Virtual Haptic Radar

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1 Abstract

We present here a first prototype of the Virtual Haptic Radar (VHR), a wearable device helping actors become aware of the presence of invisible virtual objects in their path when evolving in a virtual studio (such as a "bluescreen" filming stage [Figure 1]). The VHR is a natural extension of the Haptic Radar (HR) and its principle [Cassinelli et al. 2006] in the realm of virtual reality: while each module of the HR had a small vibrator and a rangefinder to measure distance to real obstacles, the VHR module lacks the rangefinder but accommodates instead a (cheap) ultrasound-based indoor positioning system that gives it the ability to know exactly where it is situated relatively to an external frame of reference.

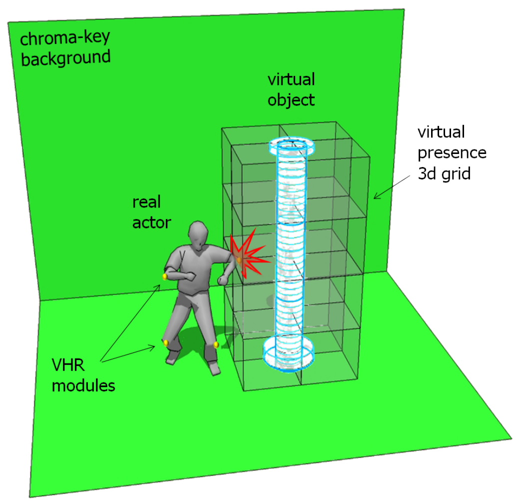

Figure 1: *Actor avoiding a virtual column on a chroma-key stage.*

2 Working principle

Each module maintains a simplified 3d map of the current virtual scene that can be updated wirelessly. If the module founds that its own position is inside the 'force field' of a virtual object, it will vibrate. Although similar systems have been proposed in the past, notably [Tom 2009] and [Kim 2006], these systems do not address exactly the same kind of problem: in [Tom 2009], the wireless vibrators are used to steer actors through a virtual set; a central system is in charge of tracking the modules. More close to our proposal seems [Kim 2006], but there vibrotactile cues are introduced only as a support for virtual object manipulation very much along the lines of haptic feedback techniques in immersive VR environments. Instead, the VHR is a general solution that works by giving the user an intuitive (propioceptive-based) understanding of the (virtual) space surrounding him. The same principle was exploited successfully to improve navigation and confidence of gait of blind subjects using the Haptic Radar (results yet to be published). It is also important to understand that the requirements for our tracking system are fundamentally different from that of traditional (optical or magnetic based) mo-cap systems: (1) each VHR module must know its own position in the room, independently from the others and without the need for a centralized computer; (2) the tracker must be inexpensive in order to enable scalability; (3) the modules must be invisible to the cameras (in particular, they should not emit or reflect visible light); and (4) interference should be minimal or inexistent if one wants tens of modules to work simultaneously (this puts aside most non-sofisticated magnetic trackers).

3 Proposed system

With these considerations in mind, we first considered optical based methods such as [Raskar and al. 2007], which have been shown to satisfy all these constraints. However, we eventually preferred to develop a custom system based on ultrasonic triangulation and radio synchronization (the main reason for this choice being avoiding the design complexity of the spatio-temporal structured optical beacon). Our prototype simply consists on 2 to 8 ultrasonic beacons emitting bursts every 15ms. A radio signal synchronizes receivers with the start of an ultrasound sequence. The receivers, concealed under the clothing, contain a micro-controller that computes the difference of arrival times, triangulates its own position and determines the adequate level of vibration.

4 Experiment

We data-logged computed positions from a single module as it scanned a 9x9 grid of constant height and 151mm pitch. 200 samples were used to compute mean and error for each point in the grid. The experiment showed geometrical aberrations easily corrected using a simple lockup table; the tracking precision is 18 mm along one axis, and as small as 4 mm along the other. A sample rate of 33 samples/sec could be achieved with this simple protocol (this sample rate does not depend on the number of receptors). For more information and a video demo, check www.k2.t.u-tokyo.ac.jp/perception/VirtualHapticRadar/

5 Conclusion

We successfully demonstrated this cheap solution for virtual object collision avoidance in a plane about 4x4 meters wide. Future work will aim to decrease directivity of the ultrasonic beams which was shown to limits the range of movements of the user as well as improving the triangulation algorithm in order to compute height.

References

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SIGGRAPH Asia 2009, Yokohama, Japan, December 16–19, 2009.
ISBN 978-1-60558-858-2/09/0012