AC 2011-2011: MOBILE ROBOT SIMULATION IN A VIRTUAL WORLD

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Second Life virtual world offers 3D modeling tools, scripting support, and a physics engine which provide a platform to develop mobile robot simulations and interactive educational exhibits. Benefits of employing virtual world simulation tools include rapid prototyping, low-cost development and delivery, collaboration, and access to an international community. An interactive robotics exhibit in the area of mobile robot programming education has been constructed and deployed in the virtual world. A second exhibit to enable 3D human-robot interaction studies has also been established. Student access, involvement, and collaboration in the virtual robotics exhibits have been successful. Simulations developed in 3D virtual worlds, such as Second Life, can serve as a highly accessible virtual laboratory and can support a variety of educational and research objectives in the area of mobile robotics and human-robot interactions.

1. Introduction

Second Life is an online virtual world developed by Linden Laboratories and released in 2003 [1]. Users create accounts, log in, and take the form of customizable avatars. Avatars can interact, communicate, access media, engage in construction, collaborate, navigate, and may attend live concerts, workshops, lectures and meetings. Many corporations, non-profits, government agencies, and universities participate in Second Life virtual world. All of the venues, including buildings, cities, towns, university libraries, classrooms, museums, dance clubs, art centers etc. were created by residents of the virtual world. Currently, there are between 60,000 and 80,000 residents online in Second Life at any given time. The residents of Second Life (there are over 1 million registered users) represent a wide range of backgrounds, ages and nationalities and represent a truly international community.

The Second Life virtual world provides 3D building tools and scripting capabilities which facilitate the prototyping and presentation of engineering designs and models[2]. Scaling, translation, rotation and shaping tools enable residents of this virtual world to create a variety of objects including automobiles, motorcycles, ships, buildings, furniture, bridges, amusement parks, etc. A native scripting language provides the ability to animate and transform objects programmatically and also permits the interaction of objects with avatars and the environment. A physics engine is supported which provides the effects of gravity, friction and collision detection. Due to the immersive and socially interactive capacity of Second Life, designs and prototypes may be constructed, tested and evaluated in a collaborative fashion. Designs constructed in this virtual environment are of a persistent nature and can be viewed and accessed by avatars controlled by people throughout the world via the internet. A basic account in Second Life is available free of charge and this basic account affords access to all of the building and programming tools described herein. It should be noted that it is necessary to purchase virtual land if an organization desires to permanently host facilities and exhibits in Second Life.

There are many examples of organizational and professional presence in Second Life and I shall describe two virtual locations that host robotics-related resources. One such virtual site is NASA Jet Propulsion Laboratory (JPL) presence on Explorer Island in Second Life. There are a host of 3D models and interactive exhibits related to the ongoing space programs supported by NASA. Meetings and educational presentations are also held for staff and the public at this site. Some of the builds and exhibits are constructed and maintained by volunteers working with the NASA organization and professional throughout the world. One of the exhibits shown below (figure 1) is a virtual 3D model of the Mars rover. The rover is animated and moves across a simulated Martian surface. The virtual site also provides interactive links to additional information concerning the Mars mission and the role of robotics to support mission goals.

Figure 1: NASA Virtual Robot Demonstration

Another relevant and presently existing site is the IEEE virtual presence in Second Life. This site is currently used for meetings, professional talks, and to promote the mission of the IEEE organization. The Robotics and Automation Society (RAS) has sponsored robotics demonstrations on the site that may be accessed by any of the users of Second Life [3]. Included in the suite of demonstrations is a path following robot, a soccer playing robot, and a virtual bartender robot. One of the animated demonstration exhibits is shown in Figure 2. An avatar (operated by this author) is shown in the image interacting with the robot demonstration.

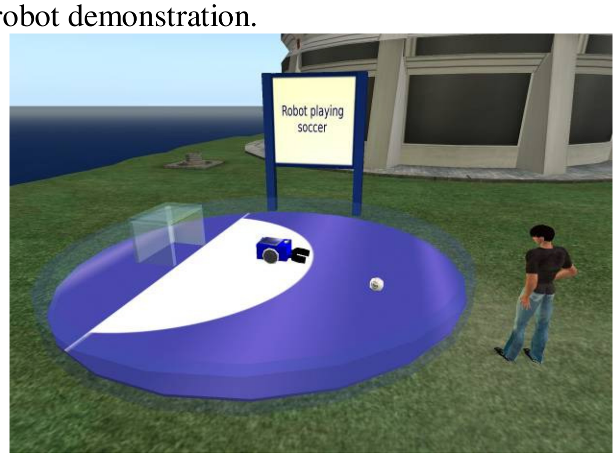

Figure 2: IEEE Virtual Robot Demonstration

2. Robot Simulations in a Virtual World Environment

Robot motion in Second Life virtual world is accomplished through the native scripting language. This scripting language is based on a finite state machine model. Each state contains event listeners which respond to avatar and environment events such as timers, collisions and communication. Based on these events, the software will execute functions which can result in the motion of objects and other appropriate operations. The language offers a rich set of functions and event handlers, and the syntax of the scripting language resembles C++ and Java. Data types such as integers, floats, strings, vectors, lists, quaternions (rotations) are supported. Scripts can be created, modified, compiled, and tested directly in the virtual world without the use any special tools. The scripting language can also be used to interact with the physics engine (Havoc 4) of Second Life. For example, parameters for buoyancy and friction can be modified under programmatic control. In addition to gravity, arbitrary forces and impulses can be applied to objects in the virtual world. Beyond collision sensing, there are also functions to support "sensors" which can detect and identify objects and avatars in the vicinity of robot objects. Objects in Second Life may also respond to communication (text chat) from avatars and also object-to-object communication is supported. These features provide a useful set of tools to develop and prototype robotics algorithms. Typically, sophomore-level undergraduates who have completed a computer science programming course can successfully participate in creating scripts within Second Life. A comprehensive treatment of scripting is beyond the scope of this paper, and the author has found the following resources to be useful for scripting in Second Life [4,5,6]. Several of the key robotics initiatives which have been constructed in Second Life will be briefly discussed below.

The first project to be described is an interactive, 3D virtual exhibit that demonstrates and teaches basic mobile robot programming. The exhibit requires users to create a list of commands to control the motion of a mobile robot in a maze (see Figures 3 and 4). The goal for the user is to create an appropriate sequence of commands which result in a successful navigation of the maze. Users can create simple notecards in Second Life and insert text commands such as "Forward 2.5" which translates into move the robot forward for 2.5 seconds. Commands allow for motion to be applied for a variable amount of time, and also permit turning. These notecards can be dropped into the robot object, then can be parsed by the robot script and are translated into robot motion. A set of instructions, command formats, and helpful tips for the exhibit are posted in Second Life at the exhibit site. Commands are translated into actual forces applied to the robot model, and the robot responds (moves) realistically with collision detection and friction as supported by the physics engine. The user is encouraged to experiment and iteratively develop a program, consisting of a sequence of high-level commands that result in the robot moving successfully from the start position through the maze. This particular interactive exhibit is geared towards the novice user and does not require any knowledge of the low-level scripting language to initially access and interact with the robot. This exhibit was tested by a small group of undergraduate freshman students enrolled in an introductory information science course at the Penn State Abington campus in the fall of 2010, and all of the students were successful in completing the task of moving the robot from the start position through the maze to the goal area. This group of freshman students, none of whom have completed any formal computer science programming course, represents the target audience for this particular exhibit. A scripting feature is also in place to email the instructor when a user successfully completes the robot maze challenge. Additional data collection and reporting will also be considered for future improvements.

The overall objective is to have these resources serve as a virtual laboratory that is accessible to any students with internet access (and a free Second Life account). Undergraduate students have been involved in both developing and evaluating the robotics exhibit.

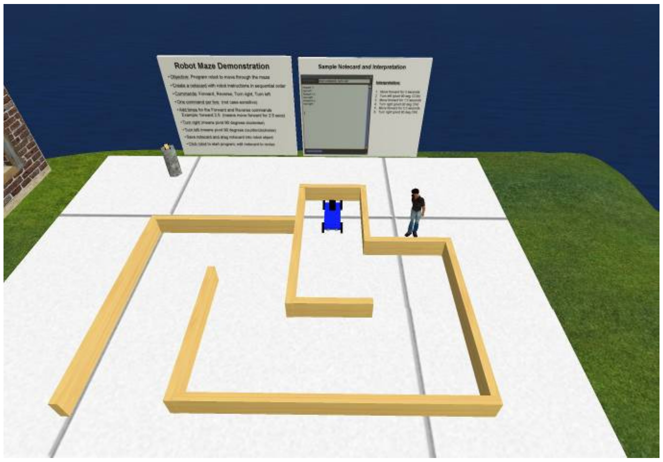

Figure 3: Virtual Robot in Maze

Figure 4: Virtual Robot in Maze

Our second initiative is the development a 3D virtual living space that can be used to model and evaluate human-robot interactions. As can be seen in figures 5 and 6 below, a virtual 3D living room space and kitchen have been constructed in Second Life. Many of the individual furnishings depicted (including furniture, appliances, etc) in the figures below have been purchased for a nominal fee inside the virtual world and these appliances were originally designed and built by other residents. The availability of such materials and resources minimizes the time and cost to setup realistic living environments. Faculty and several students collaboratively established this virtual living space in several hours of time. Within this environment we have programmed a floor cleaning robot (inspired by the iRobot Roomba robot product) to navigate in the living space under a variety of simple control algorithms. The vacuum robot moves throughout the living environment and uses motor controls, sensors, and collision detection to navigate autonomously.

It is relatively easy to reconfigure furniture and to add avatars and a variety of robots into the virtual environment to evaluate the interactions. We have succeeded in our effort to determine the feasibility of designing a virtual living space to study the interaction of human and a simple robot. We are currently designing other robot models and human-robot interaction scenarios and studies. These results may have a very positive impact on the study of robots in the areas of smart homes, elder care, aging-in-place, accessibility, emergency response, and safety in a living environment shared with robots (see Figure 7). This virtual approach provides a very low-cost solution to prototyping solutions in a 3D interactive environment and also has the advantage of sharing results with an international audience. The ability to engage cooperatively and interactively is one key advantage of virtual worlds over other simulation tools. We are planning to perform additional testing in this virtual living environment and also to share the environment with other students and researchers interested in utilizing virtual world technology to promote this technology.

Figure 5: Virtual Living Space with floor robot

Figure 6: Virtual Living Space: kitchen area

Figure 7: Avatar in wheelchair with floor robot

3. Summary and Conclusions

The Second Life virtual world is a useful tool for prototyping and simulating a variety of robotics applications. A rich set of building and scripting tools as well as a physics engine are available to the developer. An educational robot exhibit focused on mobile robot programming was constructed, deployed and successfully tested. A virtual living space for studying human-robot interactions has also been designed and successfully implemented in Second Life. Each of these exhibits is currently available at all times to anyone with internet access. Advantages of a virtual world implementation of virtual labs include low-cost for development and delivery, 3D modeling and scripting, support for collaborative design, access to a rich set of existing content and resources, and access to an international community. Based on these initial results and advantages, and with the expectations that virtual world technology will continue to improve, it is predicted that virtual worlds will play an increasingly useful role in the areas of robotics education and research.

References

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