A Quantitative Comparison Method of Display Scheme in Mobility Aids for the Blind

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The idea of the technological assist of the mobility of the blind person is of a rather recent origin (since World War II). With the advent of electronics and computer sciences, several mobility devices for the blind have been developed. These include, i.e., the Sonic Guide (Kay, 1966) which transmits the ultrasonic sound and receives the reflected sound by the obstacle, and therefore informs the blind user about the environment by means of the audible sound code. Another example is a laser cane.

All of these, however, represent ad hoc solutions and offer no practical suggestions for a generalized design procedure to define optimal displays for specific applications.

Suppose that a device which directs or guides a blind individual has somehow acquired information about the direction of, and width of, the path along which it should lead the blind individual (Tachi et al., 1981). The problem is the choice of sensory display of the path and its safe margins appropriate for presentation to the remaining exterio-receptive senses of the blind individual.

The central features of such a design capability must include a method to quantify the motion or movement of an unhampered blind individual walking in a real or mock-up physical environment, and the means of feeding back to the individual, in real-time, the path information and/or error from the path by means of a very flexible and potentially rich psychophysical sensory display code.

The importance of this mobility environment simulation approach was first proposed in 1965 (Mann, 1965). The realization of the system had to await Conati's fundamental work in 1977 on a system for Telemetered Real-Time Acquisition and Computation of Kinematics (Conati, 1977), a general purpose laboratory system dubbed TRACK, which coupled the high-speed, yet low-cost, laboratory mini-computer with the high-performance, multi-channel, point-monitoring, and data transferring device called Selspot. In this paper the newest version of the TRACK system operating under RSX11-M on a DEC computer PDP 11/60, which extends the ability of the previous version, is first reported.

Using this new system the performance of human subjects employing different auditory display schemes communicating the course they should follow are quantitatively compared. A method for the quantitative comparison is also proposed. An optimal auditory display scheme is sought, by measuring the movement of a human subject to a random course (generated by the computer) which displays to the subject the course error from the desired course in real-time. The transfer function of the subject employing each of several different display schemes is estimated. The effective gains and the effective time delays of the transfer functions for the several display devices are calculated according to the crossover model. Using the sum of the effective gain and the reciprocal of the time delay as the criterion of optimality, the optimal display scheme is sought and the effect of difference between the alternative display schemes is quantitatively evaluated.

Experimental Apparatus

Figure 1 shows the experimental arrangement. The movement of the human subject was measured by the newly revised TRACK system. The system consisted of the raw-data acquisition and handling device, Selspot, marketed by Selcom AB of Sweden, a PDP 11/60 mini-computer, and an auditory display device which was linked to the computer through a Laboratory Peripheral Accelerator (LPA).

The Selspot system used cameras with the lateral photo-electronic plates in their image planes which were sensitive to infrared illumination. Each plate detected the position of the image of a light emitting diode (LED) and thereby provided two-dimensional position data from each camera for up to 30 LEDs which were serially pulsed to at a rate of 315 Hz.

The two cameras were positioned accurately in laboratory coordinates and their two-dimensional image position data were manipulated trigonometrically by the computer to yield three-dimensional data of the LEDs. By arranging three or more LEDs on a plane attached to a segment of a moving human (in this case the abdomen) the location and orientation of the human subject could be tracked in real-time.

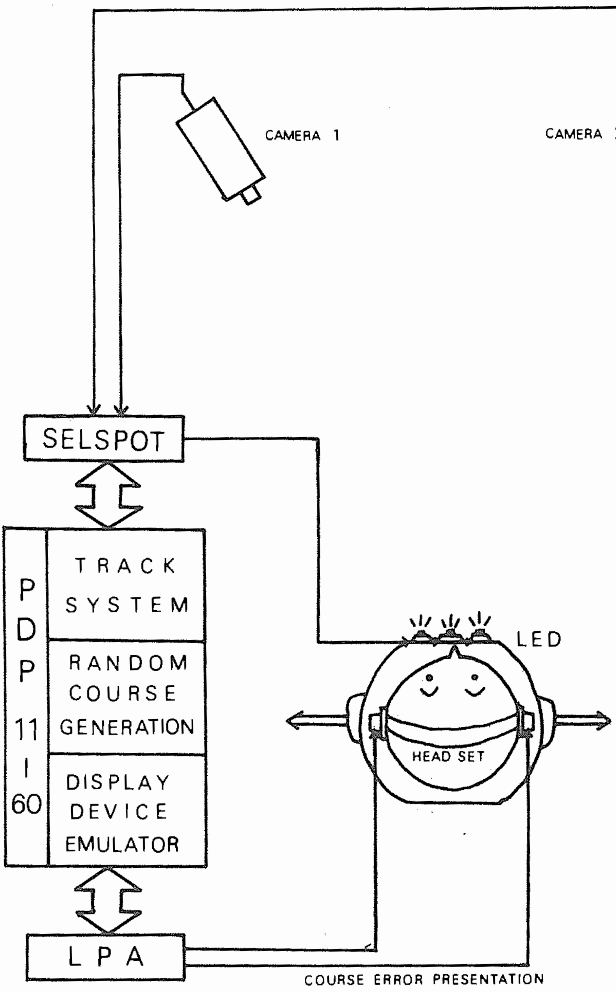

Figure 1—Experimental arrangement for real-time evaluation of the display devices for the blind.

Band limited random noise was generated by the computer and was used to define the course which the subject should follow. Error in the human's location relative to the indicated course was fed back to the subject via auditory signals through a headset (Electrostat-Dynamic Systems k-340) through the LPA's D to A converters.

Experimental Goal and Method

The computer system emulated several display devices which used