Wireless Virtual Reality System Based on a Minimum Set of Inertial Sensors

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ABSTRACT

Using the whole body to interact in Virtual Reality experiences leads to significant benefits as increasing the levels of engagement and satisfaction.

This paper presents the ongoing project Orion. Its main objective is to design, develop and evaluate a wireless Virtual Reality system that is based on a minimum set of inertial sensors. Using this system, the users will be able to really walk to navigate across the 3D environment and interact with virtual objects using their hands directly.

After describing similar systems, the project objectives are presented and the challenges to overcome are identified. Next, the performed work is described as well as preliminary results from pilot studies and the tasks to address subsequently.

Categories and Subject Descriptors

H.5.1 [**Information interfaces and presentation**]: Multimedia information systems – Artificial, augmented and virtual realities.

General Terms

Algorithms, Design.

Keywords

Inertial sensors, signal processing, trackers, Virtual Reality, natural interaction, immersion, presence.

1. INTRODUCTION

Virtual Reality (VR) has been evolving during the past 25 years at least. However it is not present yet in our daily lives. This is due to ergonomic issues, the high cost of the devices and their limitations to feed our senses properly. But the reason why VR does not disappear, is the huge potential behind this technology. The potential of learning any knowledge, of living any experience and enjoying, without limits, anything we were able to imagine.

This paper presents the ongoing project *Orion: One moRe step In virtual reality interactiON* [3], [5]. It aims to create a low cost VR system that provides highly satisfying virtual experiences. In addition, it uses a reduced number of inertial sensors to improve ergonomics aspects while decreases the cost of the system. Users will be able to really walk to navigate across the virtual environment while they interact directly using their hands.

Optical tracking has been employed previously to let the users walk across large virtual environments [2, 9]. An inertial sensors based approach is also possible [1]. It does not rely in an infrastructure to provide absolute references and it also contributes to reduce the cost of the system. [10] proposes a different approach based on inertial sensors that includes hand tracking.

2. PROPOSED SYSTEM

An inertial sensor is placed on each shoe to estimate the positions of the feet (Figure 1). From them, the position of the head is derived. Its orientation is measured by an inertial sensor that is placed on the head mounted display (HMD) that the system uses to provide stereoscopic images. A sensor is carried on the shoulder to synchronize the head and the forward direction. Two additional sensors attached to the hands, will let the user manipulate virtual objects. The virtual environment is rendered in the main computer according to the movements of the user and the images are sent to the HMD through a low latency video link.

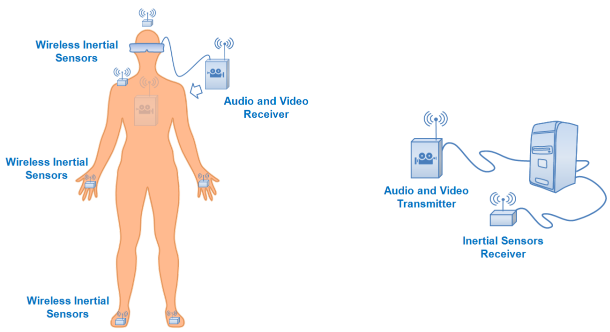

Figure 1. Components of the proposed system.

Oculus Rift (development kit 1) from ***Oculus VR*** is the employed HMD together with ***InertiaCube3*** sensors from ***Intersense*** and the wireless video link from ***Sensics***.

Many challenges arise during the development of this system. They are summarized briefly in the section below.

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3. DIFFICULTIES TO OVERCOME

Magnetometers usage indoors: To deal with drift errors in the yaw angles, magnetometers are usually employed but they are affected by significant distortions indoors.

Latency: Values above 16ms degrade the quality of the virtual experience and increase the chances of suffering cybersickness [6]. The latency of the proposed system is 75ms. It comes from the sum of the latencies of the components.

Feet position: It must be estimated in real-time by integrating twice the acceleration of the movements. This leads to drift errors.

Head position: It must be derived from the position of the feet. It has to simulate the oscillating gait movements of the head.

Head velocity: It is roughly constant while walking. However, velocity obtained from the feet changes drastically during the gait.

Point of view and forward directions: Due to drift errors of yaw angles indoors, these directions must be synchronized somehow. An equivalent problem is reported in [7].

Clear space: It is the main drawback of the proposed approach. It can be relieved by applying redirect walking techniques [8].

Inertial hand tracking: It is more challenging than foot tracking. The variety of movements is greater and acceleration is weaker.

4. RESEARCH WORK

To address part of these challenges this structure is proposed:

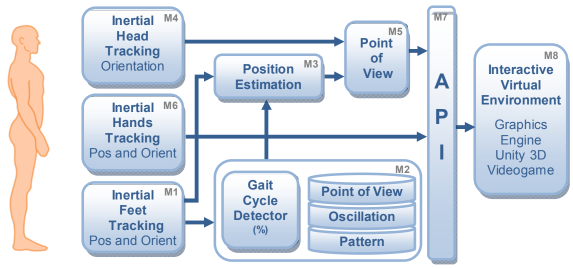

Figure 2. Proposed system modules.

The positions of the feet (M1) are estimated using Kalman filtering and the technique proposed in [4]. From them, the oscillation of the head (M2) and its position are derived (M3). The orientation of the head (M4) is combined with its position in M5. The real walking (M1-M5) and hand tracking (M6) functions are exposed through a dynamic-link library (M7) so they can be easily used in video games and graphics engines.

During the initial tests (Figure 3), the errors of the system become clearly noticeable when the head is close to virtual objects.

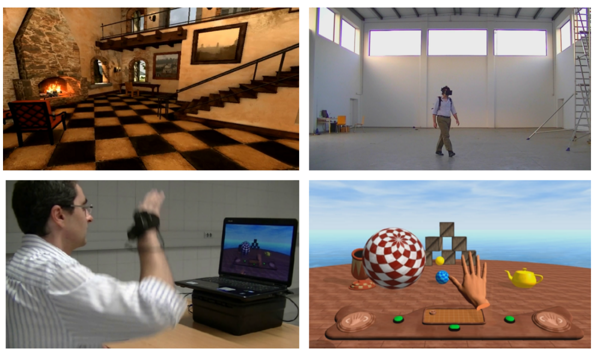

Figure 3. Real walking and hand tracking pilot tests.

Yaw drift error also becomes an issue to overcome. Due to the drift errors, the hands movements cannot last longer than 2 seconds and the user has to put his/her hand on the initial position after few movements.

Future work involves task like: synchronizing body and head yaw angles, making the head velocity constant, rendering avatars, multiuser operation and evaluation of new sensors.

5. CONCLUSIONS

The approach proposed in the ongoing project Orion and the initial work have been presented. The main challenges to be addressed have been identified. Some of them are difficult to overcome due to the limitation of the technology. For instance, latency problems or magnetometers usage indoors. Others, mean interesting research topics as the synchronization of yaw angles or inertial hand tracking. Initial results and future work have also been presented.

6. ACKNOWLEDGMENTS

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