Sumo simulator for educational robotics

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Abstract. Throughout the 21st century, robotics has assumed an important role as an educational resource for teaching science and computational thinking. However, the pandemic imposed a physical limit that forced us to find resources that allow access to similar content within virtual environments. This article presents the development of a sumo simulator with characteristics like the physical world, which facilitates the maintenance of remote activity even in environments with limited hardware resources. In addition, it explores the benefits discovered through the use of the simulator. and the design of long-term robotics competitions on this platform.

Keywords: robotics simulator, educational robotics, sumo.

1 Introduction

Incorporating robots into classrooms provides students with a thoughtful and hands-on learning environment. By collaborating in teams to design, build, program, and document autonomous robots, they not only gain technological knowledge, but also develop essential skills needed for today's world of work. (Eguchi, 2017). On the other hand, given that the demand for technology professionals, including programmers, designers, and engineers, continues to increase, the study of robotics can be an effective way to foster vocations in these fields, as well as promote the participation of women, who are underrepresented in the technology industry (Miller & Nourbakhsh, 2016). It is for these reasons that robots have become a teaching resource present in many primary and secondary schools around the world.

However, the cost of purchasing and renewing materials, and the fear that some teachers have regarding the complexity of interacting with the physical world (Reich-Stiebert & Eyssel, 2016), continue to be a limit for this expansion to be complete. Furthermore, the pandemic has highlighted the need for resources that can be accessed remotely and virtually.

On the other hand, the increase in the computing power of graphics cards and the decrease in their cost have allowed the popularization of the use of robotics simulators based on a physics engine. These simulators open the doors to the construction of

realistic environments, where simulated robotics is not simply a programming challenge, but also where the same variables come into play as in the real world.

For these reasons, since 2020, robotics educational proposals based on simulators have grown. This article presents the development of a robotic sumo environment for educational robotics, along with a set of tools that allowed automating competencies based on the developed sumo. Additionally, the impact of its use on competitions within Argentina and Latin America is described.

2 Selection of a Robotics Simulator for Use in Education

Below are the characteristics that a simulator must have for its successful integration into education (Hughes, Shimizu, et al., 2019):

- The software must be free or low-cost to reach as many educational institutions as possible. Indeed, one of the reasons why physical robotics has not reached all classrooms is due to its purchase and maintenance costs.
- The user interface must be simple and intuitive. This is not a usual characteristic of industry-oriented software.
- The installation must be simple enough not to become a barrier to entry.
- It must not have high computing requirements, as the cost not incurred in the software would be transferred to the equipment.
- It must have an underlying physics engine that brings the behavior of the robots closer to the real world.

Based on these requirements, a comparison was made between different programs available on the market. They were Virtual Robotics Toolkit, CoderZ, Eyesim VR, CoppeliaSim, Gazebo and Webots. Finally, the selected platform was Webots. This simulation environment is also very popular in the academic and hobbyist fields. Its physics engine is ODE, which is very robust and has been on the market for a long time. It allows for the creation of cloud-based servers, freeing users from needing powerful machines to use it. It has a large library of worlds, robots, and objects, and users can design their own as well. It is free and open source, running easily on Windows, Linux, and MacOS. The robots can be programmed in C, C++, Java, Python, Matlab, or ROS. Its user interface is very simple, as are the tools for building worlds, robots, and models (Michel, 2004).

3 Development of the Sumo Platform

3.1 Simulated world construction

In Argentina, since the year 2000, the National Robotics Olympiad and Project Fair, known as Roboliga, have been held. In 2020, a special edition was planned to cele-

brate its twentieth anniversary, but unfortunately, the pandemic prevented its realization. Additionally, the National Institute of Technological Education requested the collaboration of the author of this article to maintain activities related to robotics and programming in the virtual context that predominated in educational institutions at that time. For these reasons, after conducting a study to select the simulator most suitable for current needs, it was decided to create a simulation environment for Robotic Sumo. This competition, which has a large number of participants, involves various aspects of robotics, and presents a simple problem with clear rules for the competitors.

Robotic Sumo wrestling consists of two robots whose objective is to push the opponent out of the arena, known as the dohyo. The arena is usually black with a white border around it so that the robot can detect its limits with its sensors. The robots have color or brightness sensors for the floor and distance sensors to detect the opponent, among others.

Despite Webots' physics engine being very precise, Sumo fights are a stressful test, as collisions are generated that must be constantly evaluated. For this reason, a cylindrical robot already presents in the library (Elisa - 3) was chosen, since this surface presents a simple plane for these collisions.

During the initial tests, the fights between robots lacked definition because it was impossible for two cylindrical robots to push each other without slipping and losing pressure. As a result, all the fights ended in a draw. To address this challenge, a prebuilt robot like the models developed by the students was sought. The choice fell on the Microbot, a robot with an irregular structure that easily latches onto another to drag it to the edge of the combat area. Additionally, the Microbot is equipped with a distance sensor oriented towards the floor, two bumpers, and a differential movement system. To adapt it to the sumo competition, the position and direction of the distance sensor were adjusted, and two brightness sensors directed at the floor were added to detect the white line. A noise threshold was added to the sensors to resemble real-world sensors. Furthermore, work was done on the collision mesh since its original structure did not match the actual format of the robot.

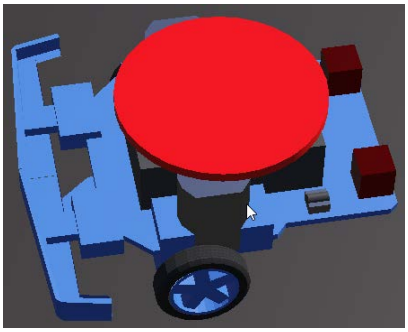


Figure 1 - Final design.

For the competition, an environment was created with a black dohyo with a white border. Initially, an attempt was made to construct a cylinder with a height of 5 cm, as in the real-world competition. However, due to the construction characteristics of cylinders in Webots (which are a set of circular sectors), abnormal collisions with the floor were generated. Therefore, the fighting area was defined as a flat image applied to the base floor.

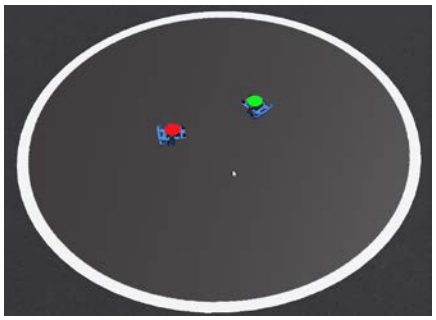


Figure 2 – Dohyo.

The rules of the Robotic Sumo competition are:

a) The fight lasts 2:30 continuous minutes.
b) Both robots start at a predefined point on the dohyo, facing a certain direction.
c) If the center point of the robot goes outside the white line, it is considered to have left the dohyo and is out of combat.
d) If a robot remains without a change of position for 20 seconds, it is considered out of combat.
e) If one of the robots reaches 15 seconds without changing position, and the other has been in the same state for 10 seconds or more, a relocation is performed. This consists of placing the robots at the starting point, but modifying the direction in which they point.
f) If at the end of 2:30 none of the robots is out of combat, the fight is considered tied.

To referee the fight, an automatic system was developed that not only verifies the rules of the game, but also enables the loading of the code of the two competing robots, performs the original positioning and the necessary relocations during the fight. This development is based on the Robocup Junior rescue simulator.

3.2 Robot programming

The robot is programmed in Python language. To simplify this task, and to hide some low-level aspects of the class's operation, it was decided to make a wrapper with methods for:

- Assign and obtain the velocity of the left and right wheels.
- Wait a certain amount of time.
- Get the current time.
- Obtain the brightness value of the sensor pointing at the floor in a range of 0 to 100.
- Obtain the red, green, and blue values from the sensor pointing to the floor.
- Obtain the distance of each of the left and right sensors.
- Obtain the status of the left and right bumpers.

To perform debugging tasks, the print command writes to the console that has the Webots interface.

On the other hand, to further simplify the entry of new participants into the world of simulation, a Blockly-type visual programming language was developed, which has the same control and decision methods and structures as those available in Python.[1]

4 Use of the Sumo simulator in competitions

Although physical robotics presents a set of variables that are drastically limited in a simulated experience, the developed environment allowed Sumo competitions to be carried out with the same level of indeterminism as in the real world. The fights are still fun and exciting for the students.

One of the problems with physical competitions is that, due to budgetary reasons, they are carried out in one or two days. This means that any problem that may arise in a robot during that period leaves its team out of competition. Furthermore, the gap between competitions does not encourage students to reflect on the strengths and weaknesses of their designs.

In contrast, virtual competitions facilitate the participation of teams from anywhere in the world at zero cost. In addition, long-term tournaments can be organized, with zone competitions and final brackets. This enables in-depth analysis of the participants in relation to the problems of their robots, as well as the virtues and defects of the robots with which they are going to compete. Despite the limitations inherent to simulation, this experience enriches the learning obtained, providing aspects that are not possible in a physical competition.

During 2021, given the success of the simulator in 2020, and with the aim of being able to hold a long-term competition, it was decided to organize a Latin American championship with a duration of approximately 6 weeks. Given the success of the first edition, its annual organization is maintained. The participating teams are:

[1] The entire development is available at virtual.roboliga.ar

- Virtual Roboliga 2021: 165 teams from Argentina, Panama, Mexico, Cuba, and Colombia.
- Virtual Roboliga 2022: 83 teams from Argentina, Colombia, Panama, and Ecuador.
- Virtual Roboliga 2023: 72 teams from Argentina, Panama, Bolivia, and Brazil.

5 Future works

From the experience with the use of the simulator, beyond overcoming the problems caused by the isolation of the pandemic, some characteristics were glimpsed that could complement or overcome common difficulties of physical robotics. That is why the development of a learning environment that simulates the usual challenges of mobile terrestrial robotics, such as line following, obstacle avoidance, and others, began. To compare the physical and virtual worlds, physical robots were designed with characteristics like the simulated one, and a set of activities were developed with a control group and an experimental group. These experiments will be carried out shortly.

New worlds and robot designs are also in production, to build a set of didactic sequences that allow an introduction to robotics complementary to the activity with the physical world.

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