Development of Port Equipment Simulators using Virtual Reality

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Abstract

This article presents partial results on the development of simulators for port facilities developed by the Group of Virtual Reality applied - GRVa / LAMCE / COPPE / UFRJ. The simulator training is economically more attractive than just the use of machines in real environments, generating lower costs throughout the process, this type of approach is one of the key factors to reduce accidents, because the training itself is not free of risk situations and equipment breakdowns. The paper presents the solutions employed and a comparison with current training methods, without, however discard them, but using a hybrid system that encompasses both the virtual and the real.

Keywords: Virtual Reality, port training, job training, simulation, educational model, animation.
Introduction

Creating simulators for port equipment using Virtual Reality has proven to be an effective tool in the implementation of training programs and professional qualification in the port field. When we consider the main parameters in comparison to traditional methods, we can see a drastic reduction in cost and time required to train these professionals, also reducing possible risks that a real training could cause. The simulators can expose the professionals under training to the same risks and adverse situations that occur in real life, without, however causing physical or financial harm. Port equipment simulators fundamental aim is to reduce costs and operational risk (Bruzzone, Mosca et al., 2000) and are used in learning, training and updating of current or future operators of these equipments, reaching its maximum utilization. We can define port equipment as a set of large structural facilities, used for moving cargo between different types of transport with diversity in load capacity and technology.

The simulators described in this article were created and developed by the Applied Virtual Reality Group - GRVa Laboratory of Computational Methods in Engineering - LAMCE, COPPE / UFRJ and are produced and commercialized in partnership with Virtualy Simulation Technology, located in the companies incubator at UFRJ. The focus of this partnership is in the development of simulators with applications in the port and transport area. The technology in simulation of Virtualy received "Certificate of Exclusivity in National Production" issued by ABINEE - Brazilian Association of Electrical and Electronics Industry. This certificate attests that only Virtualy produces such technology in series in Brazil.

Use of Virtual Reality in the Development of Simulators

One of the main reasons for the use of VR is the growing need for continuing education in response to rapid technological changes. The computer in this context is used as a tool to support education and is becoming indispensable to improve the
dynamics and quality of the teaching process. The VR conquers more space as a tool for virtual environments creation, due to its characteristics, which allow the development of interactive solutions with a better capacity of simulation and greater sense of immersion in the user, resulting in environments of high cognitive potential. Examples of work using port simulators in VR can be found in (Bruzzone, Fadda et al. 2011). In three-dimensional environments created with VR resources, the user expands their possibilities for manipulation and visualization of objects. In a virtual world an operator can make choices, search and manipulate objects. Ideally a simulation should be as faithful as possible to reality, but usually we encounter a lot of difficulties for this to become reality, most VR systems have shortcomings: expensive, has poor visual graphics and low performance. These are some of the limitations that technology itself and a lack of prior simulation optimization can reflect.

The GRVa / LAMCE / COPPE experience

The Group of applied Virtual Reality (GRVa), Laboratory of Computational Methods in Engineering (LAMCE) at COPPE / UFRJ, has significant experience in development in the areas of virtual reality, augmented reality, offshore simulation, computer vision and scientific visualization. Its team consists of researchers, engineers and graduate students, masters and PhDs, under the coordination of the teachers Luiz Landau and Gerson Cunha.

From 2010 the team has been developing cranes and port equipment simulators in Virtual Reality. The simulators operate from a replica cabin with all active commands integrated into a system of advanced visualization. The 3D virtual scenario, which can be designed in cave or interconnected monitors, simulates sounds and weather conditions in real time. The scenarios are reproductions of the environment in Brazilian ports, including the port of Santos and Rio de Janeiro, Espírito Santo Portocel.
Through a consortium between the University of Genova, Italy, and Coppe / UFRJ, the technology developed in GRVa / LAMCE and now commercialized by Virtualy was provided for training operations at Italian ports: a simulator of Portainer operates at the Port of Cariari, Sardinia, and a truck simulator of port operations was installed at the Port of Genova.

The same base technology used in the offshore simulators is used in the development of other models of simulators serving the civil construction, port, mining and aviation sectors.

Besides developing port equipment simulators the group began developing of mining machinery simulators. Were developed the following simulators: (a) Porteiner, (b) reach stacker, (c) mobile crane (d) Transteiner (e) Roller bridge, (f) Ore truck, (g) Bulldozer, (h) Wheel loader, (i) construction crane, (j) offshore crane; (k) onboard crane, and (l) ship unloader simulator.

(a) Screenshot of the Porteiner simulator. 
(b) Screenshot of the Reach stacker simulator
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<td>(c) Mobile.</td>
<td>(d) Screenshot of the Transteiner simulator.</td>
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<td>(e) Roller bridge.</td>
<td>(f) Screenshot of the Ore truck simulator.</td>
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<td>(g) Bulldozer.</td>
<td>(h) Wheel loader.</td>
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The Simulators Construction Process

The geometric modeling of the visual elements of the simulation was generated by the software Autodesk 3Ds Max. The programming of interaction was created through a computer application that uses the physics engine based on Newtonian mechanics. Once modeled the elements of the simulator and arranged in the correct coordinates was started the models import from the 3D content generator to the application that generates interactivity.
To export the content generated with 3Ds MAX, we used the Collada file, generated by the software through an external free plug-in, Open Collada, applying then the interactivity with Quest3D, which is a development tool for the generation of 3D real-time applications, the software Quest 3D uses Visual Programming feature that allows the creation of 3D models, textures and creating web applications or executables, by people with no background in programming. This feature also allows artists and designers to test scenarios and interface solutions regardless of whether they are or not programmers.

Not disposing also the possibility to program, because the simulator provides the LUA scripting language and the creation of features and programming plug-ins in C++.

The physics engine used was the Newton, which generates a physical environment extremely realistic and widely configurable, the simulator dynamically generates shadows in real time, including a system for generating climate with rain, snow and clouds (Figures 1 and 2), positioning of the sun at various times of the day and wind speed for a better realism in the crane operations, so that the operator has a sensation as close as possible to reality.

The configuration of the coefficients of static and dynamic frictions makes the floor and friction between different materials close to reality, sound is configured according to its position within the simulator, so that each sound is emitted from a specific direction, in addition, the closer is the operator to a machine, the higher is the perceived sound.
Figure 1: Mining truck simulator with rain and snow simulation.

Figure 2: the clouds move dynamically according to the wind direction and speed.

An example of use of the physics engine applied to modeling of hydraulic pistons able to exert force on the structure that is being simulated can be observed in Figure 3, which shows screens of a Reach Stacker simulator.
In order to meet the required degree of realism to the simulation, we used the change of the center of gravity feature for the containers, thus increasing the degree of difficulty of stabilization and dynamic behavior through the Reach Stacker spreader and the Transtainer as in other situations that this feature would be required (Ju et al, 2010), besides the use of collision geometry for the perfect coupling of the spreader to the container.

In Figure 4 are the Transteiner simulator screens developed based on the concept of changing the center of gravity of the container to be corrected by the operator through the spreader.
Figure 4: Screenshots of the Transteiner simulator.

Rearview mirrors were included to the Reach Stacker Simulator and to the mining truck so that when operated, possible obstacles on the back of the vehicles can be identified (Figure 5) as well as real light effects on their headlights and reverse light devices, operating day and night (figure 6).

Figure 5: Rearview mirrors which generate reflection in real time.
The panels of the simulators were executed from the Arduino platform, which allows seamless interaction between the simulation and the user so as to represent the real panel with maximum fidelity.

Arduino is an electronic prototyping platform consisting of a multipurpose printed circuit board developed with an Atmel AVR microcontroller. It has input and output circuit with open source, which allows you to control various peripherals, such as motors, lights, sensors, buttons, accelerometers, etc. Also used by designers and artists to create interactive works, the Arduino platform uses programming language C / C++, also features a USB interface or serial lines for input and output analog and digital to be able to connect it to other equipments.

Figure 7 shows the platform of a Transtainer simulator, the respective Arduino panel with its circuits and an image of the computer screen containing the programming codes.
Figure 7: Transtainer Simulator with its platform and panels (left), Arduino board (center) and programming code (right).

Final Considerations

For the development of the simulators an extensive research on the functioning and operation of this type of machinery was necessary, from operation and maintenance manuals. In addition, theoretical and practical courses on operation of this equipment were attended. They were taught by professionals with wide experience in the use of this equipment.

The group consists of a multidisciplinary development team composed of researchers, engineers, graduate students, teachers, and it was coordinated by the doctors from COPPE / UFRJ, as most of the required knowledge as is part of team formation, as: programming, 3D modeling, design knowledge, etc.

The development time of each simulator varies according to the complexity of its operation, the size of the development and the 3D modeling team, and the amount of physical interactions to be executed, depending also on the fact of being only a visual simulator or making use of mathematical modeling , which may extend the time for its completion. Considering these factors, it might take about 1to 3 years to finalize the developing of a simulator process.
It was chosen the 3Ds Max Software for the development of the three-dimensional models due to its flexibility, for being the most compatible with most systems used to develop and generate models of high quality and similar to real ones.

The Quest 3D software has an extremely effective physics engine, but caused some issues during the course of its use due to the fact that few Brazilian professionals are trained and capacitated with knowledge of visual programming used by this software, bugs related to the software itself that were bypassed after a lot of research and testing utilizing various methods and difficulty in finding video cards which would correspond to a good final result of frames per second when generating an executable of the simulator. Most problems using Quest 3D were solved by searching on the forum and the tutorials available on the website of the manufacturer, that are very informative.

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