Touch Screens for Flat Panel Applications

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INTRODUCTION

Input devices for computers systems traditionally have been keyboards or keypads. These devices are simple and very low cost. As systems become more complex with advance hardware, keyboards have grown in size, adding many single-stroke key functions to aid in high-speed use of the computer. Keyboards have grown to include well over 100 key switches, which makes them very large devices. Reducing the overall size and complexity of the keyboard while increasing its functionality is gaining popularity.

Non-keyboard systems fall into two main categories: those that are independent from the video output (i.e., tabletop digitizing tablets or a mouse), and those that work in conjunction with the video output (i.e., over screen input systems). Over screen systems have two main types of input devices: pen input and touch screens. Pen input systems use the pen as the input device. These systems are used when hand-writing recognition or capture is important or if there are very small targets on the screen. The touch screen devices are activated by the human finger. This is important for quick operation and response where a stylus (pen) would be awkward. Finger operated touch switches, however, are not well-suited for small targets or when hand-writing is required.

In both cases, the actual switching mechanism sits directly on the video screen. In this way, the actual key switch can have its legend, appearance or location appear directly on the scene. Further, when the computer operation no longer requires the key switch function, the system simply erases the switch in order to display other key switches. Using this feature, a computer system can have a limitless number of key switches and functions.

THEORY OF OPERATION

Pen input and touch screens are similar in overall systems design and interaction. Each device places an X,Y grid across the face of the device. Touching the device with either a pen or the fingertip, sends the corresponding coordinate pair to the computer. The computer is interrupted while it searches its program to see what function is attached to that particular coordinate pair. An X/Y coordinate can refer to a key-code or an entire command string or complex macro. In either case, the touch switch coordinates and their programmed functions are interrelated to the video screen, but are separate in function. The video screen is not directly tied to the touch switch. Software programming of the computer is the link between the video screen and its touch buttons and the touch targets on the touch screen placed over it. The communication link to the computer can be a serial or a parallel ASCII link via a communication port or to the keyboard port. The touch device can also communicate directly to the computer at the bus level using binary or Hex. Communications at the bus level is much faster and more direct than the other approach. In a PC environment, the bus-level approach is the most preferred method because of the performance enhancement and the hardware and software are readily available. Non-IBM PC systems will probably find ASCII communication far easier to deal with since no new hardware will need to be developed.

All pen input digitizers operate in a high-resolution mode with a large number of targets per inch. Touch switch overlays come two ways. They can be full matrix switches, similar to the digitizer, with very high resolution or with a fixed matrix, offering lower resolution. The full matrix types use an analog input of either a resistance or capacitance value. These values are then translated into a digital coordinate. The fixed matrix type are wide X/Y traces, whose intersecting point are quite large, typically one half inch square. The resolution is quite coarse and the number of touch targets is very low. The only benefit to fixed-matrix-touch switches is the low price of its controller. A low-cost keyboard decoder is all that is required rather than the more complicated and costly A/D converter based converter board. Resistive and capacitive technologies are offered in both matrix arrays while acoustical wave is offered only as full matrix. Infrared is listed as a full-matrix type but in reality is truly a high-resolution fix-matrix type of touch switch.

TOUCH-INPUT SYSTEMS

Considerations For Software

Pen-input systems need to recognize the limitations of handwriting recognition software. Needless to say handwriting capture is fail-proof. Handwriting is simply captured but not recognized by the computer. Handwriting recognition is another story. Today, handwriting recognition drivers are still prone to enough errors to greatly limit the operation of many applications. It is best to limit application software to predefined character target areas. In addition, the software should force the user to print in capital letters in these targets. This should greatly the efficiency and accuracy of the application software.

With touch applications, always remember, **keep it simple**!!! Displaying too many key switches or making the display too complicated can completely defeat the primary purpose of a touch screen. The primary function of touch switches is to eliminate and replace the keyboard. For this reason, it is advised that the touch switch replication of the keyboard should do more than match a keyboard key by key. That is to say, to simply display key caps that represent, for instance, an entire qwerty keyboard is far less functional than higher-level function switches. There are two compelling reasons for this. First, the a touch switch version of a keyboard, qwerty, 10 key or otherwise, is far less convenient to use than a keyboard. Considering the angle of the screen, the size and layout of the screen, and the lack of tackle feedback will greatly affect the user's ability to quickly and efficiently use the 'touch screen' keyboard. Most typists prefer a 10 to 13 degree angle of the keyboard to maintain a proper typing angle. In normal operation mode, it is rare to find a video display at this angle. Most full-size keyboards are 15 inches wide. Even keyboards in notebook computers are 11 inches wide. The most common widths of flat displays are less than 10 inches wide. This fact makes it nearly impossible to accurately reproduce a full size keyboard on a flat display. Lastly, and perhaps most important, typing on a flat screen offers the operator zero tactile feedback. Without feeling the switch action of the keys, typing is very difficult.

More important than the mere keyboard replacement, consider a higher role of the touch screen. With advanced computer power, coupled with the increased use of the computer by novice users, the visual aid of the video output computers now plays an active role in aiding the user. Touch screens facilitate the computer to 'ask' the user particular questions required for an operation. Rather than requiring the user to think about the operation and then laboriously typing in the answer character by character, the computer can now present specific questions in graphical form to the user who will merely 'touch' the answer. Once the user touches the correct button/ answer, the screen can instantly reconfigure itself with a new set of questions or steps in an operation. With the use of these high-level 'buttons,' the computer will guide the user through the entire operation. Human factor studies have found that operations increased 30% by using touch switches over the manual keystroke operations.

When laying out a screen for use with a touch screen keep in mind the following guidelines:

- Keep available key switches to a minimum. Reading and reacting to key switches goes down proportionally to the number on the screen. Too many forces the operator to read and then think about the choices. This is very time consuming.
- Keep the key switches large. Not only should there not be many but if they are too small or too close together there is a large possibility for error or operating delay. Human factor studies have determined that touch targets should be a minimum of 3/8 inch square and have a 1/8 inch gap between the switches. This 1/2 center key switch is the minimum. Again, they should be as large as possible.
- Use graphics to enhance the function of the switch. Make the switch appear to be 3-dimensional and reverse video or XOR the video when the switch is activated. Using audio feedback can further enhance this feature.

Finger-driven touch switches can, in limited use, be used to replicate and replace a mouse. The pen input type touch device, as mentioned, is best suited for this application. It can travel quickly, has the ability to respond with mouse 'clicks' and has the fine resolution necessary for mouse replacement. In general, finger-driven touch switches cannot adequately replace the mouse function. The touch resolution and the size of the finger does a poor job in this respect. Finger driven touch switches have mouse drivers developed for PC applications but is advised to consider them only in custom applications where the software understands that the 'mouse' is a human finger.

Considerations For Hardware

Choosing the best touch device for an application depends largely on the cost performance requirements. As with most electronic hardware, there is a variance between the different technologies and their features. Typically, low-cost touch technologies have limited performance or environmental characteristics, whereas the more expensive types have superior performance. The following is a listing of the various technologies, outlining their particular strengths and weaknesses.

Resistive

Resistive touch screens consist of two transparent layers: the bottom layer can be made of glass or rigid plastic, while the top layer is flexible Mylar. Each of the layers are separated by insulating spacers. The touch controller puts a voltage gradient across the conductive layers oriented in the X and Y directions. Pressure from a finger or stylus causes the outer layer to come in contact with the inner layer.

When contact is made, the conductive layers electrically short to each other and the resistance value is sent to the controller. The controller then puts the R values through an analog-to-digital converter where they result in a digital coordinate.

Features:

- Highest resolution – Resistive touch switches are capable of the highest resolution of any overlay touch technology. They are capable of reaching 4096 × 4096 touch points across the screen.
- Low cost – Resistive touch is the lowest cost touch technology. In the fixed matrix format, resistive touch including the decoder circuitry can cost as little as $50 or less for the system. A full matrix, analog resistive touch can cost less than $100 complete. The decoder circuitry to ‘read’ the analog values is neither complicated nor costly to develop.
- Adaptable for different sizes – A resistive touch switch can be made to accommodate various sizes for a reasonably low cost for the NRE. If initial quantities are sufficient, some manufacturers will waive the NRE charge completely. Resistive technology can be developed in different sizes with very short turn-around times.

Concerns:

- Calibration – The resistance value at a coordinate location can drift over time and temperature. This requires the screen to be calibrated at regular intervals to ensure the touch target on the display corresponds to the resistance values assigned to it.
- Delicate – The top resistive layer is Mylar. This layer can be scratched or torn if a sharp or metallic item is used for a touch stylus. It can also be burnished to a dull, hard-to-see-through surface with constant use.
- Heat can also damage the resistive touch switch. Touching the top layer when very warm, +40°C, can actually stretch the Mylar, which ruins the switch.
- Transparency – Resistive touch switches require a large amount of Indium Tin Oxide (ITO). This resistive layer can cut the transmissivity of the touch screen by up to 27%. This can greatly affect the viewability of the flat screens, especially with TSTN LCD and EL displays.

Infrared Red

Infrared switches use emitting and detecting LED arrays, in an X and Y arrangement over the face of the display. When touched, paired LED beams are broken on both axis. The broken beam coordinate is interrupted much as a simple keyboard. The LEDs are arranged on 1/4 inch physical centers, but with the aid of coordinate averaging, I.R. touch switches can interpret a virtual beam between two physical beams. This give I.R. switches an effective resolution of 1/8 inch centers.

Features:

- Simplicity – I.R. touch switches are very simple X/Y arrays. They can be decoded with a common keyboard decoder circuit.
- Solid state – I.R. switches use all solid state devices. There is no mechanical mechanism to wear out or break.
- Transparent – Since the switch mechanism is light, there is no overlay to block the light transmission of the flat panel. 100% of the light of the screen is transmitted, with no loss or distortion from the touch switch.
- Sealable – I.R. touch switches are completely enclosed in their bezel, easily allowing them to be sealed from the environment.

Concerns:

- Coarse resolution – I.R. switches can only be built on 1/4 inch centers. Even with software averaging, the closest resolution support by I.R switches is 1/8 inch centers. On standard 9.5 diagonal displays, this equates to 63 × 32 touch targets.
- Complex to build/develop – I.R. switches are printed circuit boards with the LED array of emitters and detectors. The layout and design of this board is reasonably complex and costly to develop. Since the LED array fits on the front of the display, the IR switch must be made for specific display models. It is common not to find IR switches in production for various displays.
- Parallax – Since the LED array sits over the face of the screen, the beam path can sit as much as 1/8 inch over the display face. This means that a user could touch or activate the switch without actually touching the screen.
- False triggers – Since it only requires breaking the light beam to activate the switch, anything in the path of the LEDs can trigger the device.

Capacitive

Capacitive overlay technology uses a touch sensor that is a glass overlay with a conductive coating bonded to its surface. A low current flows across the capacitive panel and establishes the frequencies of four oscillator circuits at the panel’s corners. When the screen is touched by a conductive stylus, the impedance alters the frequency of the four oscillators. The touch coordinate is calculated from the differential frequency change of the four oscillators. This, in turn, determines the X and Y coordinate of the touch activation.

Features:

- Durability – Capacitive touch switches are unaffected by dirt, water or grease.
- Fast response – It responds faster to the touch than resistive or acoustical wave technologies but cannot respond 'before' the touch like Infrared touch.
- Reliability – The user touches a sheet of glass with only a coating on it. There is no mechanical switch mechanism to wear out or fail.

Concerns:

- Non-capacitive touches – Capacitive touch switches uses the conductivity of the stylus (human finger, metal stylus, etc.). Non-conductive items cannot be used with conductive touch switches. This is especially important in medical applications when rubber gloves are used.
- Circuit Sensitivity – The touch switch can be affected by the emissions of the display. Additionally, electrically noisy circuits can also disrupt the operation of the switch.

Acoustical Wave

Acoustical wave touch sensors utilizes the ability of inaudible, high frequency acoustical waves, traveling over the surface of the sensor at very precise speeds in very straight lines. Acoustical signals generated by an X or Y transmitting transducer travels to a reflective array, then across the surface of the screen, to a second reflective array and finally, to a receiving transducer.

Features:

- Z Axis – Acoustical wave switches have the ability to measure the Z axis on the switch. The harder the user presses on the switch the dampening of the sound waves can produce a Z axis reading.
- Transmissivity – Acoustical wave switches are essentially clear glass offering very high transmissivity for an overlay type switch.

Concerns:

- Damage – The transducer of the switch sits either on the front or edge of the glass. It is exposed and very prone to damage.
- Contamination – Surface contamination, water or heavy grease, can absorb some of the acoustical frequency and register a touch.

Pen Input

Pen-based digitizer touch switches use an embedded sensor board under the flat display. The embedded sensor generally radiates electromagnetic energy. The pen stylus picks up this frequency and returns it to the touch controller. Some pen-based stylus' are directly wired into the system while others are cordless.

Features:

- Embedded sensor in display – Digitizers have the unique ability to be built into a display.
- Handwriting recognition – Because of the high speed/resolution of the sensor and the pen stylus, a digitizer pen-based touch can be used for handwriting recognition applications.

Concerns:

- Pen – All pen-based systems need the pen. The tethered based pens are inconvenient and awkward. Non-tethered pens are costly and easily misplaced.
- Display technology – Due to emissions, metallic frames and radiation from the display, not all display technologies are suitable for pen-based applications. Currently, TSTN LCD technology is the only display technology utilizing pen-based touch systems.

VENDORS

The following is a listing of some manufacturers of the touch switch technologies mentioned in this report. The list covers all of the technologies; it is not necessarily a complete list. Although every step was taken to make the list complete and comprehensive, it is impossible to in-cluded all manufacturers.

Resistive

Elographics
105 Randolph Road
Oak Ridge, TN 37830
(615) 482-4100

Touch Technology
5524 Bee Caves Road
Austin, TX 78746
(512) 328-9284

W. R. Brady
Thin Film Prod. Div.
8225 West Parkland Court
Milwaukee, WI 53223
(414) 355-8300

Transparent Devices
717 Lakefield Road
Bldg. D
Westlake Village, CA 91361
(805) 497-8500

Infrared

Carroll Touch
P.O. Box 1309
Round Rock, TX 78680
(512) 244-3500

Dale Electronics
1122 23rd Street
Columbus, NE 68601
(402) 563-6505

Capacitive

Microtouch
10 State Street
Woburn, MA 01801
(617) 935-0080

Touch Technology
5524 Bee Caves Road
Austin, TX 78746
(512) 328-9284

Acoustical Wave

Elographics
105 Randolph Road
Oak Ridge, TN 37830
(615) 482-4100

EXZEC
1840 Oak Ave.
Evanston, IL 60201
(708) 866-1869

Pen-Based Digitizers

Wacom
501 S.E. Columbia Shores Blvd.
Suite 300
Vancouver, WA 98661
(206) 750-8882

Kurta
3007 East Chambers
Phoenix, AZ 85040
(602) 276-5533

Scriptel
4145 Arlingate Plaza
Columbus, OH 43228
(614) 276-8402

Logitech
6505 Kaiser Drive
Fremont, CA 94555
(510) 795-8500

CalComp
2099 Gateway Place, Suite 550
San Jose, CA 95110
(408) 441-4126

NOTES

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