

EXHIBIT 3

SECOND, COMPLETELY REVISED EDITION

Handbook of Human-Computer Interaction

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North-Holland

HANDBOOK OF HUMAN-COMPUTER INTERACTION

Second, Completely Revised Edition

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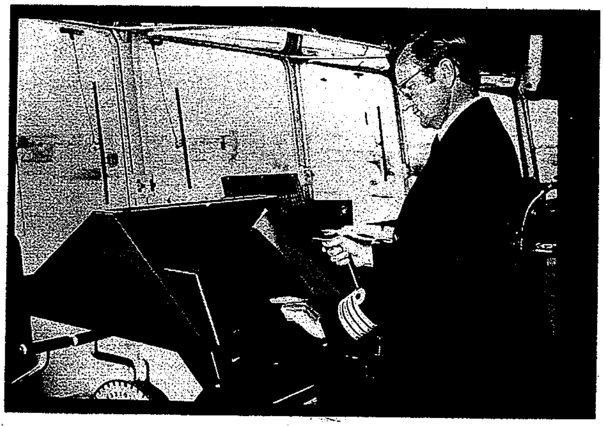

Figure 1. A capacitive touch screen. (Courtesy of MicroTouch Systems, Inc., Methuen, MA.)

tive human performance and preference data are then presented to aid in the selection of an appropriate device for a particular application. While brief descriptions of the technologies underlying each device type are provided in this chapter, Sherr (1988) addresses input device technologies in much greater detail.

55.2 Touch Screens

55.2.1 Technologies

A touch screen device produces an input signal in response to a touch or movement of the finger on the display. Figure 1 depicts the use of a touch screen in a ship navigation radar system. There are two fundamental principles of touch screen operation; either an overlay is contacted or signals projected over the screen are interrupted.

In the first category are resistive, capacitive, piezo-electric, and cross-wire devices. The resistive touch screen has two layers, one resistive and one conductive. When pressure is applied, the two surfaces touch and a circuit is completed. The capacitive touch screen has a conductive film deposited on the back of a glass overlay. The body's capacitance causes an electrical signal to be generated when an individual touches the overlay. The piezo-electric touch screen employs a glass overlay with a force transducer at each corner of the overlay. When a touch is applied at a particular location on the overlay, the forces transmitted to the transducers are used to determine the initial location of the touch. Movement of the finger following the initial touch is not reliably detected with this technology. The cross-wire device uses a grid of horizontal and vertical wires set in transparent sheets placed on the display. A voltage is applied to either the vertical or horizontal wires and a signal is produced when a touch forces a vertical and horizontal wire together at their intersecion.

Surface acoustic wave and infrared touch screens are activated when the finger interrupts a signal. In a surface acoustic wave touch screen, a glass plate is placed over the screen and ultrasonic waves are generated on the glass by transducers placed along the edges. When a waveform is interrupted, the reflected horizontal and vertical waves are detected by the transducers. On an infrared touch screen, light emitting diodes are paired with light detectors and placed along opposite edges of the display. When the user touches a finger to the screen, light beams are interrupted.

Touch Resolution

Resistive screens tend to have the highest touch resolution, with from 1000 x 1000 to 4000 x 4000 discrete touch points. The resolution of capacitive screens is relatively high, while that of surface acoustic wave screens is generally lower. Infrared screens may have as few as 25 x 40 touch points due to limitations on the number of light emitters and detectors that can be placed around the screen (Logan, 1985). For applications requiring high touch resolution, infrared devices may be unsuitable. Even if high touch resolution is not required, the greater the number of touch points, the easier it is to map them to targets on the display; screen design may thus become more flexible. If a target is not placed directly under a touch point, errors in selection may occur (Beringer and Peterson, 1985).

Parallax

Parallax occurs when the touch surface or detectors are separated from the targets. For all touch screen technologies, the touch surface will always be at least slightly above the target due to the glass surface of the display. An overlay separates the finger and the target even more. This problem can be alleviated by requiring the user to be directly in front of the target and to place the finger perpendicular to the screen. Unfortunately, such a requirement somewhat offsets the advantage of the naturalness of the required input, especially for targets at the sides of the display.

When infrared touch screens are used with curved CRT displays, the parallax problem is more severe. Because light beams travel in a straight line, the beams must be positioned to pass above the curved display surface. When the user touches the screen, the beam may be broken at a point that is not directly above the