SEMINAR ON

TOUCH SCREEN TECHNOLOGY

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Abstract:
A touchscreen is a display that can detect the presence and location of a touch within the display area, generally refers to touch or contact to the display of the device by a finger or hand. Touchscreen is also an input device. The screens are sensitive to pressure; a user interacts with the computer by touching pictures or words on the screen. Touchscreens can also sense other passive objects, such as a stylus. The touchscreen has two main attributes. First, it enables one to interact with what is displayed directly on the screen, where it is displayed, rather than indirectly with a mouse or touchpad. Secondly, it lets one do so without requiring any intermediate device, again, such as a stylus that needs to be held in the hand. Such displays can be attached to computers or, as terminals, to networks. They also play a prominent role in the design of digital appliances such as the personal digital assistant (PDA), satellite navigation devices, mobile phones, and video games.

HISTORY
Touchscreens emerged from corporate research labs in the second half of the 1960s. One of the first places where they gained some visibility was in the terminal of a computer-assisted learning terminal that came out in 1972 as part of the PLATO project. They have subsequently become familiar in kiosk systems, such as in retail and tourist settings, on point of sales systems, on ATMs and on PDAs where a stylus is sometimes used to manipulate the GUI and to enter data. The popularity of smart phones, PDAs, portable game consoles and many types of information appliances is driving the demand for, and the acceptance of, touchscreens. The HP-150 from 1983 was probably the world’s earliest commercial touchscreen computer. It did not actually have a touchscreen in the strict sense, but a 9” Sony CRT surrounded by infrared transmitters and receivers which detect the position of any non-transparent object on the screen.

Until the early 1980s, most consumer touchscreens could only sense one point of contact at a time, and few had the capability to sense how hard one is touching. This is starting to change with the commercialisation of multi-touch technology.

Touchscreens are popular in heavy industry and in other situations, such as museum displays or room automation, where keyboard and mouse systems do not allow a satisfactory, intuitive, rapid, or accurate interaction by the user with the display’s content.
Historically, the touchscreen sensor and its accompanying controller-based firmware have been made available by a wide array of after-market system integrators and not by display, chip or motherboard manufacturers. With time, however, display manufacturers and chip manufacturers worldwide have acknowledged the trend toward acceptance of touchscreens as a highly desirable user interface component and have begun to integrate touchscreen functionality into the fundamental design of their products.

Technologies
There are a number of types of touchscreen technology available now

1. Resistive
A resistive touchscreen panel is composed of several layers, the most important of which are two thin, metallic, electrically conductive layers separated by a narrow gap. When an object, such as a finger, presses down on a point on the panel's outer surface the two metallic layers become connected at that point: the panel then behaves as a pair of voltage dividers with connected outputs. This causes a change in the electrical current which is registered as a touch event and sent to the controller for processing. In another way The resistive system consists of a normal glass panel that is covered with a conductive and a resistive metallic layer. These two layers are held apart by spacers, and a scratch-resistant layer is placed on top of the whole setup. An electrical current runs through the two layers while the monitor is operational. When a user touches the screen, the two layers make contact in that exact spot. The change in the electrical field is noted and the coordinates of the point of contact are calculated by the computer. Once the coordinates are known, a special driver translates the touch into something that the operating system can understand, much as a computer mouse driver translates a mouse's movements into a click or a drag.

2. Surface
Surface acoustic wave (SAW) sumit technology uses ultrasonic waves that pass over the touchscreen panel. When the panel is touched, a portion of the wave is absorbed. This change in the ultrasonic waves registers the position of the touch event and sends this information to the
controller for processing. Surface wave touch screen panels can be damaged by outside elements. Contaminants on the surface can also interfere with the functionality of the touchscreen, an acoustic wave system, two transducers (one receiving and one sending) are placed along the x and y axes of the monitor's glass plate. Also placed on the glass are reflectors -- they reflect an electrical signal sent from one transducer to the other. The receiving transducer is able to tell if the wave has been disturbed by a touch event at any instant, and can locate it accordingly. The wave setup has no metallic layers on the screen, allowing for 100-percent light throughput and perfect image clarity. This makes the surface acoustic wave system best for displaying detailed graphics (both other systems have significant degradation in clarity).

3. Capacitive

Capacitive touchscreen panel consists of an insulator such as glass, coated with a transparent conductor such as indium tin oxide (ITO). As the human body is also a conductor, touching the surface of the screen results in a distortion of the local electrostatic field, measurable as a change in capacitance. Different technologies may be used to determine the location of the touch. The location can be passed to a computer running a software application which will calculate how the user's touch relates to the computer software. And in capacitive system, a layer that stores electrical charge is placed on the glass panel of the monitor. When a user touches the monitor with his or her finger, some of the charge is transferred to the user, so the charge on the capacitive layer decreases. This decrease is measured in circuits located at each corner of the monitor. The computer calculates, from the relative differences in charge at each corner, exactly where the touch event took place and then relays that information to the touch-screen driver software. One advantage that the capacitive system has over the resistive system is that it transmits almost 90 percent of the light from the monitor, whereas the resistive system only transmits about 75 percent. This gives the capacitive system a much clearer picture than the resistive system.

4. Surface capacitance

In this basic technology, only one side of the insulator is coated with a conductive layer. A small voltage is applied to the layer, resulting in a uniform electrostatic field. When a conductor, such as a human finger, touches the uncoated surface, a capacitor is dynamically formed. The sensor's controller can determine the location of the touch indirectly from the change in the capacitance as
measured from the four corners of the panel. As it has no moving parts, it is moderately durable but has limited resolution, is prone to false signals from parasitic capacitive coupling, and needs calibration during manufacture. It is therefore most often used in simple applications such as industrial controls and kiosks.

5. Projected Capacitance

Projected Capacitive Touch (PCT) technology is a capacitive technology which permits more accurate and flexible operation, by etching the conductive layer. An XY array is formed either by etching a single layer to form a grid pattern of electrodes, or by etching two separate, perpendicular layers of conductive material with parallel lines or tracks to form the grid (comparable to the pixel grid found in many LCD displays). Applying voltage to the array creates a grid of capacitors. Bringing a finger or conductive stylus close to the surface of the sensor changes the local electrostatic field. The capacitance change at every individual point on the grid can be measured to accurately determine the touch location.[5] The use of a grid permits a higher resolution than resistive technology and also allows multi-touch operation. The greater resolution of PCT allows operation without direct contact, such that the conducting layers can be coated with further protective insulating layers, and operate even under screen protectors, or behind weather and vandal-proof glass. PCT is used in a wide range of applications including point of sale systems, smartphones, and public information kiosks. Visual Planet's ViP Interactive Foil is an example of a kiosk PCT product, where a gloved hand can register a touch on a sensor surface through a glass window.[6] Examples of consumer devices using projected capacitive touchscreens include Apple Inc.'s iPhone and iPod Touch, HTC's HD2, G1, and HTC Hero, Motorola's Droid, Palm Inc.'s Palm Pre and Palm Pixi and more recently the LG KM900 Arena, Microsoft's Zune HD, Sony Walkman X series, Sony Ericsson's Aino and now Vidalco's Edge, D1 and Jewel, and the Nokia X6 phone.

6. Infrared

Conventional optical-touch systems use an array of infrared (IR) light-emitting diodes (LEDs) on two adjacent bezel edges of a display, with photosensors placed on the two opposite bezel edges to analyze the system and determine a touch event. The LED and photosensor pairs create a grid of light beams across the display. An object (such as a finger or pen) that touches the screen
interrupts the light beams, causing a measured decrease in light at the corresponding photosensors. The measured photosensor outputs can be used to locate a touch-point coordinate. Widespread adoption of infrared touchscreens has been hampered by two factors: the relatively high cost of the technology compared to competing touch technologies and the issue of performance in bright ambient light. This latter problem is a result of background light increasing the noise floor at the optical sensor, sometimes to such a degree that the touchscreen’s LED light cannot be detected at all, causing a temporary failure of the touch screen. This is most pronounced in direct sunlight conditions where the sun has a very high energy distribution in the infrared region.

However, certain features of infrared touch remain desirable and represent attributes of the ideal touchscreen, including the option to eliminate the glass or plastic overlay that most other touch technologies require in front of the display. In many cases, this overlay is coated with an electrically conducting transparent material such as ITO, which reduces the optical quality of the display. This advantage of optical touchscreens is extremely important for many device and display vendors since devices are often sold on the perceived quality of the user display experience.

Another feature of infrared touch which has been long desired is the digital nature of the sensor output when compared to many other touch systems that rely on analog-signal processing to determine a touch position. These competing analog systems normally require continual recalibration, have complex signal-processing demands (which adds cost and power consumption), demonstrate reduced accuracy and precision compared to a digital system, and have longer-term system-failure modes due to the operating environment.

7. Strain gauge

In a strain gauge configuration, also called force panel technology, the screen is spring-mounted on the four corners and strain gauges are used to determine deflection when the screen is touched. This technology has been around since the 1960s but new advances by Vissumo and F-Origin have made the solution commercially viable. It can also measure the Z-axis and the force of a person’s touch. Such screens are typically used in exposed public systems such as ticket machines due to their resistance to vandalism.
8. Optical imaging

A relatively-modern development in touchscreen technology, two or more image sensors are placed around the edges (mostly the corners) of the screen. Infrared backlights are placed in the camera's field of view on the other sides of the screen. A touch shows up as a shadow and each pair of cameras can then be triangulated to locate the touch or even measure the size of the touching object (see visual hull). This technology is growing in popularity, due to its scalability, versatility, and affordability, especially for larger units.

Dispersive signal technology

Introduced in 2002 by 3M, this system uses sensors to detect the mechanical energy in the glass that occurs due to a touch. Complex algorithms then interpret this information and provide the actual location of the touch.[10] The technology claims to be unaffected by dust and other outside elements, including scratches. Since there is no need for additional elements on screen, it also claims to provide excellent optical clarity. Also, since mechanical vibrations are used to detect a touch event, any object can be used to generate these events, including fingers and stylus. A downside is that after the initial touch the system cannot detect a motionless finger.

Construction

There are several principal ways to build a touchscreen. The key goals are to recognize one or more fingers touching a display, to interpret the command that this represents, and to communicate the command to the appropriate application.

In the most popular techniques, the capacitive or resistive approach, there are typically four layers;

1. Top polyester layer coated with a transparent metallic conductive coating on the bottom
2. Adhesive spacer
3. Glass layer coated with a transparent metallic conductive coating on the top
4. Adhesive layer on the backside of the glass for mounting.

When a user touches the surface, the system records the change in the electrical current that flows through the display.

Dispersive-signal technology which 3M created in 2002, measures the piezoelectric effect — the voltage generated when mechanical force is applied to a material — that occurs chemically when a strengthened glass substrate is touched.
There are two infrared-based approaches. In one, an array of sensors detects a finger touching or almost touching the display, thereby interrupting light beams projected over the screen. In the other, bottom-mounted infrared cameras record screen touches. In each case, the system determines the intended command based on the controls showing on the screen at the time and the location of the touch.

**Development**

Virtually all of the significant touchscreen technology patents were filed during the 1970s and 1980s and have expired. Touchscreen component manufacturing and product design are no longer encumbered by royalties or legalities with regard to patents and the manufacturing of touchscreen-enabled displays on all kinds of devices is widespread.

The development of multipoint touchscreens facilitated the tracking of more than one finger on the screen, thus operations that require more than one finger are possible. These devices also allow multiple users to interact with the touchscreen simultaneously.

With the growing acceptance of many kinds of products with an integral touchscreen interface the marginal cost of touchscreen technology is routinely absorbed into the products that incorporate it and is effectively eliminated. As typically occurs with any technology, touchscreen hardware and software has sufficiently matured and been perfected over more than three decades to the point where its reliability is unassailable. As such, touchscreen displays are found today in airplanes, automobiles, gaming consoles, machine control systems, appliances and handheld display devices of every kind. With the influence of the multi-touch-enabled iPhone, the touchscreen market for mobile devices is projected to produce US$5 billion in 2009.

The ability to accurately point on the screen itself is taking yet another step with the emerging graphics tablet/screen hybrids.

**Ergonomics and usage**

**Finger stress**

An ergonomic problem of touchscreens is their stress on human fingers when used for more than a few minutes at a time, since significant pressure can be required for certain types of touchscreen. This can be alleviated for some users with the use of a pen or other device to add leverage and more accurate pointing. However, the introduction of such items can sometimes be problematic
depending on the desired use case (for example, public kiosks such as ATMs). Also, fine motor control is better achieved with a stylus, because a finger is a rather broad and ambiguous point of contact with the screen itself.

**Fingernail as stylus**

These ergonomic issues of direct touch can be bypassed by using a different technique, provided that the user's fingernails are either short or sufficiently long. Rather than pressing with the soft skin of an outstretched fingertip, the finger is curled over, so that the top of the forward edge of a fingernail can be used instead. The thumb is optionally used to provide support for the finger or for a long fingernail, from underneath. This method does not work on capacitive touch screens, as fingernails lack the electrical properties required to be sensible by capacitive sensing. The fingernail's hard, curved surface contacts the touchscreen at a single very small point. Therefore, much less finger pressure is needed, much greater precision is possible (approaching that of a stylus, with a little experience), much less skin oil is smeared onto the screen, and the fingernail can be silently moved across the screen with very little resistance allowing for selecting text, moving windows, or drawing lines.

The human fingernail consists of keratin which has a hardness and smoothness similar to the tip of a stylus (and so will not typically scratch a touchscreen). Alternately, very short stylus tips are available, which slip right onto the end of a finger; this increases visibility of the contact point with the screen.

**Fingerprints**

Touchscreens can suffer from the problem of fingerprints on the display. This can be mitigated by the use of materials with optical coatings designed to reduce the visible effects of fingerprint oils, such as the oleophobic coating used in the iPhone 3G S, or by reducing skin contact by using a fingernail or stylus.
Combined with haptics
The user experience with touchscreens without tactile feedback or haptics can be difficult due to latency or other factors. Research from the University of Glasgow Scotland [Brewster, Chohan, and Brown 2007] demonstrates that sample users reduce input errors (20%), increase input speed (20%), and lower their cognitive load (40%) when touchscreens are combined with haptics or tactile feedback, [vs. non-haptic touchscreens].

"Gorilla Arm"
The Jargon File dictionary of hacker slang defined Gorilla Arm as the failure to understand the ergonomics of vertically mounted touch screens for prolonged use. The proposition is that human arm held in an unsupported horizontal position rapidly becomes fatigued and painful, the so-called "gorilla arm". It is often cited as a prima facie example of what not to do in ergonomics, despite contrary evidence. Vertical touchscreens still dominate in applications such as ATMs and data kiosks in which the usage is too brief to be an ergonomic problem. Discomfort might be caused by previous poor posture and atrophied muscular systems caused by limited physical exercise. Fine art painters and draughtsmen have worked in similar postures with vertically mounted surfaces to draw on for millennia.