A simulator using Virtual Reality techniques for training driver to manual interventions on the tracks.

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Abstract
Track controllers may loose the control on some switches and then have to stop all the trains on the line. This comes generally from a stone blocking a switch blade or a default in a blade sensor. In order to help the traffic continue as soon as possible, the controller must ask the driver of the next train to control, and probably, to manually switch the blades. All the driver using the French high speed line have to be trained . Driver efficiency and reactivity is then very important, but the frequency of these technical problems is very low and keeping the driver's skill up-to-date means training him continuously along its driver life.
For the moment, the training about these tasks are made on tracks, but teachers have more and more difficulties to train the drivers. The tracks are more and more used by a growing traffic. Moreover, the training is expensive because it implies a transportation on tracks. The training is time constrained and actually, it looks like a demonstration and is not an interactive process between trainees and the teacher. The training in its actual form does not reach the required quality level to let the driver be efficient in these tasks. Consequently impacts on traffic quality is important and leads to customer reactions.
Using a simulator and virtual reality is then natural and economically interesting.
As there is no real danger in the simulator, a trainee can make errors which are very important in the learning process. Time is not limited. The simulator is more accessible than tracks. There is no weather condition consideration and several different situations may be seen by each trainee.
An original Artificial Intelligent system helps the trainee to interact with the virtual world and the teachers to choose in real time the best pedagogical strategy.
The simulator looks like a big screen. On front of it, the trainee uses a treadmill to walk in the virtual environment and interacts with virtual objects with a dataglove.
On the computer side, high quality images are provided by personal computer powered by Linux at a reasonable frame rate.
The simulator was designed in the spirit of using standards, free software and very low cost materials.

1. Introduction

Fiacre is a research project which aims at designing a training simulator prototype using Virtual reality techniques. Despite the fact that the simulator will be used by the train driver, Fiacre is not a driving simulator but a learning system for the control and the handling of switch blades on high speed line.

1.1. Background

Due to some mechanical or electrical problems or due to a stone blocking a blade, the track controller of a high speed line may lose the control and have to stop all the train arriving on it. The driver is then asked to control and eventually handle the switch manually to let the traffic continue. The driver efficiency and reactivity is then very important but the frequency of these problem is very low. So, a driver with an old training may be asked to quickly solve a default in a dangerous field and as fast as possible. More than the pure skill needed to accomplish the task of controlling or handling the blades, the way the driver find new strategies and adapt his technical skill to the situation is very important because there are as much different situations as there are switches. Weather condition may be very different as well. Training then need to be tuned precisely and refresh from time to time to keep the driver's knowledge as useful as possible. The actual training is based on a classical method and Virtual Reality is used to get ride of huge problems caused by the training in situ. Cost consideration is, as well, a sensitive part of the project and is favourable to the simulator option for this training.

1.2. Virtual reality definition

Among the long list of Virtual reality definition, this one is sufficient to define the scope of this paper and has no more pretensions.
"VR goal is to immerse a user in a coherent and interactive world substituted completely or partially to the real world".

2. the present training

the present training is based on, first, a theoretical part which is presented to the trainee in a classroom then a kind of demonstration on the track is performed on a real switch. The line controller is an actor of this training as the radio communication is a part of the training.
The main drawbacks of this training are the followings:

- The traffic is altered during the training.
- The teacher cannot use this line for a long time and is limited to half an hour.
- Just one trainee has the possibility to do the procedure.
- Demonstrations are function of the weather conditions and of the traffic on the line.
- The teacher cannot show more than one physical implementation of a switch.
- The trainee cannot make errors which are known to be very formative.

As the main difficulty in the procedure is the way the driver lives the emergency situation, this kind of training is not adapted and does not reach the required pedagogical objectives. Among the studied solution, Virtual reality was the most interesting.
The paradigm of this new way of training was to immerse the trainee in a near real situation where acquired knowledge is not just a checklist of things to do but is more based on the "know how". Then, realism need to be tuned. It give the feeling of immersion. But, Virtual Reality give some opportunity to go farther than just reality and we may profit of VR features to, for example, showing hidden mechanisms (the inside switch engine), show a global view of the tracks or abstract concepts (schematic view of complex systems).

3. training organisation

As FIACRE was planed to be build in a simulator centre, we map the training on the actual driving simulation session to this training. Training is given to a group of Five to six trainee. One trainee is immersed in the simulator while the other group members are watching. This training is planned to be part of the initial driving training. The main difference introduced in this training is the impossibility for the other trainees to react during the simulation.

4. Requirements
   4.1. Immersion
      1.1.1. walking

As walking along the tracks is an important part of the task and as we wanted the user to keep in mind the same space time feeling, we included a treadmill in the simulator. We tested a standard sport training treadmill but it did not reached our needs, we asked a manufacturer to build one function of our specifications (more power and 2 meter long). The main drawbacks of the first one was its too short length and its lack of power.
A joystick is placed near the trainee to let him choose the direction he wants to go to. Treadmill speed is control by the user position on it and can be stopped by releasing the joystick.

      1.1.2. Seeing

We choosed to display images on a large screen (3 meter large and 2 meter high) and to calibrate the simulation to give the illusion of being on front of a real window open to the virtual world. Point of view is tracked so that movements are taken into account by images. Display resolution is 1280 by 1024 provided by a LCD rear video projector. Stereoscopic display was not kept as it may give visual problems to some users and obliged them to use glasses.
Head mounted display was not considered too much as it is incompatible with a treadmill and the use of a screen avoid sickness. Despite the fact that, for cost consideration, a multi-screen solution was not kept (but would have been useful), the field of view is large enough to give a good immersion (from 90° to 130°).

      1.1.3. interacting

The trainee is equipped with a data glove to catch, touched and handle objects in the virtual world. A magnetic tracker is placed on the hand to let the system determine the position and the orientation of the hand. A second tracker is placed on the back of his neck. This let the system adapt the point of view, function of the position of the user on front of the screen and to control the treadmill speed too. The magnetic tracker is not place on the trainee's head to avoid a too invasive equipment.

      1.1.4. hearing

Sounds are very important for immersion and a synthesis system is used to create an acoustic virtual environment. We generate sounds for immersion and for user actions feedback too. The sounds are:

- background noise for immersion (nature sounds)
- event sounds like crossing train, engine sounds, etc.
- feedback sounds like beeping when the user catch an object.

Sound synthesis is a stereoscopic trans-oral synthesis.

      1.1.5. helping the user to overcome VR drawbacks

The display is not stereoscopic and distance evaluation is difficult. So, a system is automatically placing the user on front of the important elements in the virtual environment function of his movements and his wishes. This helps the trainee to interact with objects. Actions are simplified as it is not important to reproduce realistic movements. For example, to open a box, the user have to keep a key and touch the box with the key.

5. HAL

HAL for Help agent for learning is a smart agent system which help the trainee to interact with the system and the teacher to organise efficiently the session. Errors are tracked during the session and advises on different strategies are proposed to the teacher. HAL is based on the works done by Domitile Lourdeaux for her Ph.D. thesis.

6. Fiacre hardware architecture

Fiacre has been designed to be a low cost simulator in a field (VR) known to be very expansive. The last progress in some technical aspects related to VR gave the opportunity to manage this challenge. The video game industry pushes the video card manufacturers to offer new hardware solutions which was compatible in term of performance with the technical level we wanted to reach and the cost limits we imposed ourselves.
From a first prototype based on high end Unix SGI machine, we, now, are able to offer solutions based on PC technologies with off-the-shelf hardware.

architecture

As shown on the picture, what is the most impacting aspect in the project is the treadmill and the video projector.
A dual pentium is used for image synthesis and a second PC (duron 800) is used for devices control and sound synthesis.

7. Software description

FIACRE is a LAN of Linux PC (Mandrake and Red Hat) and takes advantages of open source software (free software).
Devices are controlled by the VRPN Package; a public domain software which, by a client/server architecture, feed the simulation with data from devices.
A sound generator was designed based on the OpenAl library maintained by the Loki entertainment company as an open source library (GNU license).

The graph scene is written with our own XML language and is parsed with the libXLM library from Daniel Veillard (GNU license)
Image generation use Linux performer (2.2).

Geometries use the performer binary format.

8. Components used in FIACRE :

Devices :
- Microsoft Joystick
- 5dt glove
- Ascension Flock-of-birds with 2 sensors and an extended range antenna
- 2 meter long customised treadmill
- Sound Blaster Live 1024

CPU :
- dual Pentium III at 800 MHz for image synthesis
- Duron at 800 MHz PC for device control and teacher actions

and
- Barco 6300 reality video-projector
- 100 Mb/s net switch
- CPU switch

9. Software description
- SGI performer 2.3
- VRPN 5.3
- Linux Mandrake 7.2
- Red hat 6.0

10. Conclusion
We are very confident in the possible generalisation of this new kind of application and may launch an industrial production for this simulator next year.

11. References

D. LOURDEAUX, Ph. FUCHS , J-M BURKHARDT, An intelligent tutorial agent for training virtual environments, 5th world multiconference on Systemics, Cybernetics and informatics SCI'01 , Orlando, Floride, July 2001.

Ph. DAVID, D. Lourdeaux, J-N TEMEM. Quelques applications de la réalité Virtuelle à la SNCF. Revue générale des chemins de fer. N°4 April 1999

VRPN : http://www.cs.unc.edu/Research/vrpn/

OpenAl: http://www.openal.org/home/