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APPLICATION OF VIRTUAL REALITY ENVIRONMENT FOR SIMULATION OF HAZARDS IN THE FORKLIFT USAGE

Досліджено деякі основні завдання і ризики в дії автокарів. Для моделювання ризикованої ситуації застосовували комп'ютерну програму віртуального оточення для популярної моделі автокара Komatsu FB30H-2R. Проста модель в архітектурі VRML забезпечує інтуїцію в поведінці завантаженого автокара на кривій. Також обговорено основні результати моделювання завантаженого перевороту автокара.
Ключові слова – віртуальна реальність, моделювання, ризик, автокар

In the paper some basic risk problems in operation of forklifts have been investigated. To simulate hazardous situation during the operation of a popular forklift Komatsu FB30H-2R model, a computer application for virtual environment has been introduced. A simple model in VRML architecture provides an insight into the behaviour of the loaded forklift on curve. Basic results of the simulation of loaded forklift overturn have been discussed.
Key words: virtual reality, simulation, hazards, forklift,

Introduction

The goal of the study is simulation of hazards in the factory transport system carried out in the virtual environment. The object under investigation is the forklift with its driver.

According to the studies of National Institute for Occupational Safety and Health (NIOSH) in the USA, forklifts belong to the most dangerous machines in industrial use [8]. In the NIOSH statistics connected to injuries and diseases at work, the overall number of incidents related to the usage of forklifts exceeds 18.000. There are different causes of those incidents. Very dangerous is driving a loaded forklift in curve. That report has been compiled on a data from 56 fatal accidents during the operation of forklifts in production process in the years 1985 –2006 [8]. This is the reason for the numerous studies in many countries, also in Poland, focused upon safety improvement in the operation of forklifts. All reports say that the main hazard is the tip over of the vehicle and restricted view for the driver during the particular operations.

There are many regulations as well as national and international standards related to the operation of forklifts [e.g. 1, 2, 3, 4]. The basic technical data of the particular forklift are located on the vehicle plate, among the others the maximum load is stated. The safety regulations point out that if the load is high, the vehicle has less stability therefore the adequate centre of gravity of the vehicle must be observed to prevent the tip over, for instance through pivoting the mast towards the operator.

To operate a forklift, a special licence is required as well as a positive result of a psychological assessment procedure. Such licences may be issued only by certified institutions.

Particularly hazardous is driving a loaded forklift in curve where the operator can expose not only himself to the danger, but also other workers. Consequently, the simulation of the drive in curve but specially the simulation of overturn is the main goal of the study. In Poland the licensing procedures for the operators of forklifts are organised by the special institutions [5].

Fig. 1. Forklift simulator in Central Institute for Labour Protection [5]

The virtual reality technology

Development of the computing, particularly the technology of the virtual reality (VR – Virtual Reality) enables to get realistically looking worlds with original 3D objects. The VR technology complements the traditional computer based simulation by "human-machine" interface, which let not sole observation but the active manipulation of the process.

The basic parts of the VR software system can be broken down into an Input Processor, a Simulation Processor, a Rendering Process, and a World Database. All these parts must consider the time required for processing. Every delay in response time degrades the feeling of 'presence' and reality of the simulation.

The Input Processes of a VR program control the devices used to input information to the computer. There are a wide variety of possible input devices: keyboard, mouse, trackball, joystick, 6D position trackers (glove, wand, head tracker, body suit, etc.). A networked VR system would add inputs received from net. A voice recognition system is also a good augmentation for VR, especially if the user's hands are being used for other tasks. Generally, the input processing of a VR system is kept simple. The object is to get the coordinate data to the rest of the system with minimal lag time. Fig. 2 illustrates the stereoscopic projection in VR environment.

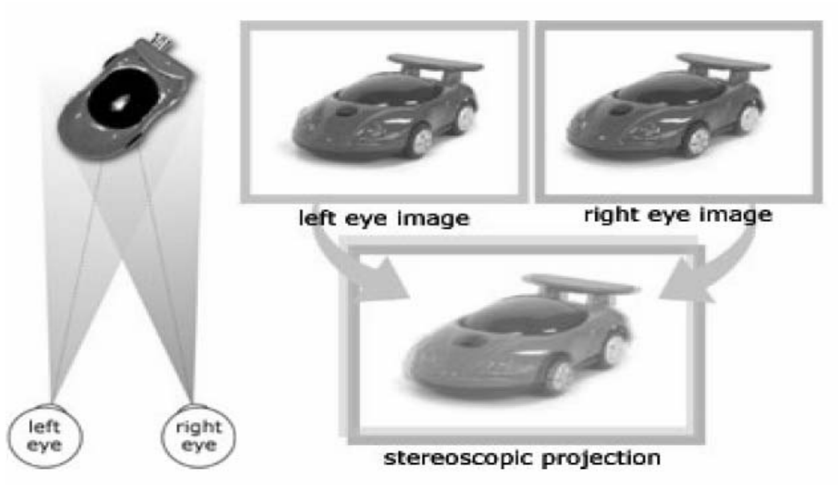

Fig. 2. Stereoscopic projection in VR environment

The core of a VR program is the simulation system. This is the process that knows about the objects and the various inputs. It handles the interactions, the scripted object actions, simulations of physical laws (real or imaginary) and determines the world status. This simulation is basically a discrete process that is iterated once for each time step or frame. A networked VR application may have multiple simulations running on different machines, each with a different time step. Coordination of these can be a complex task. It is the simulation engine that takes the user inputs along with any tasks programmed into the world such as collision detection, scripts, etc. And determines the actions that will take place in the virtual world.

The Rendering Processes of a VR program are those that create the sensations that are output to the user. A network VR program would also output data to other network processes. There would be separate rendering processes for visual, auditory, haptic (touch/force), and other sensory systems. Each renderer would take a description of the world state from the simulation process or derive it directly from the World Database for each time step. The visual renderer is the most common process and it has a long history from the world of computer graphics and animation. The reader is encouraged to become familiar with various aspects of this technology. The major consideration of a graphic renderer for VR applications is the frame generation rate. It is necessary to create a new frame every 1/20 of a second or faster. 20 frames per second (fps) is roughly the minimum rate at which the human brain will merge a stream of still images and perceive a smooth animation.

The virtual reality also allows take into consideration the problems of the occupational safety and health protection in the process of computer aided design.

In recent years virtual reality plays significant role in a manufacturing planning process. Big companies put emphasis on research in this way. Usually in every branch of industry before anything will be produced or even executed in the form of prototype are carried out a computer simulation. It involves a lot of benefits where the most important thing is saving of the cost. The other are: possibility of a planning product logistic, estimation of a manufacturing, time and cost, a safety area, possibility of caring out a breakdown simulation, workers' training and so on. Mistakes which have not been detected in the conception, design and simulation phase – generally in the first stage of a creating any product – are causing huge costs in manufacturing phase. It is repeatedly bigger than in case of detecting fault and other shortcomings in the first stage manufacturing.

The description shown above can be treated anything what is connected with an industry and not only. An object can be a car, a part of car's body, and also a factory, its department, a manufacturing line or even a single production process. In connection with this an essential element of a production is simulation. A simulation which allows to optimise a manufacturing process. Currently on the market exists not too many applications, which enable to execute planning processes that are integrated with CAD/CAM [6, 7]. One of them is Virtual Reality Modeling Language – VRML.

Application for forklift drive simulation

All objects used in application for forklift drive simulation were modeled in CAD systems Catia V5 and 3ds Max. In next step objects were exported to virtual world (to the computer programme written in VRML). Special software tool called VrmlPad was used for this purpose.

Fig. 3 illustrates the 3D model of forklift, produced by company KOMATSU. All dimensions of forklift were taken from model KOMATSU FB30H-2R.

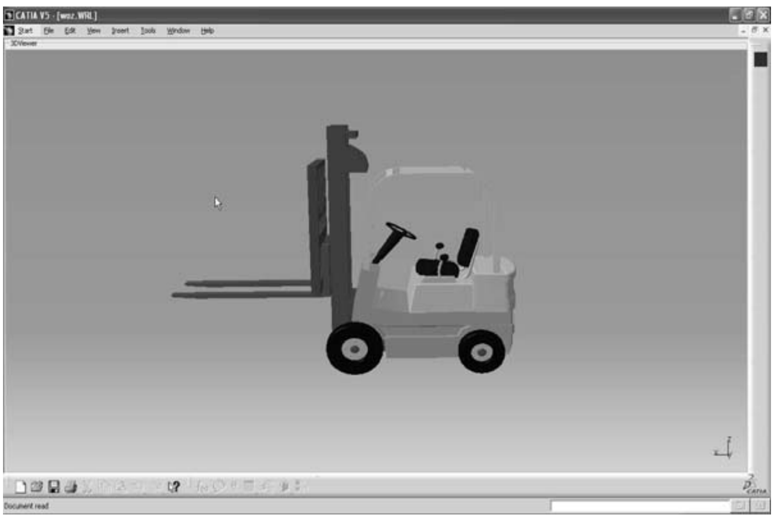

Fig. 3. Model of forklift in CATIA V5

In the next step the model of manufacturing room was created in Catia V5. This manufacturing room with magazines and roads system is an enviroment for forklift drive. Fig. 4 illustrates the view of manufacturing room from outside.

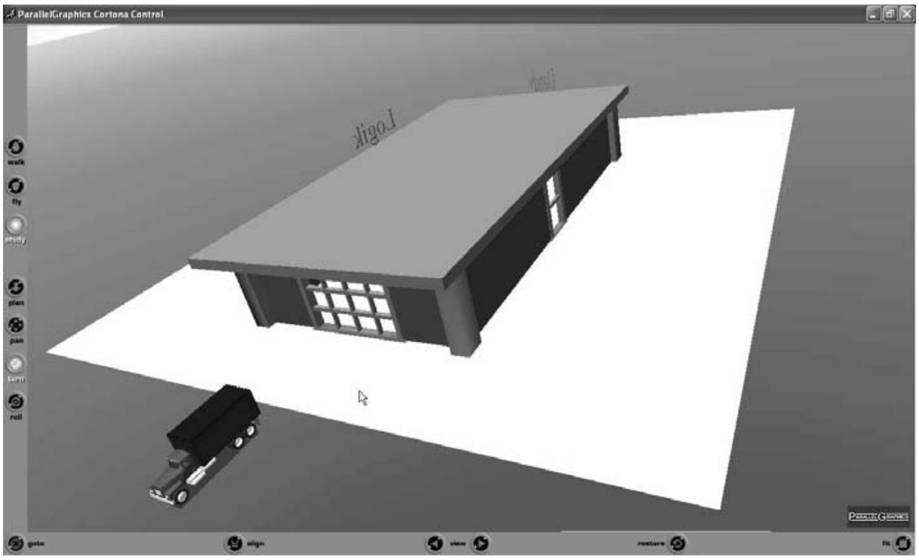

Fig. 4. Model of manufacturing room in CATIA V5

4. User control system

Every user can control the simulation as forklift driver or as a truck driver. Forklift takes some load from or to a truck. Fig. 5 is a screen copy of an application where two control panels called „Forklift" and „Truck" are indicated.

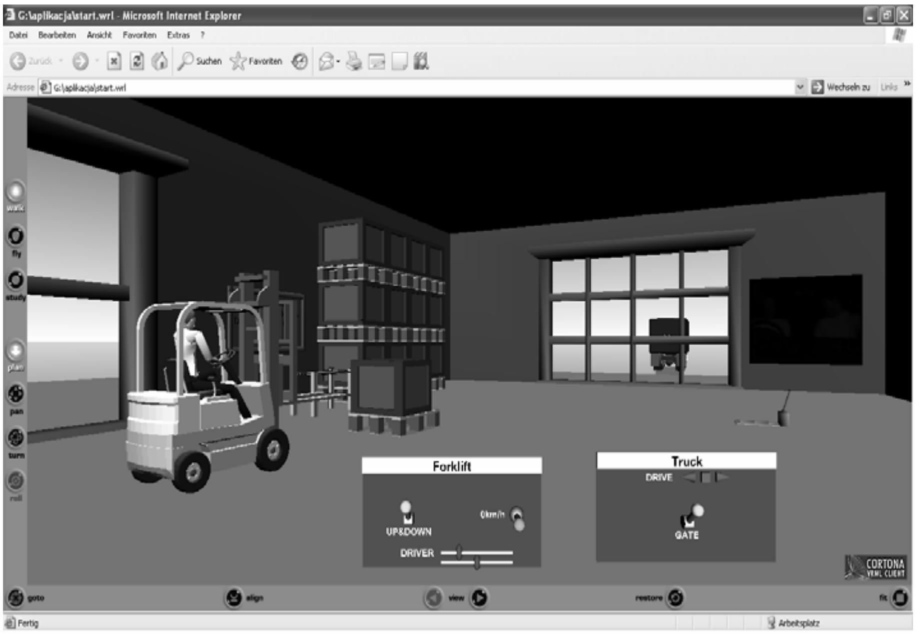

Fig. 5. User control system

Panel „Forklift" allows a control of a forklift drive (forward, back, straight-line, turn) with a given speed (DRIVE). This panel alows also a control of a fork arm carriages(UP&DOWN) and a driver head turn (DRIVER). The view from camera is changing together with a driver head turn.

Panel „Track" allows a control of a track drive (forward, back, straight-line, turn) with a given speed (DRIVE). This panel allows also a control of gates opening or closing (GATES).

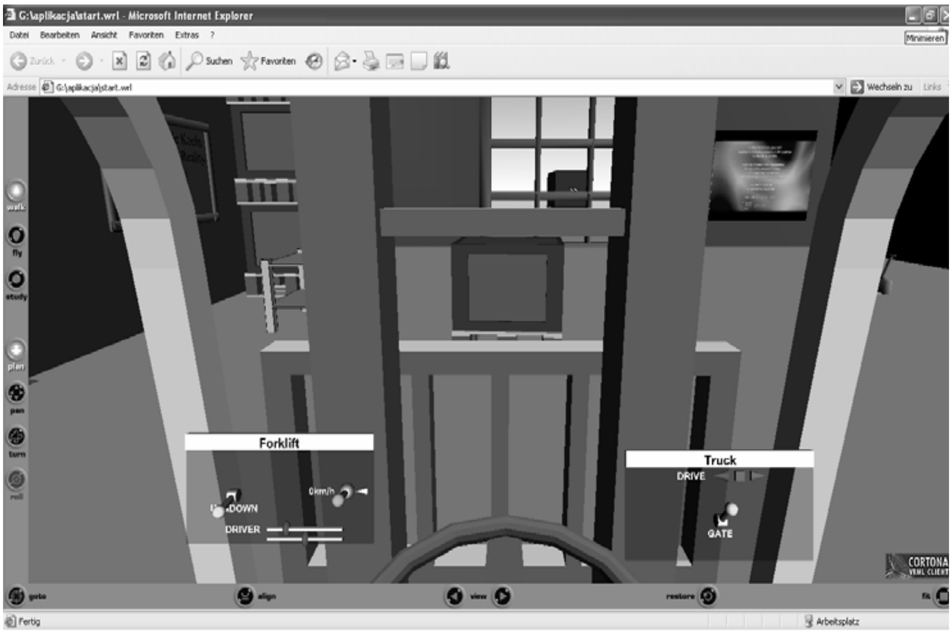

Fig. 6. Virtual 3D world seen by forklift operator

Fig. 6 is a screen copy of an application when a forklift driver turns his head (DRIVER). The view from camera is changing together with an every driver head turn.

5. Simulation of a curvilinear drive

Very simple, one degree of freedom, dynamic model of forklift was applied for simulation of a curvilinear drive. This model is presented on fig. 7.

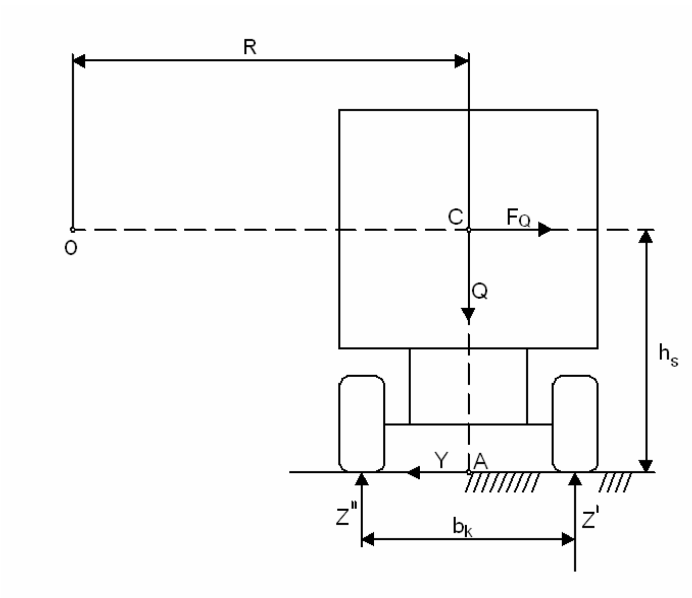

Fig. 7. Curvilinear drive model

Fig. 7 illustrates forces acting on forklift during curvilinear drive (Q – gravity FQ – force of inertion, Y, Z – reactions on forklift wheels) and main geometrical parameters (R – radius of turn, hs – height of gravity centre, bk – wheelbase). Deformations of tires and suspension were neglected.

Computer application in any time increment, on line, calculates a force of inertion and reactions on forklift wheels for a given load, height of gravity centre, radius of turn and velocity. When value of reactions on forklift wheels goes to 0, the overturn may appear.

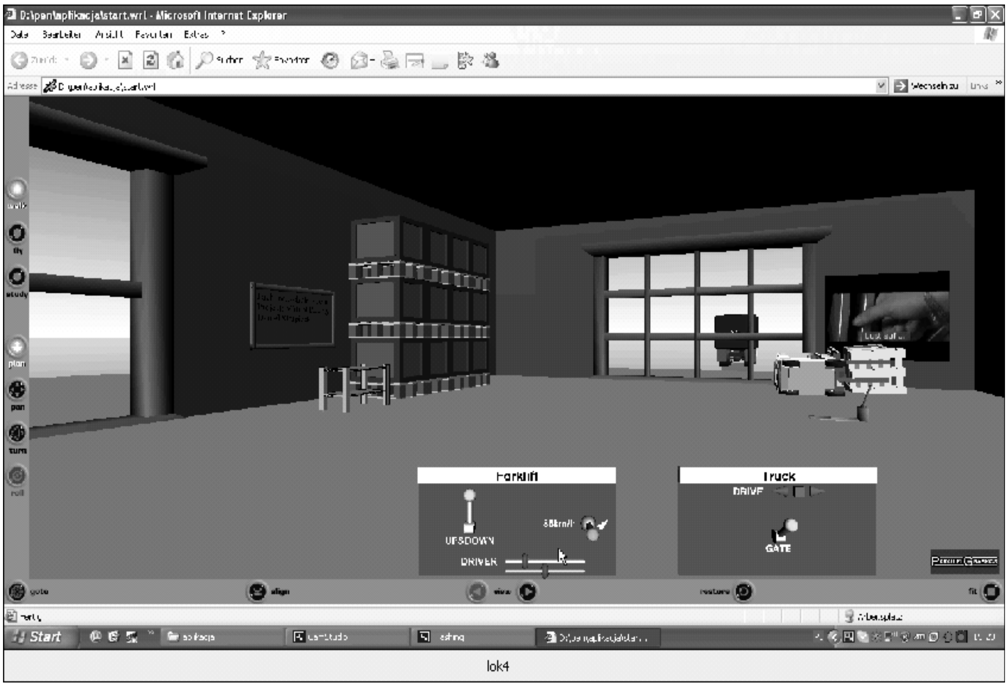

Fig. 8. Screen copy with overturn of forklift

Fig. 8 is a screen copy taken from an application, which illustrates the overturn of loaded forklift during the curvilinear drive.

Conclusions

In the paper, the basic safety problems in usage of forklifts are considered. The application in virtual reality technology for simulation of hazardous and danger situations in the usage of popular and typical forklift Komatsu FB30H-2R is proposed. The simple simulation of the curvilinear drive together with overturn of loaded forklift is modeled in VRML environment. Some results of simulation are presented and analyzed. This application can be used by designers but also by forklift drivers as a simulator.

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