Dynamic Platform for Virtual Reality Applications

Jérémy Plouzeau Jean-Rémy Chardonnet Frédéric Merienne

Le2i, FRE2005, Arts et Métiers, CNRS, Université Bourgogne Franche-Comté, HeSam, Institut Image, France

jeremy.plouzeau@ensam.eu jean-remy.chardonnet@ensam.eu frederic.merienne@ensam.eu

Abstract: In virtual reality, a simulator exists for each application and is therefore designed to fullfil simulation requirements. In this poster, we present a novel dynamic platform that can be used in different configurations. This platform aims at being as adaptive as possible for usages with different simulation devices (HMD, CAVE, ...). The platform allows to add new feedbacks to simulation with displacements and vibrations. This poster proposes different scenarii where it is possible to use this dynamic platform, bringing insight to new creative applications.

Keywords: Human machine interface, dynamic platform, virtual reality.

Introduction

Virtual reality is a tool allowing users to immerse in a virtual environment. Users can then explore and interact within the virtual environment [2, 3]. To achieve immersion, 3D real-time computer graphics and advanced display devices are usually used [1]. The need to explore virtual environments that can be infinite makes navigation interfaces and metaphors necessary [3]. As navigation tasks are mandatory, it is then necessary to have displacement feedbacks to give users the sensation of moving [3]. Usually, these feedbacks are given through visual, auditory and vibro-tactile devices.

In this poster we expose the development of a dynamic platform able to increase virtual reality experience. The use of this platform adds new feedbacks to the simulation. Unlike other dynamic devices, this platform has been designed to be as adaptable as possible, in order to suit all kinds of applications. Depending on the purpose of the simulation, the platform can induce vibrations, accelerations or positioning and displacements.

Platform

Hardware

To build the platform, we used electric actuators. Indeed, the platform needs to be able to work with different loads ranging from the weight of a person to heavy equipment, depending on the scenario (60 kg to 200 kg), and to be reactive in order not to induce latency during simulations. Latency would then provoke cyber-sickness and the platform would become useless. The electric actuators we chose are well known in the gaming field. They are mainly used to build driving and flight simulators. We used four 4250i electric actuators from D-Box. Their characteristics are detailed in Table 1.

The actuators are connected to a computer through D-Box network controllers.

Table 1: D-Box Actuators Characteristics

Features	
ACTUATOR ORIENTATION	Vertical/Horizontal
POWER REQUIREMENT	230VAC/60Hz/2.5A
MAXIMUM VERTICAL DISPLACEMENT	1.5”/34.5mm
MAXIMUM VERTICAL VELOCITY	±100mm/s
MAXIMUM VERTICAL ACCELERATION	±1 g-force
FREQUENCY RANGE	0-100 Hz
OPERATING T RANGE	0-40 °C
OPERATING HUMIDITY	10 to 75 %

Design

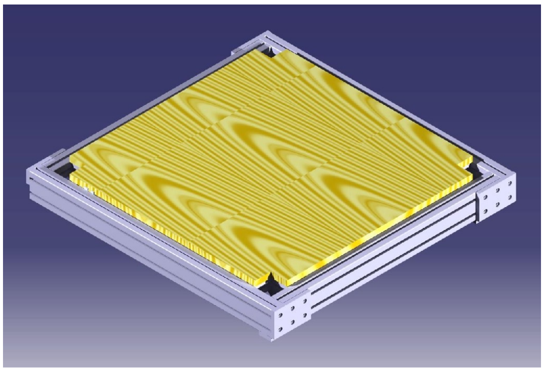

Figure 1. CAO visualization of the platform.

The platform is designed to be used with different simulation systems. It needs to be usable with an HMD like the Oculus Rift or the HTC Vive, but also in a CAVE system or other large-screen displays. Users should be able to seat on a chair placed on it or to stand on it. Furthermore the platform needs to be stable and offers a fairly good motion range: 5° for rotations at least. From these requirements, the platform is square shaped with the actuators in its corners. The actuators are placed 80 cm to each other (see Fig. 1).

The D-Box controllers are attached under the wood platform floor. The armature is in aluminum to remain lightweight (see Fig. 2).

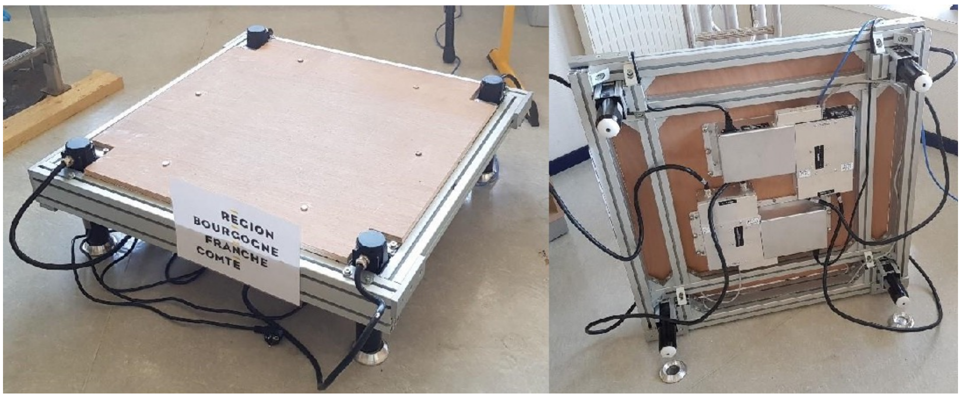

Figure 2. Top and bottom views of the platform**.**

The four actuators mounted in the same direction with this distribution give three degrees of freedom to the platform. One translation on the vertical axis, one rotation on the lateral axis and one rotation on the longitudinal axis. The motion range is 34.5 mm for the vertical translation and ± 2.5° for both rotations.

Control

We created a plugin in C++ to use the platform with Unity 5. It works like a COM port, therefore it is easily interfaceable with any software. To move, the platform needs five parameters. The first three parameters concern the translation and the rotations. They are called Heave, Roll, and Pitch respectively. The last two parameters control the vibrations in amplitude and frequency. They are called EngineTorque and EngineRPM respectively. In Unity it is possible to send these five parameters to the platform. Vibrations can be applied along with the desired position. This way, the platform vibrates and moves at the same time.

Use Cases

Figure 3. Walking simulation on left / Driving simulation on right.

Driving Simulation

The shape of the platform allows to put a chair on it. The first use that comes to mind is driving simulation (see Fig. 3 right). The actuators we chose are mainly used to build gaming simulators for driving games, and not for professional purposes as handled by car manufacturers. Here the platform offers the possibility to reproduce the acceleration of a car but also various vibrations (road vibrations, engine vibrations, ...).

In the demo we developed, as the only degree of freedom in translation the platform offers is the vertical axis, the horizontal car accelerations **a** are rendered by the platform rotations. The accelerations are transformed to]- 1; α; 1[to match the rotation maximum amplitude. The vertical acceleration is reproduced on the platform's vertical axis. We then apply a scale factor to each acceleration to adapt the feedback to the simulation type. In our demo the factors are respectively $\frac{1}{10}$, $\frac{1}{10}$ and $\frac{1}{15}$.

$$Pitch = \arctan\left(\frac{\boldsymbol{a}_z}{10}\right) * \frac{2}{\pi}$$

$$Roll = \arctan\left(\frac{\boldsymbol{a}_x}{10}\right) * \frac{2}{\pi}$$

$$Heave = \arctan\left(\frac{\boldsymbol{a}_y}{15}\right) * \frac{2}{\pi}$$

Walking Simulation

The main contribution of this platform is that it can be used sited or in standing position. It is possible to control it through joysticks or other interfaces. Thus it can be used to perform walking simulation (see Fig. 3 left). With this kind of simulation, the platform can be used in different ways.

First, the platform can indicate accelerations. We use the same method as described in the driving simulation part. We apply horizontal avatar accelerations to the platform's rotations, and vertical accelerations to the vertical axis. The equations are the same. The scale factors are just adapted to walking accelerations.

Second, it can indicate the virtual floor inclination. We measure the virtual floor inclination under the avatar's position and we reproduce the pitch and roll on the platform.

Finally, a last possibility is to use the platform to reproduce the vibrations of the feet hitting the ground. We mix movements and vibrations. Vibrations are synchronized with the virtual pace. The platform rotates from the right to the left, also synchronized with the pace, as in natural walking.

Conclusion

Our proposed platform allows to add new feedbacks to a simulation. Using it could open new solutions in order to decrease cyber-sickness and increase presence in the simulation. It also brings insight to unexplored creative applications in any field. Future studies could be done to explore this aspect, for example using acceleration feedbacks in walking simulation as a way to decrease cyber-sickness.

Our platform still has some limitations. As it is only 80 cm large, it allows users to only stand and turn on themselves. The use of an HTC Vive coupled with the platform removes one of the benefits of this HMD to perform scale 1 displacements thanks to the tracking system. On the other hand, using the platform with an Oculus Rift opens new possibilities, as its tracking system is much narrower. The motion range is the second limitation. Indeed it only allows 34.5 mm translations and 5° rotations which is not enough to fully reproduce acceleration or floor inclination. But it still allows to give basic indication about these information.

References

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