I3VR –intuitive interactive immersive virtual reality– technology

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Abstract

I3VR is the intuitive immersive Virtual Reality technology for interaction of two or more subjects in a wide space through the use of full body avatars and wireless data transmission. For this, use is made of real-time tracking of 3D body segment posture and movement through inertial sensors, also known as "sourceless" sensors. This paper describes the main characteristics of the technology and a study on the speed and accuracy of manoeuvring in a virtual environment compared to a real environment.

Keywords: virtual reality, immersive, interactive, intuitive

1. Introduction

Simulation-based design ergonomics is the science of adapting tangible products and processes to human capabilities during the design process by using numerical simulation to improve the task performance (speed, accuracy), the physical fitness/comfort, the health and/or the safety of future users. Major decisions are often taken early in the design process, before it has moved beyond the Computer-Aided Design (CAD) phase. To incorporate ergonomic considerations in this purely digital phase, a designer will need digital representations of the future users, called digital human models. The reason for this is that it is much easier to change a digital design than a mock-up or a prototype, thereby reducing time-to-market or time-to-operation, not to mention costs. The main purpose of simulations is to evaluate design options as much as possible and as early as possible. There are two different types of digital human models – agents and avatars. An agent is a digital human model driven by human intelligence that is fed into the software through principles or rules. Agents are best suited for research and development concerning localized individual actions, such as generic reaching and gazing, and in specific activities such as reaching for a seatbelt and car ingress and egress. Avatars are best suited for research and development if we want to go beyond local actions into wider spaces and beyond individual actions into team operations. This could involve simulating processes such as maintenance, safety operations, and manufacturing. An avatar is a digital human model driven by an instrumented human who is immersed in a virtual environment. Virtual Reality (VR) is the term commonly used for immersing humans in a digital environment by presenting a virtual environment on a head-mounted display (HMD) or on a flat or panoramic projection wall.

2. I3VR technology

I3VR is the technology being developed at TNO Human Factors (TNO-HF) for interaction of two or more subjects in a wide space through the use of full-body avatars and wireless data transmission. For this, use is made of a real-time 3DOF (orientation) motion capturing system, based on inertial sensors, also known as "sourceless" sensors (rate-of-turn/gyro, acceleration, and earth magnetic field data), from Xsens Technologies (see Fig. 1). The use of inertial sensor technology dispenses with the need for a "link" between the body and fixed stations in the surroundings, thereby enabling a fully portable system with an area of operation only limited by the wireless data link, eliminating interference, noise and occlusion, enlarging the area of operation, and possibly improving update rate and accuracy. Your own avatar, the avatars of others, and the virtual environment are visualized on your HMD by a processor carried in a rucksack. Absolute position data for a single reference point on the body is needed to place each avatar correctly within the virtual environment. For that, a relatively simple tracking system (optical, RF, etc.) is sufficient. Software for position prediction based on inertial sensor data is under development. The software for the simulations carried out so far, i.e. Lumo Scenario and Lumo MotionVIZ, was provided by re-lion BV.

Fig. 1: Human motion capturing suit with inertial sensors (courtesy: Xsens Technologies).

3. VR research

I3VR technology was introduced at TNO-HF for the study of military team operations and manoeuvring in urban terrain. A key research question is how well humans are able to manoeuvre in a virtual environment compared to a real environment. Delleman [1] provides an overview on human factor issues related to mechanical locomotion devices and studies on manoeuvring in a virtual environment by means of hand-held controls and body-mounted sensors. Below data from one of these studies are presented.

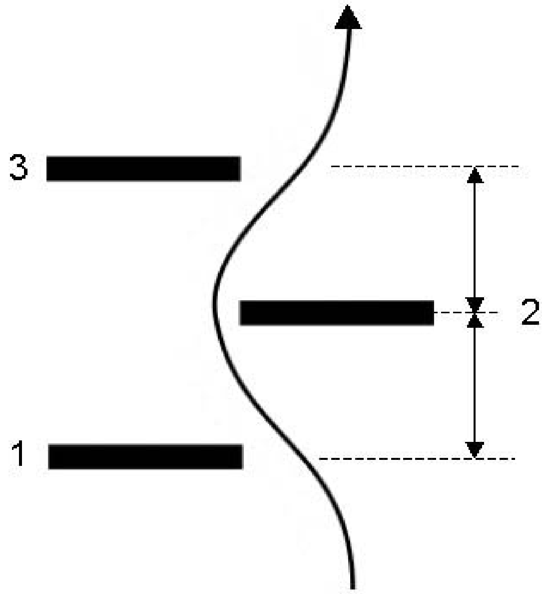

Fig. 2: Top view of the experimental set-up for testing the speed and accuracy of passing by three parallel walls.

In a first experiment performed at TNO-HF on the key research question mentioned above and for getting insight into the causes of a performance decrement in the virtual environment, if any, test subjects had to walk between the ends of two parallel walls on their left, while avoiding the end of another wall on their right (see Fig. 2). The edges of the three walls were positioned on a straight line, with mutual distances of 0.6 m, 0.8 m or 1.0 m. Three visual conditions were compared: a real environment (REAL), a real environment with a 30° horizontal field of view (REAL-FOV30), and a virtual environment with a non-stereo 30° horizontal FOV HMD (VE-FOV30). Speed between the first wall and the third wall was calculated (either 1.2, 1.6, or 2.0 m, divided by the time between these two walls measured), as well as accuracy (i.e., the distance of a lower spine sensor to the edge of the second wall, when passing by this wall). Performance was lower in VE-FOV30 than in REAL (see Fig. 3 and Fig. 4). A part of the performance degradation seems to be caused by the limited field of view, as can be seen when comparing REAL-FOV30 with REAL.

4. Discussion

The studies performed so far on manoeuvring in a virtual environment give us some insight into what to expect from immersive VR [1]. Further studies will have to look at ways of getting task performance closer to reality. Latency, HMD field of view, familiarity with the virtual environment and depth information will have to be dealt with, as well as the risk of motion sickness, cf. Bles and Wertheim [2]. Exactly how close performance in a virtual environment should come to performance in reality with respect to speed and accuracy depends on the application. For testing operational procedures, for instance, a qualitative evaluation may very well be done with current VR techniques. Whether and when more demanding applications can be dealt with will depend on enabling technology becoming available.

References

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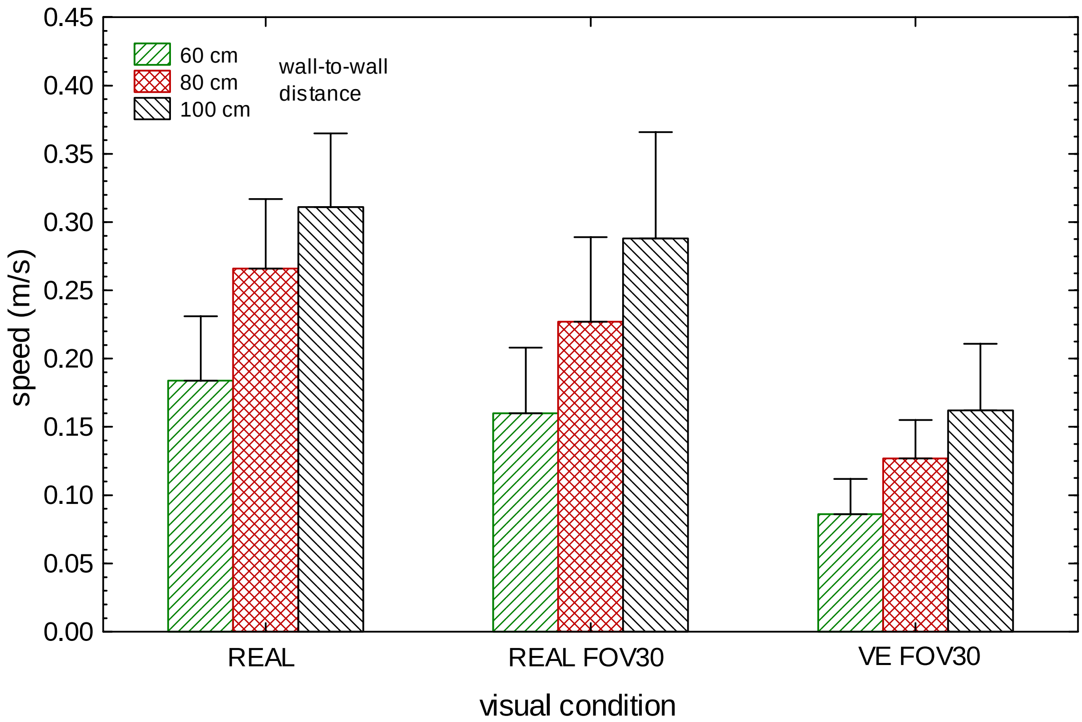

Fig. 3: Speed between the first wall and the third wall. Average group scores with one standard deviation are shown. Three visual conditions are distinguished, where REAL = real environment, VE = virtual environment, and FOV30 = 30° horizontal field of view. Three wall-to-wall distances are distinguished: 0.6 m, 0.8 m and 1.0 m.

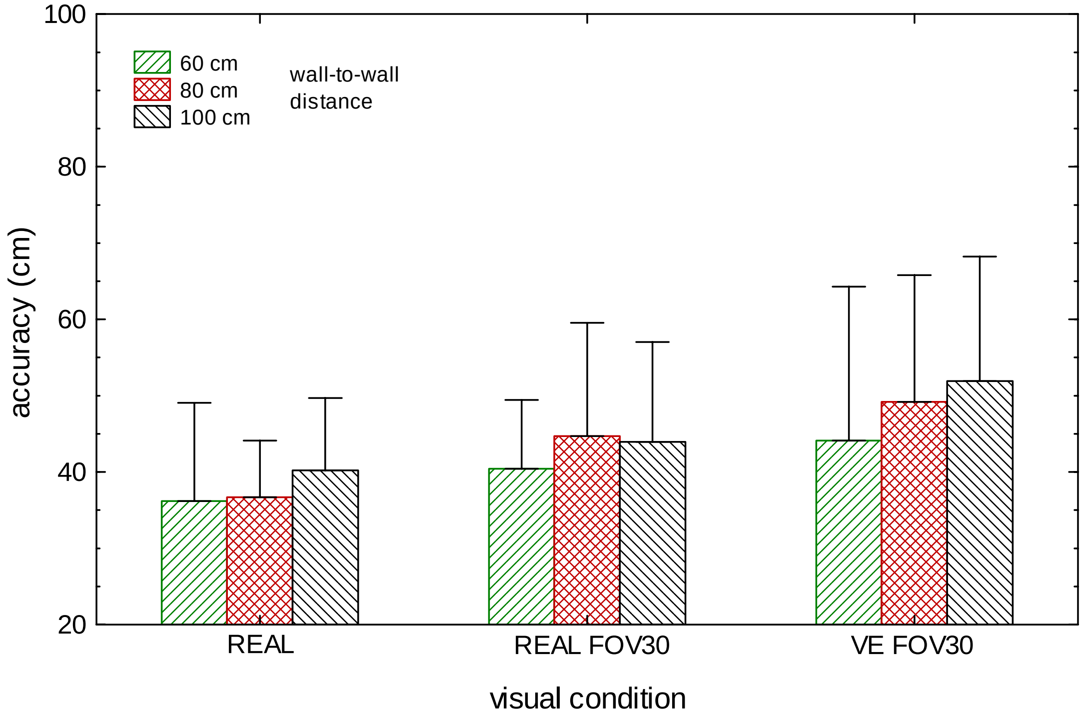

Fig. 4: Accuracy, defined as the distance of a lower spine sensor to the edge of the second wall when passing by this wall. Average group scores with one standard deviation are shown. Three visual conditions are distinguished, where REAL = real environment, VE = virtual environment, and FOV30 = 30° horizontal field of view. Three wall-to-wall distances are distinguished: 0.6 m, 0.8 m and 1.0 m.