Human Factors research and technology

Time Counts!

Some comments on system latency in head-referenced displays

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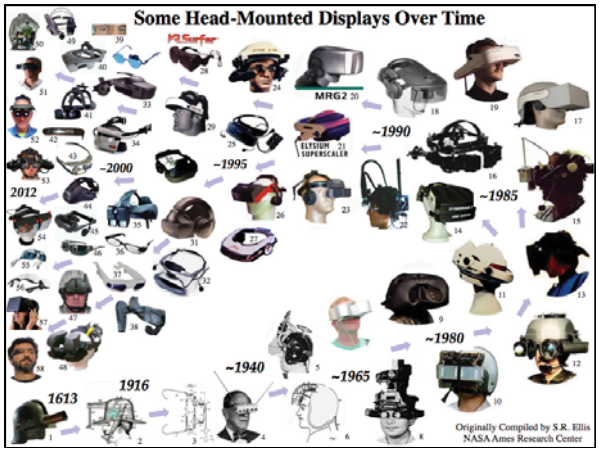
Definition of a Virtual Environment

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.

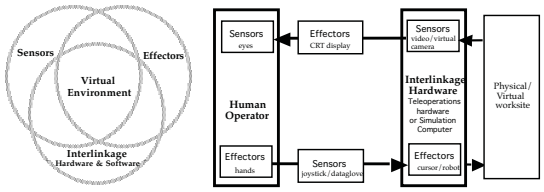
Ivan Sutherland's virtual environment *personal simulator*[1] circa 1965

[1]Haber, R. N. (1986). The simulation of high speed aircraft flight. *Scientific American, 255,*(July) 96-103.

Some Head-Mounted Displays Over Time

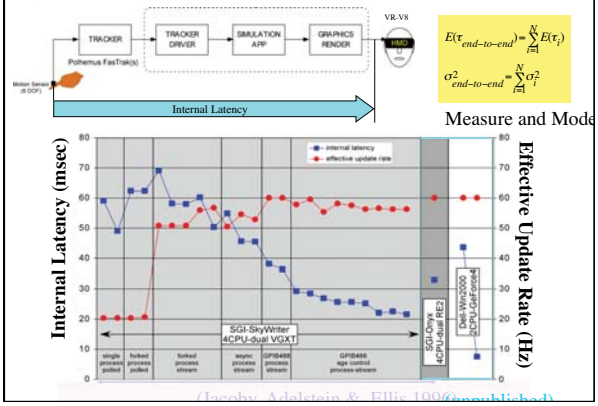


Decompositions of a Virtual Environment



Ellis, S. R. (1993) What are virtual environments? *Computer Graphics and Applications, 14*, 1, 17-22.

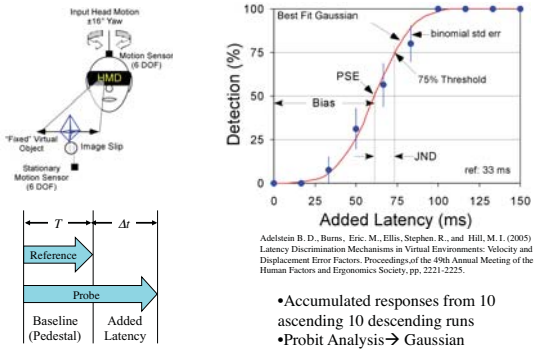
System Latency with various Polhemus Installation Environments



Measure and Mode

(Jacoby, Adelstein, & Ellis, 1996 unpublished)

Latency Detection Experiment – 2



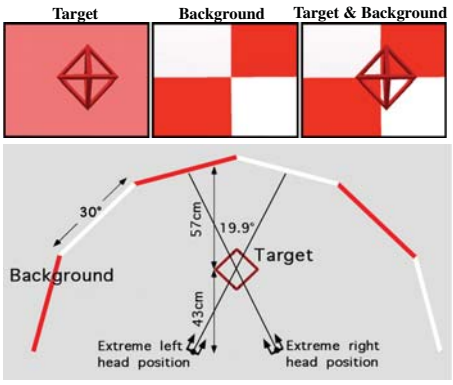
Randomized Reference-Probe Order

Adelstein B. D., Burns, Eric. M., Ellis, Stephen. R., and Hill, M. I. (2005) Latency Discrimination Mechanisms in Virtual Environments: Velocity and Displacement Error Factors. Proceedings of the 49th Annual Meeting of the Human Factors and Ergonomics Society, pp. 2221-2225.

- Accumulated responses from 10 ascending 10 descending runs
- Probit Analysis → Gaussian Quartiles → PSE & JND

Ellis, Stephen R. , Young, Mark J. , Ehrlich, Sheryl M., and Adelstein, Bernard D. (1999) Discrimination of changes of latency during voluntary hand movement of virtual objects. Proceedings of HFES. pp. 1182-1186.

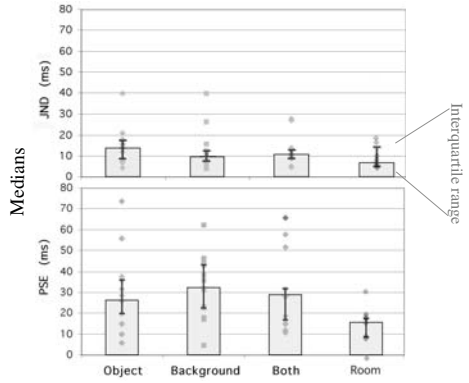
Experimental Stimuli for discrimination of Latency during Head Movements



Radiosity Rendered Room

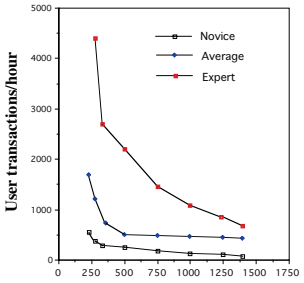
Mania, K., Adelstein, B.D., Ellis, S.R., Hill, M. (2004). Perceptual sensitivity to head tracking latency in virtual environments with varying degrees of scene complexity. In Proc. ACM SIGRAPH Symposium on Applied Perception in Graphics and Visualization, 39-47, ACM Press.

Latency Discrimination during Head Movement



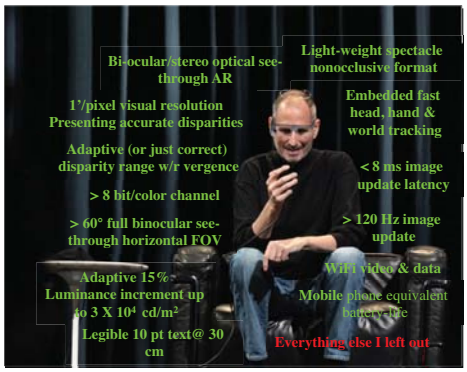
Ellis Stephen R., Mania, Katerina, Adelstein, Bernard D., and Hill, Michael (2004) Generalizeability of latency detection in a variety of virtual environments. Proceedings of the Human Factors and Ergonomics Society pp. 1836-1841

Productivity & Response Time

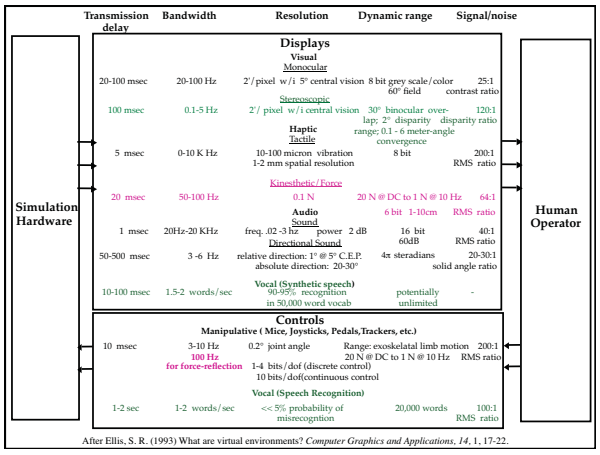


Doherty, W. J. & Thadhani, A. J. (1982) The economic value of rapid response time. IBM report GE20-0752-0 (11/82).

Some Dream Performance Specs for Virtual Environments and Augmented Reality

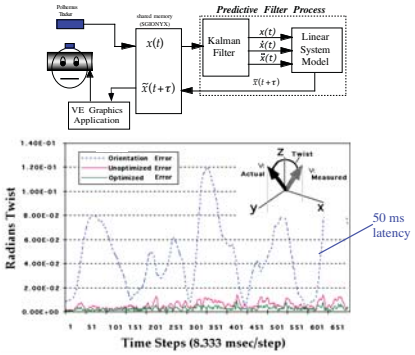


Thank you for your attention



After Ellis, S. R. (1993) What are virtual environments? *Computer Graphics and Applications, 14*, 1, 17-22.

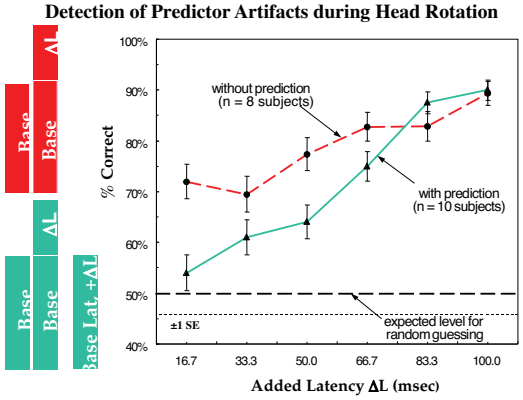
Predictive Filtering in Virtual Environment Simulation



Previous work

Friedmann, Starner & Pentland, 1992; Azuma & Bishop, 1994; Kiruluta, Tachi, 1998; Eizenman & Pasupathy, 1997; So & Griffin, 1996; Liang, Shaw & Green, 1991,

Detection of Predictor Artifacts during Head Rotation



Jung, J. Y., Adelstein, B. D. , and Ellis, S. R. (2000) Discriminability of Prediction Artifacts in a Time-Delayed Virtual Environment. Proceedings, IEA 2000/HFES2000 44th Ann. Meeting . pp. 1-499 - 1-502