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Article

Virtual reality forklift simulator - VRFS

Simulador de montacargas en realidad virtual - SMRV

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Abstract
This paper presents the development of a virtual reality (VR) forklift simulator by a team at the Universidad Tecnológica de San Juan del Río. Using Eric Ries' Lean Startup methodology, a forklift model was designed based on a pre-existing template and adapted to meet customer needs. The simulator allows users to control all forklift functions, manipulate loads with the forks, and explore a virtual warehouse environment. Functional tests were conducted with the collaboration of teachers and students, demonstrating the effectiveness and realism of the simulator. This innovative approach to training offers a safe and practical environment for pre-practice learning in reality, promoting the development of forklift handling skills. With the use of cutting-edge technology such as Unreal Engine, this simulator represents a valuable tool for training in various industrial sectors.

Virtual Reality, Forklift simulator, Unreal Engine, Blueprint

Resumen

Este artículo describe el desarrollo de un simulador de montacargas en realidad virtual, llevado a cabo por un equipo de la Universidad Tecnológica de San Juan del Río. Utilizando la metodología Lean Startup de Eric Ries, se diseñó un modelo de montacargas basado en una plantilla preexistente, adaptado para satisfacer las necesidades del cliente. El simulador permite controlar todas las funciones del montacargas, manipular cargas con las horquillas y explorar un entorno virtual de almacén. Se realizaron pruebas funcionales con la colaboración de profesores y estudiantes, demostrando la efectividad y realismo del simulador. Este enfoque innovador de entrenamiento proporciona un entorno seguro y práctico para el aprendizaje previo a la práctica en el mundo real, promoviendo el desarrollo de habilidades en el manejo de montacargas. Con el uso de tecnología de vanguardia como Unreal Engine, este simulador representa una herramienta valiosa para la capacitación en diversos sectores industriales.Words

Reality virtual, simulator simulator, unrealEngine, Blueprint

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Introduction

Virtual reality (VR) technology creates a fully immersive, computer created sensory experience that can be used for entertainment, education and training. This technology transports users to three-dimensional virtual environments, where they can interact with objects and scenarios in an almost realistic manner, opening a world of possibilities for the creation of immersive and educational experiences (Franchi, 1994).

Virtual reality (VR) simulators have become a powerful tool for training people in tasks that would otherwise be costly or dangerous to replicate in the real world. They allow users to immerse themselves in highly realistic simulated environments, where they can practice and hone specific skills without taking risks or incurring the high costs associated with traditional training.(Schofield, 2012)

Virtual reality simulators are an effective tool for measuring performance and differentiating learner skill levels, potentially improving the skills, efficiency, and performance of personnel in training. (Sikder, Tuwairqi, Al- Kahtani, Myers, & Banerjee, 2013)

For the development of the project the Unreaal Engine was used, according to Epic Games, is a video game engine developed by Epic Games, known for its power and versatility in the creation of games and interactive multimediacontent. It has been used in a wide range ofprojects, from high-end video games to architectural simulations and film productions. (Games, n.d.)

The machinery that the project is intended to simulate is a forklift. A forklift is a machine capable of lifting heavy weights, similar to a vehicle with two forks that can be slid under the weights and lifted into the air for movement.

This equipment is widely used in warehouses, factories, and other industrial settings to transport and stack materials efficiently and safely.(Jain, Shah, Sunasara, Shirgaonkar, & Jagtap, 2020).

This article focuses on the development of a forklift simulator in virtual reality, using unreal engine 5.

This initiative not only seeks to modernize the loading and unloading processes, but also represents a significant step towards the adoption of Industry 5.0, an industrial revolution that integrates artificial intelligence, advanced automation and interconnection of systems. (Sikder, Tuwairqi, Al-Kahtani, Myers, & Banerjee, 2013).

Problem

Due to the various incidents that may occur in manufacturing industry facilities, in addition to different situations that arise in the handling of heavy loads including spaces that are not authorized for all people. It is intended to develop a virtual environment, to help operators who do not know the handling and constant danger that is maneuvering with this type ofmachinery, have an immersive experience, toeffectively eliminate risks.

Justification

The implementation of forklift simulators in the manufacturing industry improves safety and efficiency in operations.warehouse. They provide a safe environment for operators to acquire skills without risk. The preventive approach seeks to reduce workplace accidents and promote safe practices.

From an economic point of view, the implementation of simulators is a strategic investment, reducing costs associated with traditional training, such as the use of real equipment and the risk of accidents. By avoiding accidents and improving operating practices, costs related to damage, product loss and medical expenses are minimized.

Methodology

The Lean Startup method, developed by Eric Ries, is a startup management model whose objective is the growth and scaling of innovative businesses in uncertain, complex and changing contexts.

Eric Ries' Lean Startup methodology pursues the continuous increase of value throughout the product development process. Key to this is the elimination of unnecessary practices and customer feedback throughout the product development stage.

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This methodology was applied with the help of professors and people related to the industrial sector on which the simulator is focused. Each Our customer, this forklift is based on a real, simply manufactured forklift.

Development

The forklift model used is a pre-existing template, the model was modified at our convenience and features were added to meet the needs of our customer, this forklift is based on a real, simply manufactured forklift.

Box 1

Figure 1
Forklift model

In addition, during the development of the project used a Logitech g923 steering wheel, which was mapped as follows in order to be able to use the 3d model. Although it is not necessary to have one of these to make use of the simulator since another input method is the standard computer keyboard of the requirements and functions were tested by the developers and people related to the industrial sector to guarantee the simulator's performance

Box 1

Figure 2
Flywheel mapping

Box 3

Figure 3
Keyboard mapping 1

Box 4

Figure 4
Keyboard mapping 2

Box 5

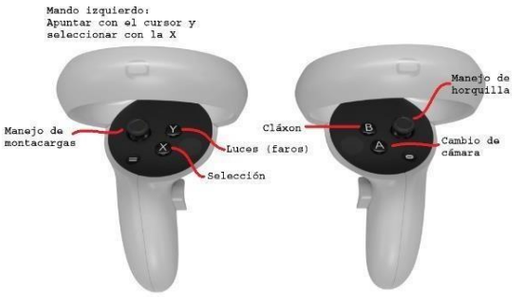

Figure 5
Command mapping

Blueprints

Blueprints in Unreal Engine are a visual programming system that allows developers to create game logic and interactive behaviors without writing code. Using a drag- and-drop approach, users can connect graphical nodes to define the functionality of their games or applications. In Romero's words, "Blueprints in Unreal Engine are a visual scripting interface that allows designers anddevelopers to create interactive content without traditionalprogramming" (Romero & Romero, 2019).

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Although the language Unreal Engine uses is C++, we don't touch the code at all, the blueprints are what we modify, merge and parse. As an example of operation, we have a function added by the development team that involves the visualization of the forklift safety laser lights, we can observe (figure 1) how the input event triggers a flip flop that gives visibility or removes the visibility of the safety lights in this case mentioned as network 1,2 and 3.

Box 6

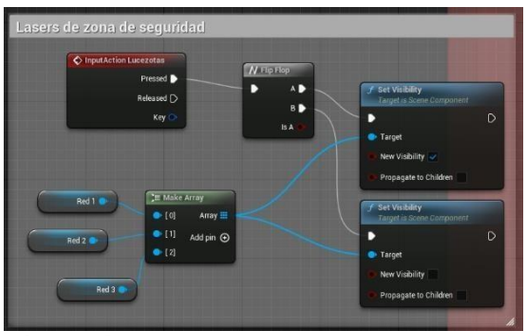

Figure 6

Blueprint of safety lights

When the function input button is pressed, in this case the A key on the Logitech steering wheel, the safety laser lights are visible and can be used in the environment.

Box 7

Figure 7

Safety lights activated

His is how all the features of the simulator, each level, model and function, is composed of logically communicated nodes, like a flowchart.

In the following image we can see the blueprint of a complete level, which includes the function described above.

Box 8

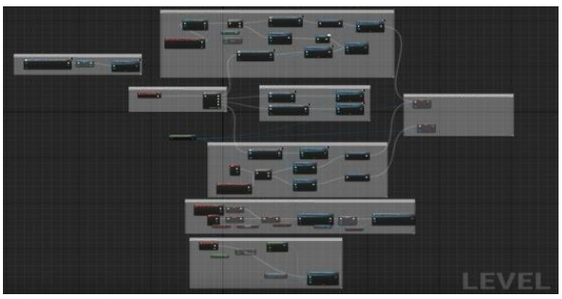

Figure 8

Bluepirnt level

esults

A total of 4 levels were developed for staff training, as described below.

Tutorial: It consists of learning how to operate the forklift, raise and lower the mast, it is basically learning the operation from scratch, coins are collected in a specific course, points are added and at the end we must take the coins to a specific place to credit or pass thelevel.

Box 9

Figure 9

Blueprint of safety lights

Level 1: A level with a low difficulty, consisting of Take 2 objects from one place to another, they are objects that are in some pallets and must be transported to others, after doing so, we must go to another warehouse to complete the level.

Box 10

Figure 10

Level 1 map

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Level 2: The difficulty in this level begins to increase, 5 objects must be placed on a specific platform, the difficulty in this level begins when the level restarts when colliding, or the same thing happens when throwing an object.

Box 11

Figure 10

Map Level 2

Level 3: Consists of an open world with a sensitive

The level will be reset when the pallets collide or do not fit properly on top of each other. The forklift software was designed to fulfill specific functions, these functions were first requested by Load handling stakeholders and professors and then tested by internal university users, which include students involved in the development of the application who were part of the meetings held with the company in question and also professors who have been in contact with the sector to which the software is directed.

The functions are defined by several objectives that the software tries to fulfill, these essential functionalities for the practical operation of the simulator, these objectives are described and analyzed below:

Controlling a forklift with all its functions

The forklift has a standard driving of the basic components of a front forklift, the natural rotation of the rear tires of the forklift, the ability to accelerate, brake andreverse with the forklift, manipulate the forks of the machinery with the corresponding levers, in the appropriate ranges of movement, turn the lights on and offwith the corresponding buttons, etc. These specifications were tested and approved by the professors in charge of the project.

Handling loads by means of forks to relocate materials

This function was tested hand in hand with game physics. A specific level focused solely on this task was developed and tested with the collaboration of teachers and students.

During the tests, it was confirmed that the simulator allowed to carry out this activity in a realistic and effective way, as, for example, carrying different weights affects the speed and ease of manipulation of the forklift.

Box 12

Figure 12

Load handling

To explore the different areas that make up a warehouse

A complete virtual environment was developed that faithfully represents a warehouse, with different sections and storage areas, such as aisles and overhead shelves.

This environment was tested with the collaboration ofteachers and students, who were able to walk through and explore the different areas interactively. During the tests,it was confirmed that the simulator provided an approximate and realistic representation of a warehouse.

Box 13

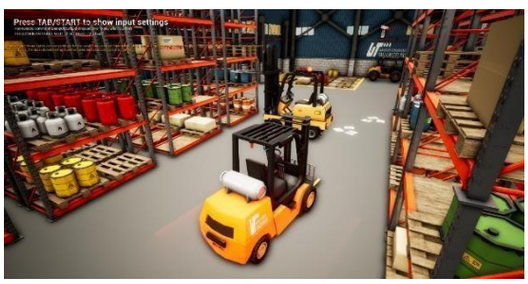

Figure 13

Warehouse environment

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Safe operator environment

Within the software were integrated functions on operator safety, such as laser indicators of the forklift safety distance, caution sounds when going in reverse and collision control, the latter was developed a specific level in which the level restarts if the user collides, these aspects were tested by teachers and students involved in the project, who could recognize that these control and safety functions meet the objective of training and basic notions of the operator.

Box 14

Figure 14
Safety lasers and collision warning

Evaluate control through measurements

The simulator has levels, each level teaches a notion of the use of the forklift or expected behaviors of the operator, it was concluded that score indicators should be included to evaluate the operator, each level has a way to evaluate the operator's performance, these functions were tested by teachers and students involved in the project andmeet the intention of evaluating the operator's progress.

Box 15

Figure 15
Level 1 scoreboard

Conclusions

The development of simulators is an area that promises much to the areas of technology and industry, to generate a safe environment for learning prior to practice in reality, I consider it an ideal method for training in any area whether manufacturing or any other.

This project was carried out with the purpose of fulfilling the essential conditions for the operation of the simulator. After developing and testing its functions, we can think that the training in the basic notions of the handling of this machinery is covered by the developed software, this software could be useful in the sector that makes use of this machinery.

The introduction of more advanced functions within the simulator itself, apart from being something expected, I think it would be necessary if we want to develop an integral and complete simulator that teaches not only basic notions but also more complex behaviors and situations that may arise in the industrial environment of the simulator.

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