ROBUS – A Mobile Robotic Platform for Electrical and Computer Engineering Education

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Abstract – By having students design mobile robotic toys for autistic children, we allow freshmen in Electrical Engineering and Computer Engineering to work on a multidisciplinary project that requires creative and innovative solutions, involving technological aspects and social impacts, close to what engineers are asked to do in real life.

Keywords – Robotic toys for autistic children; Project-based learning.

Introduction

If we want students to become good engineers, we must put them as close as possible to real challenges, similar to the ones they will face during their career. At the Université de Sherbrooke, we are dedicated in making students work on projects as part of the curricula [1]. It is no secret that this requires more work and resources than giving lessons by following a textbook, but the benefits are enormous: it creates a dynamic learning environment where students and teachers move beyond what is requested or taught in regular courses.

Our Department of Electrical Engineering and Computer Engineering offers two distinct bachelor engineering degrees. Since 1998, Electrical and Computer Engineering (ECE) is introduced simultaneously to a 200 first-year undergraduate students registered in these two distinct programs. The primary goal of this initiative is to confirm early on the career choice of these students and making them work on projects involving design and analysis abilities, autonomous learning, teamwork, communication skills and social considerations. We also want
to create a stimulating and motivating learning environment, with a reasonable workload that favors the integration and the application of engineering knowledge and skills.

To accomplish these goals, we have developed an autonomous mobile robotic platform named ROBUS (ROBot Université de Sherbrooke) that can be used in various activities of both curriculum and adequately reflects the challenges of ECE projects [2]. We also wanted to make students work on a project that pushes further their creativity and their ingenuity, with complexity appropriate to their education level, and that can serve a real purpose. The challenge we came up with, the RoboToy Contest [3,4,5], in which students have to design a mobile robotic toy to help autistic children develop social and communication skills. The idea is to see how robots could help autistic children open up to their surroundings, improve their imagination and experience less repetitive behavior patterns. The event organized This paper describes the mobile robotic platform ROBUS developed and explains how it is used in various activities such as courses, pedagogical activities and the RoboToy contest.

**ROBUS, the robotic platform and its use**

Between reconfigurable robot kits and complete mobile robot platforms, we wanted to have a robot that would give us the best of both worlds, i.e., the ability to add structural features to the robot and also addressing a variety of ECE engineering properties, at the lowest cost possible. Our mobile robot, named ROBUS [2], is shown in Figure 1. It is composed of 1) an electro-mechanical base, which is circular and surrounded by a protecting surface, allowing the robot to detect when it collides with an object; 2) an interface circuit board, providing easy access to basic circuitry of the robot like power for the control devices, bumper readings, motor controls, infrared proximity sensor signals, etc., to a control device; and 3) control devices, which can be a Handy Board [6], other microcontroller boards (like for the Motorola 68331) or a Xilinx CPLD
board. The overall cost of the electro-mechanical base plus the interface circuit board is approximately 200$CND (around 125$US).

The use of ROBUS in our EE and CE programs has evolved since 1998, starting from its use in different courses to its complete integration in an in-depth reform of our programs. In 1998-1999, seniors used ROBUS in more advanced undergraduate courses such as *Microprocessor Interfaces* (to address how to design hardware/software interfaces with sensors and actuators), *Real-Time Systems* (to design a kernel for embedded systems), *Artificial Intelligence* (to validate techniques like fuzzy logic, reinforcement learning and intelligent control architecture) and *Senior Design Project* courses. In fact, the *Senior Design Project* help us develop more rapidly the robot’s capabilities. For instance, the Handy Voice, a sound generating device that allows the robot to play messages recorded on a ISD ChipCorder (a single chip device for voice recording and playback), got designed by senior students and is now in common usage in our activities.

But the primary purpose of ROBUS is to get freshmen introduced to EE and CE, and especially concepts such as circuits, soldering, instrumentation, sensors and actuators, logic circuits, microprocessors, C programming, real-time systems, design, technical drawing, teamwork and communication. Grouped in teams of four, students receive right at the beginning of their semester a ROBUS kit completely unassembled, and their first challenge is to assemble and test the robot by using the documentation provided. This process reveals to be very exciting for many students who are introduced, for the first time in their life, to electronics. Once assembled, different strategies for the use of ROBUS were tried. In 1998-1999 [2], ROBUS was used simultaneously in different courses, like *Logic Circuits* (by designing combinational logic circuit to make the robot move freely in the environment and turn away when it collided with an object), *Circuits and Microcontrollers* (by using the Handy Board and analog circuits to make
the robot move purposefully in the environment), Teamwork (to introduce teamwork and design methodologies), Technical Drawing (using AutoCAD to draw mechanical parts of the robot), and Communication (for writing reports and presenting their work). From 1999 to 2001, we change our strategy to allow new developments in courses like Logic Circuits and Teamwork, and the robot got the be used in a smaller number of courses. Most of the work with the robot was done in the Circuits and Microcontrollers course. Finally, since Fall 2001, the robot is now integrated in our reformed programs, designed around the notions of competencies, problem-based learning and project-based learning [7]. A faculty team is in charge of all activities during a given semester. Each semester is now organized around a theme and basically includes two types of activities: several two weeks, problem-based learning units; and a design project, which extends over the entire session. ROBUS is the platform used in the first semester of both EE and CE programs, and serves as the integration platform for students to develop competencies in instrumentation, soldering, electronics, linear circuits, microcontroller architecture, C programming and multi-tasking. That is where the RoboToy Contest comes in.

RoboToy Contest

Our objective was to organize a robot competition with a social impact, close to the kind of work engineers are asked to do. Developing entertaining robots is actually a good context for doing that, since the precision required in accomplishing a task is traded for the abilities to deal with the contingencies and unpredictability of the real world, to give believability to the robotic characters and to interact with the user. That is why we created the RoboToy Contest [3,4], identified with the logo shown in Figure 2, and decide to address the topic of autism.

Autism is characterized by abnormalities in the development of social relationships and communication skills, as well as the presence of marked obsessive and repetitive behavior.
Despite several decades of research, there is currently no cure for the condition. However education, care and therapeutic approaches can help people with autism maximize their potential, even though impairments in social and communication skills may persist throughout life. The RoboToy Contest challenge is to come up with a design that can get the attention of the child and generate incentives for the child to opening up to his or her surroundings. Using a mobile robotic toy is an interesting idea because it can create novel, appealing, meaningful and sophisticated interplay situations using speech (by using the Handy Voice device for instance), appearance, sounds, visual cues and movement. It is up to the students to come up with a concept and to build the robot by adding sensors and actuators, to construct the physical structure of the robot, and to develop the capabilities they believe to be appropriate for their robots. Since autistic children cannot express their preferences to guide the design of a robotic toy, and since autism disorder is also not well known by ECE professors and students, as robotics to educators working with autistic children, design specifications cannot then be given by the professors but must instead be elaborated by students, putting them in a real engineering situation. From an engineering perspective, it gives students the opportunity to experience the difficulty of making choices and explaining them in relation to a “therapeutic” goal, instead of putting all sort of devices just for the fun of it. In addition, students have a lot of latitude in proposing creative and innovative solutions. This leads to a great variety of interesting and distinct solutions, making the best of the sensors and the actuators available, the processing capabilities of the microprocessor board and what can be done in practice, while still considering the social impacts of the designs.

The event is organized as a student activity by a team of around eight students (who participated in previous years) and two professors. In fact, the event would not be possible without the implication of students in the organizing committee. The organizing committee helps
out by organizing seminars, by having students from other faculties (like education, arts) participate, making it a real multidisciplinary experience, and by taking care of all the logistics surrounding the event. The contest is held in an exhibition hall where each team has a stand to present their design and market their product by putting up posters, preparing a presentation, showing videos, demos, decorations, etc. Teams have the morning to set up their stand, and the presentation is open to the public from noon to 4 pm. Kindergarten children are also invited to play with the robots during the exhibit. Members of a jury evaluate each robot according to criteria such as relevance of the robot design in relation to autism, technical aspects of the design, a general evaluation on the robot’s appearance and behavior, and the presentation at the stand and in front of the public. Thanks to sponsors, cash prizes as high as 2000$ are given to the top three designs, and in-kind prizes are also drawn for the participants.

Since January 1999, the RoboToy Contest has been held four times, with 75 robot entries overall involving around 500 students, mostly freshmen. Figure 6 shows some robots presented during these events. From 1999 to 2001, groups of students interested by the contest registered in teams of three to ten people, involved in ECE or in other disciplines. Students in ECE could take the RoboToy challenge to be their design project in the Circuits and Microprocessors course. Now with our reformed programs, the RoboToy Contest serves as the design project for the first semester. In groups of eight, students work all semester on this project, following the different design phases like defining the problem (requirements, planning, forming a team), formulating solutions (brainstorming, evaluation of design parameters, etc.), developing solutions and presenting their work (technical presentation, public presentation, written design report) [8].

Finally, we believe that to ensure the success of the RoboToy Contest over several years, it is required to do real experiments with autistic children. Since it is not appropriate for autistic
children to interact with the robots during such a public event, we organize activities during which robots are put in contact with children. Students can lend their robots for such experiments, or can participate on a voluntary basis. Since each child and each robot are different, very diverse interactions occur. For instance, BOBUS activates its small fan on its head when the child respond correctly to a request, since autistic children are usually fascinated by rotating objects. C-PAC has removable arms and tail, with connectors of different geometrical shapes (star, triangle, hexagon) that children are used to play with. C-PAC used its pyroelectric sensors to locate a boy that remained on the floor for the trials got to assemble the robot successfully by himself, making the robot rotates on itself while playing music. Another boy started to play with ROBUS-T as it was a real dog. Doing these experiments is more related to research than education, but they are essential in order to get students involved. It allows to see what works and what does not, to make the designs evolve over time and not just see the same kinds of robots years after years. It also helps combine research and education activities of faculty members. And most importantly, such experiments contribute to the education of autistic children and get students introduced to another reality of life, working with kids with learning disorders, something that they might never have got to know. This then becomes a complete real-life experience.

Conclusion

Surely, like other robotic contests, working on mobile robots or on a technologically challenging project may be stimulating for many students. Overall, students show great enthusiasm in these assignments that are set to demonstrate a progression in the technology and concepts used for their design with ROBUS. With the RoboToy contest, the project by itself is based on the motivation to give a solution to a real problem. When people are engaged in an
activity that is motivating by itself, chances are good that they will be interested in learning things if they see that they will serve them in regard to the accomplishment of their project. Students are then not only motivated by the engineering challenge of the project but also by the social implications of their work. The contest creates by itself interest, hands-on experience and, moreover, motivation and engagement from the students. By literally "putting pieces together", students are engaged in an integrative learning experience where they are invited to see how concepts can go together. All of this increases the chances to obtain an optimal learning experience very rewarding by itself.

Students appreciate the fact that their work can actually be used in real situations, and say that they do not participated for the prizes but because they enjoy to be challenged and to work on such an open design project. Just seeing kids play with their robots is really gratifying for them. By making it real, the activity is beneficial for everybody, the students, the professors, the collaborators and the university. The activity should also have an impact on attracting undergraduate and graduate students, which is something that we cannot evaluate yet. Our hope for the future is to continue to make the RoboToy Contest evolve (and maybe cover other application domains), and to interest other universities to join our initiative.

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References


List of figures and table captions

Figure 1. ROBUS (RObot Université de Sherbrooke) ................................................................. 10

Figure 2. Logo of the RoboToy Contest ..................................................................................... 10

Figure 3. Some of the RoboToy Contest entries ....................................................................... 11
Original figures and tables

Figure 1. ROBUS (RObot Université de Sherbrooke)

Figure 2. Logo of the RoboToy Contest
Figure 3. Some of the RoboToy Contest entries