A DISPLAY OVERLAY FOR COMPUTER INPUT

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One approach to overcoming the man-machine language barrier is to communicate through an intermediate language generally known as graphics. Position is the fundamental unit of information in this language, and the translation of position into digital information is basically a position encoding process. The subject of this paper is a computer input device that can be described as a touch sensitive x-y position encoder. Physically, it consists of a transparent glass plate that can be placed in front of a display screen, and functionally, it provides the x-y coordinates of the location at which a human finger or a passive stylus touches the glass surface.

Graphic Input Devices

Graphic input devices can be grouped into several classes as shown in Figure 1. The display sensor type provides a signal when a portion of the displayed image is in its field of view. The most familiar example is the light pen which is a light sensor. Another example is the beam pen which senses the electron beam in the CRT. The operation of these devices depends upon a continuously refreshed CRT display and they cannot be used with direct-view storage tube displays or with static displays. Devices in this group inherently perform an item selection function although position selection is possible by using a tracking cross or raster to follow pen movement. Item selection is the selection of a sub-set from a set of displayed items, while position selection is the selection of a particular location within some bounded region.

Position encoders, the other major class of input devices, inherently perform a position selection function. The selected position can be displayed to provide visual feedback to the user. Item selection with these devices requires a hardware of software comparison between the indicated position and the location of the items being displayed. Position encoders can be further classified into those encoding absolute positions and those encoding changes in position.

Input devices for encoding position increments consist of a mechanical assembly which can be manipulated to indicate changes in the position of a cursor on the display screen. Examples of this are the track-ball, the joystick, and the "mouse". The operation of these devices depends entirely on visual feedback from a dynamic display unit.

Devices accepting absolute positions rely on a direct mapping of positions from an input surface to a display surface. The input surface is usually a flat plate on which positions are indicated with a movable hand-held stylus. Devices in this group are known as data tablets or graphic tablets.

There are now several data tablets on the market based on different techniques. The first to appear was the Rand Tablet, now marketed as the Graphacon. Coded pulse trains are sent through a grid of conductors in the tablet and can be picked up with the stylus by capacitive coupling. The Sylvania Data Tablet also depends on capacitive coupling for signal sensing, but in this case the tablet has a transparent conducting layer on which an RF electric field is generated. The SAC Graf/Pen uses a spark gap in the stylus as a radiator. The sound generated by the spark is detected by strip microphones along the edges of the tablet.

The stylus used for indicating positions on data tablets is typically an active one which contains a signal sensor or a signal radiator. The stylus must be large enough to accommodate the necessary components, and, in addition, present devices require a cable connecting the stylus to the console for signal transmission. This makes some active styli difficult to use with dexterity.

If the tablet is not transparent, the input surface has to be physically separated from the display surface. This makes it necessary for the user to rely on a visual feedback process by observing the mapping of his selected position in relation to the desired position. On the other hand, a transparent tablet can be placed in front of a display screen and used as a display overlay. If the input surface has a finite thickness, the user has to cope with parallax. However, assuming a one to one mapping scale, the relationship of positional information on the two surfaces is fundamental and natural. This simplified relationship made possible with a transparent tablet reduces the time and mental effort expended, especially when the user is performing item selection.

A second advantage of a transparent tablet is that it can be used with static as well as dynamic display units. Because of the simple mapping relationship, a cursor or other visual confirmation of the selected position is not necessary. Therefore, one can perform item selection on a rear projected slide screen, a microfiche reader, a direct-view storage tube, a TV monitor, or even on hard copy material placed behind the tablet.

Touch Sensitive Input Devices

Work began on an input device which would be easy to use for item selection with a variety of display devices. This requirement evolved into several specific objectives which are related to the considerations outlined above. These objectives are:

1. The device must encode absolute positions indicated by the user.

2. The input surface must be transparent.

3. Positions are to be indicated with a passive stylus including a human finger.

Assuming that the first two objectives are met, the third allows one to select items or positions on the screen merely by pointing at them with a finger. Because pointing with a finger is man's most natural method of indicating selection, a touch activated device creates a minimum of distraction for the user. In fact, an ideal implementation of the three objectives would result in an input device that was apparent to the user in function rather than in substance.

Admittedly the human finger is a rather coarse stylus, but the resolution attainable is suitable for many types of manual information entry. For example, the words or phrases displayed for selection in an information retrieval system could be in a format suitable for this type of input technique. If a conventional keyboard is used in conjunction with the display terminal, a touch activated display overlay reduces the time spent in going from keyboard to display by eliminating the intermediate step of picking up a stylus. In addition, a portion of the input surface could be used as a touch sensitive keyboard with dynamic computer control of the associated key functions. The apparent simplicity, both physically and functionally, of this type of input device is a significant advantage if the user is a young child communicating with a computer-aided learning system. For information entry requiring more resolution than one can obtain with a finger, a suitable passive stylus could resemble an ordinary pencil with its convenient size, light weight, and freedom of movement.

A touch sensitive device has been developed for use with CRT displays by Marconi in England. A number of discrete wires, typically 32, terminate on a plastic sheet placed in front of the display tube. Body capacitance is sensed whenever a wire is touched. Another device, from Control Data Corp., consists of a row of 20 translucent strips in front of the CRT which are sensitive to finger contact.

Surface Wave Echo Ranging

The approach taken in our case to meet the objectives outlined earlier was to use a pulse echo ranging technique with high frequency elastic surface waves. In principle, the resulting device could be compared to a two dimensional radar or sonar system. Pulse modulated surface waves are generated on a glass plate and any object touching the surface reflects some of these waves back to the source. The distance between the radiator/sensor and the stylus is proportional to the time between the sending pulse and the received echo pulse.

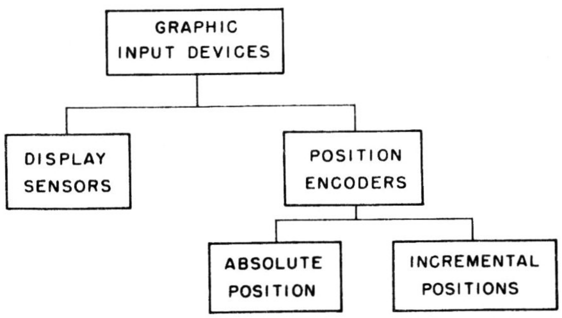

Figure 1 Input device grouping

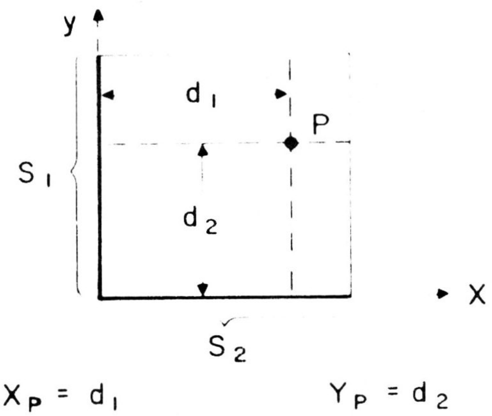

Figure 2 Stylus x-y location

The x-y coordinates of the stylus location are determined by examining the surface in orthogonal directions using linear transducer arrays fixed along the edges of a square plate. This is shown in Figure 2, where S1 and S2 are the orthogonal arrays. The X and Y arrays are activated alternately to avoid mutual interference. This method of stylus location has the advantage of providing the x-y coordinates directly. If the stylus were located by measuring its radial distance from two adjacent corners of the plate, several computational steps would be necessary to convert the data into x-y coordinates.

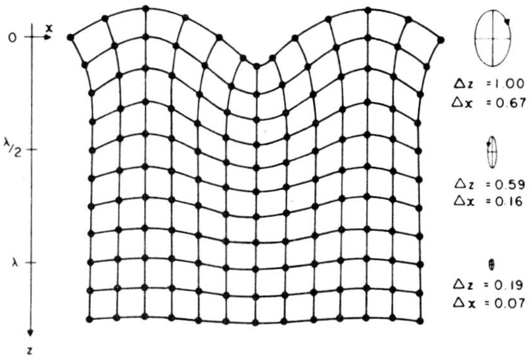

Figure 3 Surface wave propagation

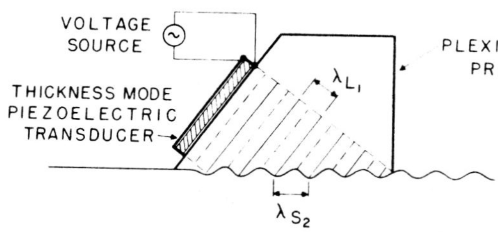

Figure 4 Surface wave radiator/sensor

Figure 3 is an illustration of an elastic surface wave propagating along the free boundary of a solid. The particle movements are elliptical because there are displacement components both perpendicular and parallel to the direction of propagation. The wave energy is considerably reduced at depths of more than one wavelength from the surface, so that a plate several wavelengths thick is sufficient for this application. Surface waves have a velocity of 3170 m/sec. on plate glass.

The carrier frequency for echo ranging is chosen on the basis of factors such as positional resolution, size of usable area, and radiator/sensor beamwidth. An ultrasonic carrier frequency of 4 MHz is being used, with a corresponding wavelength of .03 inches on plate glass. Surface waves of this frequency can be generated and sensed by an acoustic prism method as shown in Figure 4. Each transducer array consists of six interlaced groups of such radiator elements. These groups are switched on sequentially to provide overlapping coverage. The same transducers serve as radiators and sensors and are electrically switched between sending circuitry and receiving circuitry. The arrays are mounted on a 16 inch square plate which provides a 10 inch square usable surface. Because of the transparency requirement and the attenuation characteristics of surface waves, glass is the only known practical plate material. Selected 1/8 inch plate glass is being used.

The device as described is capable of a maximum average sample rate of 600 coordinate pairs/sec. This is considerably higher than would be used for item selection applications. For example, a sample rate as low as 10 points/sec. could provide a minimum response time of 0.1 sec.

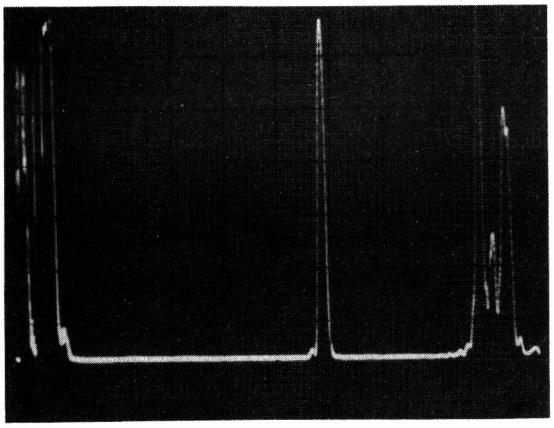

Figure 5 Echo from a finger

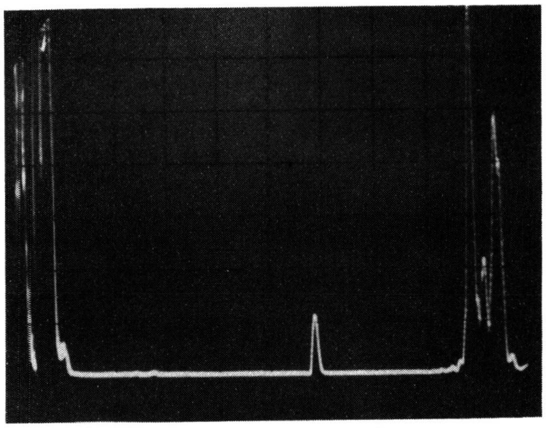

Figure 6 Echo from a 1/16 inch steel ball

Figures 5 and 6 illustrate the signals obtained from the echo ranging operation at 4 MHz. These waveforms are somewhat idealized because they were obtained with a single transducer instead of the whole array. In actual operation, the signal to noise ratio is poorer than in these figures. The horizontal scale is 35 μsec./division and the vertical axis is receiver output voltage. The signal near mid-range is the echo from the target 12 inches from the source and the signal at the end of each scan is the reflection from the far edge of the 20 inch glass plate.

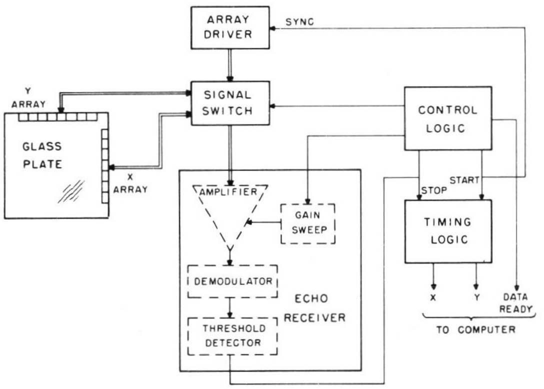

Figure 7 Position encoder block schematic

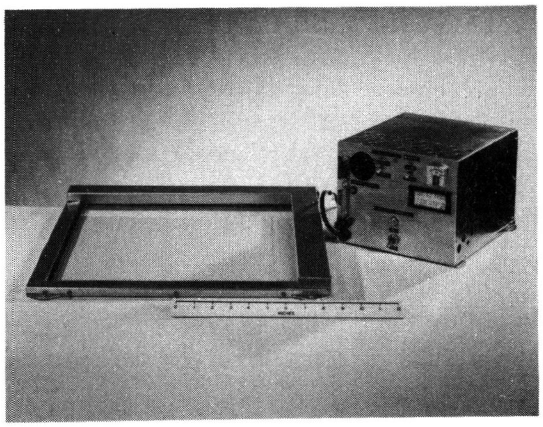

Figure 8 Touch sensitive overlay and electronics

Position Encoder Performance

Figure 7 shows how the various components of the system are interconnected. The RF signal processing circuitry consists of a radiator driver, a send/receive switch, and an echo receiver. The timing logic digitizes the signal propagation times, and the control logic maintains the correct operating sequence for the other components.

To facilitate computer interfacing, the x-y coordinates are available as a string of six ASCII characters representing two 3-digit octal numbers. The Data Ready signal from the control logic is used as a computer interrupt to initiate the data transfer. The coordinate grid is arranged so that the lower left corner is the origin and the upper right corner has the octal coordinates (377, 377). The tablet is interfaced to a PDP-8 computer for testing and demonstration.

The complete device is shown in Figure 8. The tablet is connected to the box of electronics by a cable several feet long so that all the user need see is the framed sheet of glass in front of a display screen. For reliable operation, the glass must be kept reasonably clean because an accumulation of dirt on the surface contributes to the background noise level in the receiver and may cause false echoes. In addition to sensing a finger, the tablet can be used with objects such as a pencil sized rubber tipped stylus. Only a few ounces of pressure are necessary to make an acceptable contact.

The positional resolution available with the surface wave technique involves a trade-off with other design factors such as sensitivity and tablet size, and it is not inherently limited to that achieved with the particular configuration being described. The overall usable resolution with the present equipment has been found to be about 1/4 inch, although some parts of the surface are much better than that. Even though the coordinate sample rate is high enough to follow the stylus movements used in drawing and entering graphics, the resolution of this tablet limits its use for such purposes to tracing out simple sketches. However, the resolution is adequate for pointing with a finger. Using the tablet in this way is a very natural process, and except for a small amount of parallax, a person can make use of the device without consciously being aware of its presence. It is this characteristic that makes the touch sensitive overlay well suited to applications which require the user to perform item selection operations.