Definition of a Virtual Environment

A virtual environment is an interactive, virtual image display enhanced by special processing to convince its users that they are personally and directly physically immersed in a space other than the one they actually inhabit.

Some Head-Mounted Displays Over Time

Decompositions of a Virtual Environment
System Latency with various Polhemus Installation Environments

\[ E(\tau_{\text{end}} - \tau_{\text{end}}) = E(\tau_i) \]

\[ \sigma_{\text{end}}^2 = \sigma_i^2 \]

\[ \sum_{i=1}^{N} \]

Measure and Model

Internal Latency (msec)

Effective Update Rate (Hz)

\[ \text{• Accumulated responses from 10 ascending 10 descending runs} \]

\[ \text{• Probit Analysis} \rightarrow \text{Gaussian} \]

Quartiles\(\text{PSE & JND}\)

Latency Detection Experiment – 2

Added Latency (ms)

Reference

Baseline (Prolateral)

Randomized Reference-Probe Order


Experimental Stimuli for discrimination of Latency during Head Movements

Target

Background

Target & Background

Radiosity Rendered Room


Productivity & Response Time

---

Some Dream Performance Specs for Virtual Environments and Augmented Reality

- Binosocical see-through optical see-through AR
- 1'/pixel visual resolution
- Presenting accurate disparities
- Adaptive (or just correct) disparity range w/ vergence
- < 8 bit color channel
- > 60º full binocular see-through horizontal FOV
- > 4º visual parallax
- Xia+ X 10º (~15")
- Adaptive 15% Luminance increment
- Embedded fast head, hand & world tracking
- < 8 ms image update latency
- > 120 Hz image update
- WiFi video & data
- Mobile phone equivalent battery-life
- Everything else I left out...

Thank you for your attention.
Detection of Predictor Artifacts during Head Rotation


\[
\Delta L = \frac{\text{Base Latency}}{\text{nonmarking return}}
\]

50-500 msec 3 - 6 Hz  relative direction: 1° @ 5° C.E.P.

60° field contrast ratio in 50,000 word vocab unlimited

2° disparity disparity ratio 100 msec 0.1 - 5 Hz 2'/pixel w/i central vision

30°  binocular over 120:1

20 msec 50-100 Hz 0.1 N 20 N @ DC to 1 N @ 10 Hz

64:1

1 msec 20Hz-20 KHz  freq. .02 - 3 Hz  power 2 dB 16 bit

40:1

5 msec 0-10 K Hz 10-100 micron vibration 8 bit 200:1

Manipulative (Mice, Joysticks, Pedals, Trackers, etc.) ±1 SE

1-4 bits/dof (discrete control) w (n = 8 subjects)

Vocal (Synthetic speech) Controls

Stereoscopic Displays Haptic Computer Graphics and Applications, 14,

Eizenman & Pasupathy, 1997; So & Griffin, 1996; Liang, Shaw & Green, 1991