A Macintosh interface to teach 3-D perception cues

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I present an interface between a Macintosh computer and a pair of glasses with liquid crystal shutter lenses that allow interactive demonstration and investigation of the visual system. This equipment allows a graphic image to be presented to a subject's eyes in a variety of ways. A primary application of this apparatus has been to create binocular disparity that results in a convincing illusion of depth. Other possible applications include tachistoscopic functions and monocular visual presentations.

The mechanisms of depth perception are usually demonstrated with static and fairly inflexible tools (e.g., stereoscopes and pictures that showcase texture gradients or occlusion). The obvious disadvantage to such methods is that they require several different pieces of equipment and materials that are fairly specific in use, and that are sometimes expensive. The ideal device would be accurate, low in cost, and flexible enough to allow interactive study of not only three-dimensional (3-D) perception, but also other perception mechanisms as well.

I present an interface between a Macintosh computer and a pair of glasses that have liquid crystal (LC) "shutter" lenses that allow for interactive demonstration and investigation of the visual system. This equipment allows a graphic image to be presented to a subject's eyes in a variety of ways. One primary application of this apparatus has been to create binocular disparity that results in a convincing illusion of depth. Other possible applications include tachistoscopic functions and monocular visual presentations.

Hardware

The hardware is a simple three-chip interface that takes signals generated by a Macintosh computer running specialized software and controls the lenses of the LC glasses. The interface plugs into either serial port on the Macintosh. Since there are two serial ports, two interfaces can be used simultaneously if one desires. The parts necessary for the interface should be available from any local electronics store (e.g., Radio Shack); they generally cost around \$25.00. Building the interface requires skill with a soldering iron; it takes less than 2 h. A logical schematic for the interface is included in Figure 1.

The LC glasses were part of a home video game system manufactured by the Sega Corporation for use in conjunction with one of their games. These glasses are currently available at the retail level only in Europe; availability in North America is limited to direct ordering from Sega.¹ The glasses are large enough to fit comfortably over prescription glasses. In their noncharged state, the lens are clear, but the lenses turn opaque with the application of voltage. Each lens is individually controllable to allow for full experimental flexibility.

Software

The software controls the opacity of each lens—both, one, or neither of the lenses may be opaque at any time. Software takes advantage of the glasses to create binocular disparity, resulting in a convincing illusion of depth to the user. An image is presented to the user while one lens of the glasses is opaque and the other is clear. The same image, shifted horizontally a few pixels, is then presented to the opposite eye by making the clear lens opaque, and vice versa. This shifting of image presentation between eyes occurs fast enough so that there is little discernible "flickering" of the lenses or image. The disparity between the images on the retinas of the viewer's eyes excites the binocular depth cells (Barlow, Blakemore, & Pettigrew, 1967), resulting in an image that is seemingly 3-D.

The software that is currently completed contains static demonstrations of this effect, as well as "animated" demonstrations that allow the user to rotate a wire-frame Macintosh computer in 3-D space or to navigate through a 3-D maze from a "rat's-eye" perspective.

Software nearing the final stage of development is intended to aid undergraduate students in their understanding of 3-D perception. An image is presented and students are allowed to interactively add and subtract various depth cues to the image to ascertain each cue's role in depth perception. Cues can be mixed and matched so that additive or subtractive effects can be gauged.

In the planning stage is software that will allow instructors to easily and quickly include their own images into

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Figure 1. Logical schematic for the hardware interface.

a "shell" program. This will allow for more rapid prototyping of images and will enable the instructor to build a simple demonstration program that utilizes his or her own graphics. This will help eliminate the sometimes tedious task of aligning the images properly within the display field.

Full source code of these programs is available. The source is written primarily in C code, but portions are in assembly language to speed screen refreshing. Anyone with knowledge of C can write his or her own program utilizing only the screen-handling routines of the current software.

Implications

The primary application of this apparatus has been to create binocular disparity to produce a convincing illusion of depth. The software under development will allow students to interactively examine depth cues to see their effect on depth perception. This software, in conjunction with the hardware interface and LC glasses, gives the instructor an inexpensive way to let students learn about depth perception in a "hands-on" manner. Even though similar commercial systems (Vision Research

Graphics, StereoGraphics) can provide slightly higher quality images and more software options, they rely on dedicated hardware that is generally more expensive.

As another possible application, this equipment could be used as a portable tachistoscope for researchers doing work in the field. The only drawback is that, currently, the LC lenses do not become completely opaque. This may be due to a voltage problem inherent in the design of the interface board; however, I am working on a revised interface board that incorporates an external power supply. This revised board, in addition to potentially solving the opacity problem, will also result in a more durable interface.

Any research that requires timed monocular or binocular presentation of images that can be displayed on a Macintosh screen could incorporate this apparatus. Of course, the presentation of color images would require a Macintosh capable of producing color. Animation would also necessitate a Macintosh faster than the current base machines, so that one could obtain adequate real-time feedback. Color animations would probably require a hardware graphics accelerator, like Apple's 8•24 GC card, if even medium-quality animation is desired.

If this equipment is to be used for anything other than producing stereoscopic displays, more research will be necessary to determine the response characteristics of the LC material and the hardware interface. The speed with which the lenses become completely opaque or translucent would need to be determined. In addition, the problem of achieving complete opacity of the LC material must be solved.

REFERENCES

- BARLOW, H. B., BLAKEMORE, C., & PETTIGREW, J. D. (1967). The neural mechanism of binocular depth discrimination. *Journal of Physiology*, **193**, 327-342.

NOTE

1. One may order the Sega 3-D glasses by calling Sega of America at (800) 872-7342; the price at the time of writing was \$34.95, plus \$2.20 shipping and handling.