HUMAN-COMPUTER SOFTWARE INTERFACE: STATUS AND RECOMMENDATIONS

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STATUS

The interaction techniques for virtual environments have yet to be extensively explored. There are several design principles which are likely candidates for structuring VE interface metaphors, such as:

- natural behavior as an interaction principle
- rapid prototyping for design space exploration
- knowledge-based agents for interactive guidance
- supernormal capabilities as a metaphor for sensory remapping
- respect for the physiological context of the physical body in VE design

These principles are suggestive, but need to be evaluated in task specific application domains.

Designers of virtual worlds have found that worlds can be built rapidly and that objects can be constructed in parallel by different team members. Current difficulties include:

- ineffective software, particularly for programming dynamics and interactivity
- complex hardware configurations, and especially hardware latency
- world modeling and maintenance (version control on worlds is complex)
- no theory of world construction
- physical literalism (assuming the virtual world is like the physical)
- naive models of interaction in a virtual environment
- failure of intuition (physical solutions are not virtual solutions)

CHALLENGES

Current research challenges include:

-- developing software operating systems which facilitate effective, inclusive, real-time interaction, multiple participant, multiple sensory, high bandwidth, low latency VEs

-- determining which aspects of the 2D WIMP and desktop metaphors are generalizable to higher dimensional virtual worlds

-- identifying the core of generic virtual world design tools and application independent interaction techniques

-- integration of multidisciplinary teams to address human, software, and hardware interactions, including design and analysis of experiments

-- bringing multidisciplinary knowledge to the construction of VEs, including work from database, data fusion, networking, human factors, computer supported collaborative work, and artificial intelligence communities

NEEDS

The most pressing needs:

-- software for design of and interaction with virtual worlds that is modular, flexible, and abstract, particularly interpreted languages for rapid prototyping

-- software operating systems and infrastructure to support world design, construction, and interaction, particularly software which reduces latency

-- metaphors which guide the exploration and prototyping of particular tools and techniques for use in VEs

-- measurement techniques and theories for identifying differential effects of world designs on the sense of presence

-- measurement techniques for identifying resource expenditure, cognitive load, transfer of learning, adaptation effects, and other performance parameters of different configuration of VEs

-- task specific evaluation of software tools

Secondary, less general, needs include the development of:

-- navigation techniques for high dimensional data and displays

-- location and movement techniques and software tools

-- manipulation techniques and software tools

-- event history, filtering, and recording tools

-- behavioral and dynamic models for determining the dispositions of objects

-- specification languages for world dynamics

-- editing tools for objects and for environmental spaces, including models of inter-object communication, process management, and composition rules

-- a design theory of sensory presentation modes (which sensory suites are best for conveying which tasks?)

-- languages and grammars for describing world interactions

-- the virtual body, mapping tools for connecting sensors on the physical body to an accurate physiological model in software, and in turn, to the virtual object being used as a body in the VE

-- tools that can be used for interaction and construction both inside the VE and outside on a monitor viewing the VE

RECOMMENDATIONS

Since VE design and interaction is in its infancy, these recommendations are focused on generic rather than specific goals.

Isolating and evaluating application-independent interaction techniques and metaphors.

Researchers should focus on the development of new metaphors for VEs and the identification of reusable, application-independent interfaces components, specifically those which can be encapsulated in software and distributed. One specific area with high potential is the use of voice input as a parallel input modality.

While some of this evaluation will be extensive research centered on the human's capabilities, some of it will be rapid, less formal evaluation to help interface designers choose between conflicting alternatives. In one sense, these different objectives underscore the differences between basic science
and engineering. We explicitly suggest that NSF recognize the contributions made by evaluations made at various levels of certainty. Fred Brooks refers to these as @italic(certainty shells) [note to randy: check this term], including observations, rules-of-thumb, and facts. This research needs to integrate the diverse skills and styles of multidisciplinary teams.

Software capitalization

NSF should support a software clearinghouse for code sharing, reuse, and software capitalization. The cost of having each VE laboratory develop its own infrastructure is prohibitive to the effective conduct of research.

We encourage support of world building and maintenance tools, to enable version control, composition of components developed by different design groups (tool portability), ease of customization and configurability, and expressability.

Measurement techniques to determine the quality of VEs

We will need to develop metrics to guide the exploration of VE tools, techniques, and metaphors. The quality of a VE is likely to be related to specific tasks, physiological comfort, cognitive and perceptual load, resource expenditure, intuitiveness of tools and interactions, ease of reconfiguration, transfer and adaptation effects, and even individual differences and preferences.