RIA: HAPTIC DISPLAY OF GRAPHICAL FEATURES OF A COMPUTER INTERFACE

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PROGRAM AREA
Usability and User-Centered Design

KEYWORDS
Computer, interface, force-reflection, haptic

PROJECT SUMMARY

The main focus of this work is to evaluate whether today's windows-based human-computer interface can profitably be augmented by having the pointing device supply haptic information to the user. Of particular interest is the extent to which a user can more efficiently manipulate graphical objects of the interface when these are imbued with force-feedback attributes. For example, can users acquire a button faster when it exerts an increasing attractive force on the user's hand as the cursor approaches the button? And, can hard virtual walls about menu bars, and click detents between menu items, reduce menu item selection times and menu manipulation errors?

For this study, human-subjects testing is used to determine the relative speed of interface object manipulation with and without force-reflection. Experiments are being initiated to evaluate button acquisition, menu item selection, and text manipulation tasks. The commercially-available PHANToM 3D force-reflection system (SensAble Devices, Cambridge, MA) serves as the core of several pointer configurations.

To expedite the development of new experiments, an object-oriented program has been developed. This program, CHIRA (Computer-Human Interface Research Application), allows experiments to be controlled via one or more script files. A set of general built-in commands allow control of system variables, script control flow (via goto, for and while constructs), and execution of auxiliary "subscripts" that act in the manner of subroutines. With these features, for example, it is possible to write a simple (text) script file that causes CHIRA to: 1) Accept a subject's password (which is also the name of that user's script file); 2) Open the subject's script and data files (if different); 3) locate from the end of the data file the session last executed; and 4) Start executing the commands for the next experiment session.

Custom behavior is implemented by way of object modules that are loaded (at run time) only when first named in the script file. Development of custom modules is greatly simplified by a well-defined interface to CHIRA, and CHIRA support for common functions such as setting module variables from the script. Further, use of the NextStep operating system allows low-level access to graphics objects and the event loop.

System hardware consists of a '486 computer running NextStep and CHIRA, the PHANToM configured as a force-reflecting pointer device, and a 120 MHz Pentium computer to implement the PHANToM control loop. A 96-bit parallel interface connects the two computers, allowing cursor position information to be transferred to NextStep, and graphical object attributes (e.g. button size and position) to be transferred to the Pentium, for calculation of force-reflection profiles.

PROJECT REFERENCES

A paper describing CHIRA has been submitted to the Psychonomics journal, B*ehavior Research Methods, Instruments & Computers*.

AREA BACKGROUND

Haptic perception (involving the senses of kinesthetics and vibration) is used for skills such as Braille and the method of Tadoma, by which some blind and deaf individuals receive near-real-time speech by placing their hands on a talker's face and neck to feel the articulatory correlates of speech. We use haptic perception to perform sophisticated manual manipulations even in situations where vision is not available (such as tightening a bolt under an appliance).

How, then, can we harness the capabilities of the haptic system to enrich the human-computer interface? A number of possibilities are under investigation. Many studies use force-reflecting technologies, where the user manipulates an input device that can simultaneously (under computer control) exert arbitrary forces on the user's hand. By programming the system to simulate haptic objects or patterns that are recognizable from experience, believable haptic environments have been created.

Although vision is not necessary to implement a haptic virtual environment, as shown by an early joystick simulation of a straw in a glass of water and ice cubes (Minsky et. al., 1990), the most compelling and useful environments created to date have all used a visual component that was carefully carefully coordinated with the haptic. In some cases, the haptic component has added information that could not be effectively conveyed visually. A good example is molecule docking, where molecules are designed by picking and placing individual atoms, while feeling the interatomic forces acting on the held atom as it is moved about the simulated molecule (Brooks et. al., 1990). Another potential application is CAD software for mechanical system design that allows a user to directly manipulate or even break assemblies while perceiving resultant forces.

While the above applications are rather specialized, a number of investigators are pursuing the possibility that force-reflecting technology could be used to enhance the present windows-based computer interface. A number of devices have been constructed, but few careful human-factors studies have been carried out. And that is the departure point for this grant.

AREA REFERENCES

Brooks, F.P. Jr., Ouh-Young, M., Batter, J.J. and Kilpatrick, P.J.. Project GROPE - haptic displays for for scientific visualization. *Compute Graphics* **24**, 177-185 (1980).

Minsky, M., Ouh-Young, M., Steele, O., Brooks, F.P. Jr., and Behensky, M.. Feeling and seeing: Issues in force display. *Compute Graphics* **24**, 235-244 (1980).

Multiple papers on haptics and force-reflection can be found in: Dynamic systems and control 1994, Volume 1. This is the Proceedings of the Winter Annual Meeting of the Amer. Soc. of Mechanical Engineers, Nov 6-11, 1994 (N.Y., N.Y.: ASME).

Papers on haptic force-reflecting technology can also be found in the Proceedings of the first IEEE Virtual Reality Annual International Symposium, VRAIS, Seattle, Sept. 18-22, 1993 (Piscateway, N.J.: IEEE).

Susan Lederman (Queen's Univ. in Kingston, Ontario, Canada) has written numerous articles detailing experiments in basic haptic psychophysics, Mandayam Srinivasan (MIT, Cambridge, MA) has investigated biomedical aspects of haptics, and James Colgate (Northwestern University, Evanston, IL) has developed mathematics for force-reflection.

RELATED PROGRAM AREAS

Virtual Environments

POTENTIAL RELATED PROJECTS

The combination of the PHANToM-based force-reflecting computer interface and the CHIRA program for rapid prototyping of human-computer interface experiments allows branching out in a number of research directions:

1) Basic psychophysics of the haptic senses (although the relatively small workspace of the PHANToM limits larger motions).

2) Use of the third dimension (up/down) of PHANToM motion (and perhaps rotation as well) to control additional factors in the computer environment.

3) The technology could be used to develop an interface for blind individuals, where each graphical object on the screen has a haptic "icon" in addition to the visual one.