SIMGRUA - A VIRTUAL SIMULATOR FOR TRAINING

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The development of a simulator for training, based in a virtual environment, composed for software 3D and specific interaction physical devices of the virtual reality, must have a development process suitable to the difficulties of construction of these systems. On the other hand the architecture of the system must follow to the maximum the real system in what it respects of that tasks: navigation, selection, manipulation and system control. On the other hand, the choice and evaluation of physical devices that interact with users is critical to system success.

It is intended with this document to demonstrate the development process and the architecture of a simulator of a crane of the marble quarries, that was implemented, and have as purpose to help two groups of users in their learning process: operators of cranes that intend to recycle its abilities and pupils that intend to get professional qualification in operator of cranes.

He also intends with this system, for besides promoting the learning of its users, effecting its evaluation of the performance to the cognitive and psychomotor domains. Some tests with users had been implemented who had demonstrated that the operation and satisfaction level is positive and can harness its process of teaching and learning with cranes.

1 Introduction

The extraction industry of marbles existing in Portugal, more concretely in the Alentejo region, has to its service a set of techniques, human resources and equipment, specialized in the tasks of translate marble stones in its quarries. The execution of these tasks is made in a physical environment that contains many physical risks, because the majority of the machines have great dimensions, the workers works in great heights and stone blocks would provoke crushing in its employees due its great weights.

In the quarry exists a equipment called crane, that is responsible for the translation of the marble stone blocks, between deep of the quarry and the park of blocks and that it demands a very careful and accurate operation. For that, crane operators must have adequate a professional training that allows them to acquire all the knowledge and abilities in the operation of these machines. This article intends to demonstrate some aspects related with the development of a virtual simulator, called SimGrua, that supports the professional training, initial and continued, of crane operators in marble quarries. The SimGrua is based on the use of the technologies that support virtual environments and was developed an appropriate software, that uses adequated physical devices and interaction techniques. It is important to relate that the development of these systems involves some areas of the knowledge, proper and similar, as they are the case of the human factors, person-machine interface, ergonomics, social impact, hardware and software [1].

The main aspects that we want to report in this document are related with the use of some methodologies in the development of the system and with the functional architecture where the system was based.

2 Problem description

The professional training of crane operators in Alentejo region, is based currently in one theoretical component and one eminently practical component, where this last one requires the operation of those equipment in work context. Thus, currently the practical part is based exclusively on the operation with real cranes, where the pupil, with the aid of teacher, learns to execute the proper tasks of crane operator function. However, this practical training is not clearly safety for its participants and equipment, being able to be complemented and to be improved, with all the certainty, through the use of a similar based virtual environment.

The crane is an equipment of great dimensions and weight, which makes it very expensive. The crane is an equipment of great dimensions and weight, which makes it very expensive. The crane is also an equipment of variety and complexity, depending on the different types of block manipulation that exist. At a time when the crane costs thousands, the equipment costs thousands.

The purpose of this project is to develop a virtual and realistic environment, that allows the participation of the crane operators in the virtual world.
Figure 1: Main components and articulations of crane structure

1. Initial version (Virtual Space 3D): Three-dimensional representation of the virtual environment of the crane, with prominent features of the crane's components. This version allows users to interact with the crane model in a virtual environment.

2. Goal: To create a detailed and accurate representation of crane components, including their structural integrity and functional aspects, to enhance the user experience and facilitate learning.

Development methodology:

The development process of this virtual environment involves several stages:

1. Problem identification: Understanding the scope of the problem and the requirements for the virtual environment.
2. Literature review: Gathering information on existing crane models and virtual environments, focusing on their strengths and weaknesses.
3. Model development: Designing a virtual model of the crane using 3D modeling software and incorporating the latest technologies.
4. Testing and refinement: Conducting tests with users to evaluate the virtual environment and making necessary adjustments to improve its functionality and user interface.
5. Implementation: Deploying the virtual environment on various platforms and devices to ensure compatibility and ease of use.
6. Maintenance and updates: Regularly updating the virtual environment to address any issues and incorporate new features.

In summary, the development methodology is designed to create an interactive and user-friendly virtual environment that effectively represents the crane's components and functions, providing a valuable tool for training and educational purposes.
2. **Interlaced version 2** (User Navigation): Implementation of techniques and interaction devices in navigation process of the user in the virtual environment.
   - **Goal:** To navigate in the virtual environment, on natural way, without provoking in the user physical fatigue and mental effort, and using the minimum number of possible navigation metaphors.

3. **Interlaced version 2** (Crane Operation): Implementation of mechanisms that allow the user to control the movements of the active components of the crane, using a physical interaction device named "buttons box", that allows to simulate the cinematic and mechanical characteristics of these components (arm and cable/hook), when in operation.
   - **Goal:** To allow that the user controls the movements of the dynamic crane components, through the use of a similar device ("buttons box") that is used in the real quarries and allows that in real time system reply to users data inputs.

4. **Interlaced version 3** (Collision Detection Handling): Implementation of the mechanisms that allow the system to detect collision between active components of the crane and other quarry objects, like: hook/stones, hook/quarry wall, arm/stones, arm/quarry wall and arm/floor.
   - **Goal:** allow user to execute selection and translate stone blocks tasks, based with simple metaphors, as well, the system must detect manipulation errors provoked by inadequate user actions.

5. **Interlaced version 4** (Collaborative Work): Implementation of mechanisms that allow the crane operator to interact with assistant operator of maneuver, gift in the deep of the quarry, through a gestural and verbal language.
   - **Goal:** To allow that the crane operator and its assistant of maneuver can communicate, between each one of its virtual environments, and where the results of its actions must be propagated in real time.

6. **Interlaced version 5** (Pedagogical Exploration): Implementation of mechanisms that allow to explore some pedagogical resources of the system.
   - **Goal:** To allow that operator crane actions can be evaluated and monitored for the system and teacher, being able the system to be setup with some pedagogical options.

This type of methodology proved that it allows a good communication between requirements team and development team, minimizes the risk of the system if not adequated for final users and assures a better correspondence between the real world and the specifications.

4. **SimGrua functional architecture**

A great challenge in the virtual environment construction is the exploration and use of a panoply of different types of hardware and software technologies, based on some methodologies and techniques during the project phases. As it can be verified in Figure 2, the system was designed to use a set of different technologies that allowed to get initial goals.
It was designed to use different input and output peripheral devices, one conventions as mouse, keyboard, microphone and video display, and others not conventional like head tracker, data glove and "buttons box". The use of each one of these devices tries to provide, in the execution of each task, the best interaction conditions for system users.

Although the navigation process in the virtual environment can use the keyboard and mouse devices, it was verified that the use of head tracker device and its associated interaction technique is more efficient for users in their tasks. The head tracker used was the Polhemus FastTrack.

The chosen device to control the crane mobile components (arm, cable and hook) is the "buttons box" that is the same type that it is used in real life scenarios.

In the real environment, there is a direct relationship exists between crane operator and his assistant: he communicates with the crane operations and she communicates with the crane operations. They do not have the information of an operation's error until it is too late or the fact that allows the operator to control the equipment. The requirement of the simulation is to have the interaction of the system.
use a 3D data glove to capture the operation assistant gestural language and a microphone to capture its sonorous information, whose are transferred to the subsystem of crane operator through local area network.

The system functional core was based on a simulation engine, that supports three-dimensional visualization, management of users behaviors and the other objects of the system, management of different input/output physical devices and allows a multi-user collaborative tasks. The visualization engine was developed in the Java programming language, using for that, a API (Application Programming Interface) Java3D[5] in the following tasks: scenegraph creation, rendering cycle, management of inputs and outputs data from users interaction devices and management of behaviors between objects in the system (example: collisions). The 3D model of the virtual environment had been described in format VRML (Virtual Reality Modeling Language)[6]. The user visualization of the virtual environment is showed in video CRT (cathode ray tube) display.

The system also has mechanisms to manage the data generated by pupils and teachers, before, during and after the training sessions. These data are stored in a SQL (Structured Query Language) database given) managed by the database management system MySql.

5 Conclusion

The SimGrua was tested during its period of development by technician people of marbles extraction industry area and by training technician people. The tests was implemented in usability areas and in the system performance. In usability area the gotten results show us that the users level of satisfaction and their system learning level was sufficiently reasonable. In system performance area, some tests about different quarry 3D models was made, having as goal to get a model that became the system interactive. A visualization system is considered interactive if render between 15 and 25 frames per second. Thus, a three-dimensional model of the quarry was gotten that confers a reasonable performance to the system, assuring a level of acceptable realism in the tasks executed by the users.

References