

[i] J. Lopez y D. Matarrita (2009). Hitos RoboSports, PowerPoint en http://robosportscostarica.blogspot.com/.

es.wikipedia.org/wiki/Ingeniería

[ii] Set of instructions or well defined rules, finite and organizes that allow persons to carry out an activity by means of successive steps that do not generate doubts to execute it.

es.wikipedia.org/wiki/Ingeniería

[iii] PDF. RoboCup soccer junior rules, 2010
www.robocup.com