Graphical Simulator for a Robotic Environment

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ABSTRACT

In this paper we present a didactic tool named "STORM", which simulates a real environment in which students can control and program a robot in a very basic way by simply setting switches to configure an action or an activity to be carried out by the robot. The control interface is totally graphic, so it can be used by students from primary schools to universities. The objective of the simulator is to create learning objects to develop the dynamic and strategic competences of students in addition to concepts such as robot navigation and control, and computer programming.

KEYWORDS: robotics, simulation, robotic education.

The use of robotics in education is already established across all age groups. There are several automated toys and systems available on the market that stimulate student reasoning. However, most of these do not present an educational strategy or methodology, but instead explore the current technologies used in their manufacture. In addition several scientific projects have been developed in education with the objective of exploring the great appeal that robots have for people, and the motivation that they generate, especially in children.

Although robotics is very attractive to children and adults, some questions arise that have to be answered, (Johnson, 2003, 16):

- Do children learn anything from robotics?
- Is this different from other ways of learning?
- Is this popular interest in robotics a trend, or is it likely to be sustained long-term?
- Are there gender issues to be addressed?
- What is the best way to exploit the potential of robotics?

While many schools presently use robotics, mainly as an extracurricular activity, there is little scientific evidence confirming the real benefits that their use provides, and that could answer the above questions (Johnson, 2003, 16). But experiences show that robotics is a successful tool when the educational approach is *edutainment* (education + entertainment); robotic competitions and social robots are good examples of this.

We also cite other issues that are raised in the employment of robotics as an educational tool, such as: the cost of robots and robotic environments, the lack of teachers trained in using this equipment, students' lack of previous knowledge in computer programming and logical concepts, disconnection between the pedagogical strategies used in robotics activities and other school activities.

In an attempt to resolve these issues, this paper presents an instructional tool as part of a broader project in educational robotics developed by the GISDI (Group of Integration Systems and Intelligent Devices) of the Computer Science Department of the UNESP, Sao Paulo State University, which forms part of the pedagogical context that guides this project. The system is a simulator based in a real mobile robot. It is entirely controlled by switches and enables children to develop simple conditional structures to complete different tasks, such as walking in a line or finding an object in space. Because it is a simulator it can be used by many students without the need for large investments in equipment. Since the activity of programming the robot using a formal computer language can be difficult for those who have no previous background in computer science, the interface is totally graphic, so it can be used by students from primary schools to universities, as well as by teachers to design the activities. The purpose of this robotic simulator is to serve as a tool for creating learning objects to develop the students' dynamic and strategic competences by exploiting didactic material in addition to concepts such as robot navigation and control, and computer programming.

Robotics and Education

The multidisciplinary aspect of robotics allows it to be applied to a large spectrum of areas that no other media can support. As such, it is different from and more flexible than other methods of learning.

The objective of educational robotics is to develop skills such as problem solving strategies, thought formalization, and socialization, as well as to support the acquisition of various concepts. Four major approaches in educational robotics are used depending on their field of application (Denis & Hupert, 2001, 466): a techno-centric approach aimed at the development of technical situations often closely-related to the industrial world; an approach based on the creation and exploration of micro-worlds based on the learner's project; an approach based on computer assisted experimentation, connected to scientific contents; a programming or algorithmic approach.

There are many works on the use of robotics in various stages of children's education. In each case, the educational objectives differ according to the age of the student and the educational strategy followed. Robotic toys such as the Tamagotchi, Furby and AIBO, and products developed by the partnership of companies and universities as Lego Mindstorms, Curlybot, and éTUI have attracted much commercial interest.

The Logo programming environment for computer screens, when coupled to a small robot, the Floor Turtle, as developed by Papert (1993) in the Artificial Intelligence Laboratory at MIT is today widely used and studied due to the potential it demonstrated following the educational strategy proposed by Papert. Since the 1980s, this idea has been expanded and combined with components of LEGO by Fred Martin, Seymour Papert and Mitchel Resnick, at the same laboratory, resulting in a precursor of the module Lego Mindstorms.

The Curlybot is a small semi-sphere shaped robot that fits in the hand of a child conceived with the aim of developing computational and mathematics concepts in child above 4 years of age (Frei, Mikhak & Ishii, 2000, 1). Equipped with sensors and actuators, the Curlybot can record and repeat the movements performed; the direction, velocity and acceleration of the movements are captured and very accurately reproduced. Through interacting with the Curlybot children rationalize about the movements and sequences that are programmed. Also, a pen may be attached to the Curlybot creating an image of its movements on paper, producing and composing geometric shapes. The interesting part of this initiative is that programming is performed by physical movements rather than through computers. Thus, the Curlybot presents itself as a preparatory alternative to the Logo educational environment proposed by Papert.

Another relevant work offering a new approach to the use of robotics in education is proposed by Blat and colleagues (2001). The mobile robot called éTUI is designed to stimulate reflection on perception, autonomy and learning in children from the ages of 4- to 8-years-old; the robot changes behavior when it encounters an obstacle. The éTUI is equipped with position sensors, optical sensors to determine the distance and brightness of objects, and sound and light actuators that allow it to express itself to children. The range of behaviors, which can be programmed, alters the decision processes of the robot when it encounters changes in the environment. The behavior set also establishes situations in which the robot understands the problem with which it is presented and reacts to it. Thus, a child, observing the behaviors and procedures performed by the robot, reflects on abstract issues like perception, orientation, autonomy and learning. Therefore, the skills encouraged by éTUI—similar to the approach of the Curlybot—provide an opportunity for young children to reach the levels of knowledge laid out in the philosophy proposed by Papert without the need of a computer.

Also, in special education, the use of technology integrated with education enables children with disabilities to begin acquiring knowledge from experience, equally participating with their peers in learning activities based on robotics, instead of remaining simple observers (Harwin, Ginige and Jackson, 1988; Jackson, 1988).

The use of robots in educational and therapeutic approaches is based on social skills such as the abilities to imitate, to learn by interpreting gestures, and to recognize voices through a study of social relationships with humans. This initiative explores the use of audio and video processing and learning algorithms with the goal of creating educational games and entertainment for normal and special children (Robins et al, 2005).

The work of Salter, Dautenhahn and Boekhorst (2006) with very young children and children with autism has a different approach, in which traditional forms of human–robot communication, such as speech or gesture recognition, may not be appropriate with these users, and touch may help to provide a more natural and appropriate means of communication for such instances. They developed a project involving a spherical robot that acquires information regarding natural touch from analyzing sensory patterns over time to characterize the information received.

STORM (Theoretic Online Simulator of a Mobile Robot)

STORM is an environment that allows the creation of learning objects applied to robotics. According to Wiley, learning objects (Wiley, 2002, 1) are elements of a new type of computer instruction that are based on an object-oriented paradigm of computer science.

The simulator consists of a wheeled robot that has two touch sensors and two optical sensors, (Fig. 1). Also you can create an environment containing obstacles and marks on the ground to carry out a variety of activities. The navigation and control of the robot is done through switches that control the drive motors and sensors. In this way students have contact with the most basic way of operating a digital device. In addition, the task planning is performed through a graphical interface, and requires no previous knowledge about programming.

The first version of the simulator was developed with Adobe Flash CS4 in ActionScript 3 code, which allowed an easy distribution of the system through the web and the reutilization of the code because it is an object oriented language.

The next step of this project was to upgrade the software to a 3D environment, providing a more immersive environment for children to explore different viewpoints of the robot and the tasks it must complete. With the engine Sandy 3D—an open source 3D API which allows the application of materials and textures, parsing of different 3D files and parameterized creation of several 3D primitives—it was possible to write the code in high level, without the need to worry about hidden surface removal, lighting and many others ready-to-use algorithms.

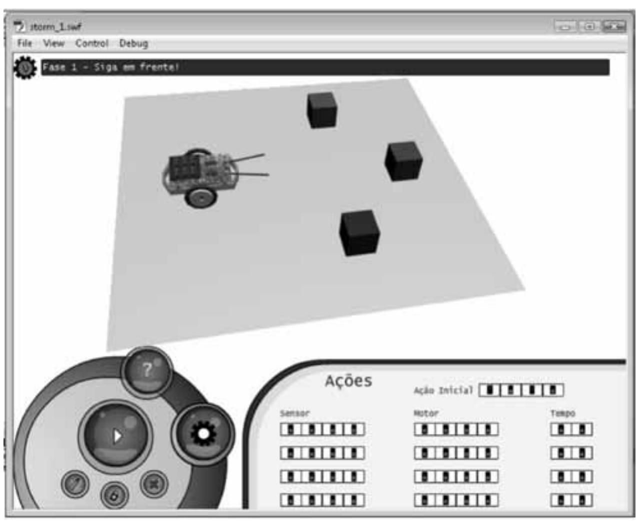

Figure 1. The robot structure

Applications

The STORM control interface, shown in figure 3a, consists of a set of switches named: *initial action, sensors, motors* and *time* (Fig. 3a). The switches for initial action determine the primary motion of the robot; two switches command the left wheel and two command right wheel. If the first switch is turned on the wheel rotates forward, and the other rotates the wheel backward. So we can create a basic navigation and control activity where students learn how to move the robot forward and backward, and turn right and left. The set of switches called sensors, motors and time establish a condition associated with the status of the sensors. For example, to make the robot to walk forward the first and third switches of initial action must be turned on (Fig. 3b). In this condition the robot will walk forward until it reaches an obstacle. Then another behavior may be established "If the left touch sensor is activated, then the robot have to turn right during a unit of time to avoid the obstacle". To translate this condition into the binary language, the status of the sensors, motors and time switches should be like those that appear in figure 3c (Fig. 3c).

Therefore, many activities can be proposed in the professor module of the simulator within the context of navigation and control of robots. Of course the small number of switches limits the range of programs that is possible to create. This was done to prevent the difficultly of establishing the logic of a behavior from increasing .

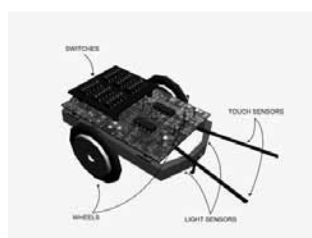

Figure 2. STORM environment

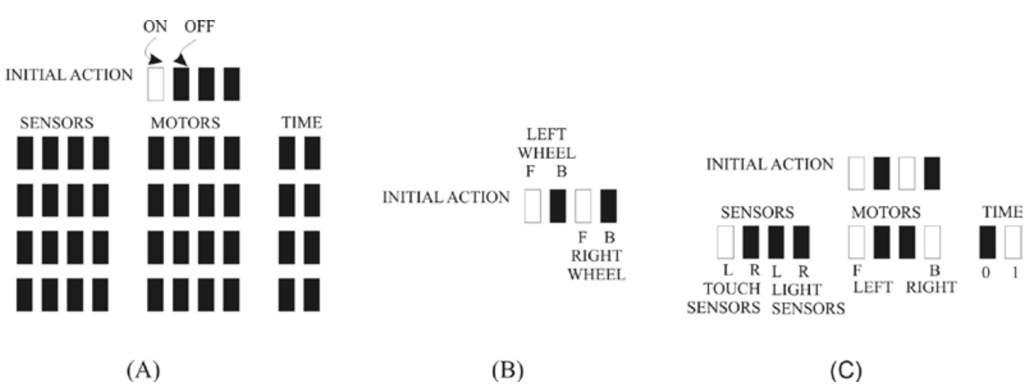

Figure 3. STORM control interface

Conclusions

Considering the initial goal of creating a simulator of a robotic environment for the development of learning objects applied to robotics, specifically the principles of robot navigation and control, we can say that the tests carried out with students from fifth to eighth grades of primary school in Brazil, illustrated that the simulator is readily understood by children and teachers. The capacity of the simulator to be accessed via the internet expands the number of users and the possibilities of application due to interaction between students and teachers from different schools. The next step in this project is to develop a set of learning objects containing the basic documents: pedagogical design, roadmap presentation and the teacher's guide—to be tested, evaluated and improved.

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