

Apple, microsoft, ibm and others: the touchscreen comes of age



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A touchscreen is an electronic visual display that the user can control through simple or multi-touch gestures by touching the screen with one or more fingers. Some touchscreens can also detect objects such as a stylus or ordinary or specially coated gloves. The user can use the touchscreen to react to what is displayed and to control how it is displayed (for example by zooming the text size).

The touchscreen enables the user to interact directly with what is displayed, rather than using a mouse, touchpad, or any other intermediate device (other than a stylus, which is optional for most modern touchscreens).

Touchscreens are common in devices such as game consoles, all-in-one computers, tablet computers, and smartphones. They can also be attached to computers or, as terminals, to networks. They also play a prominent role in the design of digital appliances such as personal digital assistants (PDAs), satellite navigation devices, mobile phones, and video games and some books.

The popularity of smartphones, tablets, and many types of information appliances is driving the demand and acceptance of common touchscreens for portable and functional electronics. Touchscreens are found in the medical field and in heavy industry, as well as for automated teller machines (ATMs), and kiosks such as museum displays or room automation, where keyboard and mouse systems do not allow a suitably 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

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integrators, and not by display, chip, or motherboard manufacturers. 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 touchscreens into the fundamental design of their products.

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History The prototype^[1] x-y mutual capacitance touchscreen (left) developed at CERN^{[2][3]} in 1977 by Bent Stumpe, a Danish electronics engineer, for the control room of CERN's accelerator SPS (Super Proton Synchrotron). This was a further development of the self-capacitance screen (right), also developed by Stumpe at CERN^[4] in 1972.

E. A. Johnson described his work on capacitive touch screens in a short article which is published in 1965^[5] and then more fully—along with photographs and diagrams—in an article published in 1967.^[6] A description of the applicability of the touch technology for air traffic control was described in an article published in 1968.^[7] Frank Beck and Bent Stumpe, engineers from CERN, developed a transparent touch screen in the early 1970s and it was manufactured by CERN and put to use in 1973.^[8] This touchscreen was based on Bent Stumpe's work at a television factory in the early 1960s. A resistive touch screen was developed by American inventor G. Samuel Hurst who received US patent #3, 911, 215 on Oct. 7, 1975.^[9] The first version was produced in 1982.

From 1979 to 1985, the Fairlight CMI (and Fairlight CMI IIx) was a high-end musical sampling and re-synthesis workstation that utilized light pen technology, with which the user could allocate and manipulate sample and synthesis data, as well as access different menus within its OS by touching the screen with the light pen. The later Fairlight series IIT models used a graphics tablet in place of the light pen. The HP-150 from 1983 was one of the world's earliest commercial touchscreen computers.^[11] Similar to the PLATO IV system (1972), the touch technology used employed infrared transmitters and receivers mounted around the bezel of its 9" Sony Cathode <https://assignbuster.com/apple-microsoft-ibm-and-others-the-touchscreen-comes-of-age/>

Ray Tube (CRT), which detected the position of any non-transparent object on the screen.

In the early 1980s General Motors tasked its Delco Electronics division with a project aimed at replacing an automobile's non essential functions (i. e. other than throttle, transmission, braking and steering) from mechanical or electro-mechanical systems with solid state alternatives wherever possible. The finished device was dubbed the ECC for " Electronic Control Center", a digital computer and software control system hardwired to various peripheral sensors, servos, solenoids, antenna and a monochrome CRT touchscreen that functioned both as display and sole method of input.

The ECC replaced the traditional mechanical stereo, fan, heater and air conditioner controls and displays, and was capable of providing very detailed and specific information about the vehicles cumulative and current operating status in real time. The ECC was standard equipment on the 1985-1989 Buick Riviera and later the 1988-89 Buick Reatta, but was unpopular with consumers partly due to technophobia on behalf of some traditional Buick customers, but mostly because of costly to repair technical problems suffered by the ECC's touchscreen which being the sole access method, would render climate control or stereo operation impossible.

Multi-touch technology began in 1982, when the University of Toronto's Input Research Group developed the first human-input multi-touch system, using a frosted-glass panel with a camera placed behind the glass. In 1985, the University of Toronto group including Bill Buxton developed a multi-touch

tablet that used capacitance rather than bulky camera-based optical sensing systems (see History of multi-touch).

In 1986 the first graphical point of sale software was demonstrated on the 16-bit Atari 520ST color computer. It featured a color touchscreen widget-driven interface.[14] The ViewTouch[15] point of sale software was first shown by its developer, Gene Mosher, at Fall Comdex, 1986, in Las Vegas, Nevada to visitors at the Atari Computer demonstration area and was the first commercially available POS system with a widget-driven color graphic touch screen interface.

Sears et al. (1990)[17] gave a review of academic research on single and multi-touch human-computer interaction of the time, describing gestures such as rotating knobs, swiping the screen to activate a switch (or a U-shaped gesture for a toggle switch), and touchscreen keyboards (including a study that showed that users could type at 25 wpm for a touchscreen keyboard compared with 58 wpm for a standard keyboard); multitouch gestures such as selecting a range of a line, connecting objects, and a “ tap-click” gesture to select while maintaining location with another finger are also described.

In ca. 1991-1992, the Sun Star7 prototype PDA implemented a touchscreen with inertial scrolling.[18] In 1993, the IBM Simon - the first touchscreen phone - was released.

An early attempt at a handheld game console with touchscreen controls was Sega's intended successor to the Game Gear, though the device was ultimately shelved and never released due to the expensive cost of <https://assignbuster.com/apple-microsoft-ibm-and-others-the-touchscreen-comes-of-age/>

touchscreen technology in the early 1990s. Touchscreens would not be popularly used for video games until the release of the Nintendo DS in 2004. [19] Until recently, most consumer touchscreens could only sense one point of contact at a time, and few have had the capability to sense how hard one is touching. This has changed with the commercialization of multi-touch technology.

Technologies

There are a variety of touchscreen technologies that have different methods of sensing touch.

Resistive Main article: Resistive touchscreen

A resistive touchscreen panel comprises several layers, the most important of which are two thin, transparent electrically-resistive layers separated by a thin space. These layers face each other with a thin gap between. The top screen (the screen that is touched) has a coating on the underside surface of the screen. Just beneath it is a similar resistive layer on top of its substrate. One layer has conductive connections along its sides, the other along top and bottom. A voltage is applied to one layer, and sensed by the other. When an object, such as a fingertip or stylus tip, presses down onto the outer surface, the two layers touch to become connected at that point: The panel then behaves as a pair of voltage dividers, one axis at a time. By rapidly switching between each layer, the position of a pressure on the screen can be read.

Resistive touch is used in restaurants, factories and hospitals due to its high resistance to liquids and contaminants. A major benefit of resistive touch technology is its low cost. Additionally, as only sufficient pressure is necessary for the touch to be sensed, they may be used with gloves on, or by using anything rigid as a finger/stylus substitute. Disadvantages include the need to press down, and a risk of damage by sharp objects. Resistive touchscreens also suffer from poorer contrast, due to having additional reflections from the extra layer of material placed over the screen.

Main article: Surface acoustic wave

Surface acoustic wave (SAW) 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 touchscreen panels can be damaged by outside elements. Contaminants on the surface can also interfere with the functionality of the touchscreen.

Capacitive touchscreen of a mobile phone Main article: Capacitive sensing

A 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 an electrical conductor, touching the surface of the screen results in a distortion of the screen's electrostatic field, measurable as a change in capacitance. Different technologies may be used to determine the location of the touch. The location is then sent to the controller for processing.

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Unlike a resistive touchscreen, one cannot use a capacitive touchscreen through most types of electrically insulating material, such as gloves. This disadvantage especially affects usability in consumer electronics, such as touch tablet PCs and capacitive smartphones in cold weather. It can be overcome with a special capacitive stylus, or a special-application glove with an embroidered patch of conductive thread passing through it and contacting the user's fingertip.

The largest capacitive display manufacturers continue to develop thinner and more accurate touchscreens, with touchscreens for mobile devices now being produced with 'in-cell' technology that eliminates a layer, such as Samsung's Super AMOLED screens, by building the capacitors inside the display itself. This type of touchscreen reduces the visible distance (within millimetres) between the user's finger and what the user is touching on the screen, creating a more direct contact with the content displayed and enabling taps and gestures to be even more responsive.

A simple parallel plate capacitor has two conductors separated by a dielectric layer. Most of the energy in this system is concentrated directly between the plates. Some of the energy spills over into the area outside the plates, and the electric field lines associated with this effect are called fringing fields. Part of the challenge of making a practical capacitive sensor is to design a set of printed circuit traces which direct fringing fields into an active sensing area accessible to a user. A parallel plate capacitor is not a good choice for such a sensor pattern. Placing a finger near fringing electric fields adds conductive surface area to the capacitive system. The additional charge storage capacity added by the finger is known as finger capacitance, <https://assignbuster.com/apple-microsoft-ibm-and-others-the-touchscreen-comes-of-age/>

CF. The capacitance of the sensor without a finger present is denoted as C_P in this article, which stands for parasitic capacitance.

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.

Projected capacitance

Back side of a Multitouch Globe, based on Projected Capacitive Touch (PCT) technology.

Projected Capacitive Touch (PCT; also PCAP) technology is a variant of capacitive touch technology. All PCT touch screens are made up of a matrix of rows and columns of conductive material, layered on sheets of glass. This can be done either by etching a single conductive 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 a grid. Voltage applied to this grid creates a uniform electrostatic field, which can be

measured. When a conductive object, such as a finger, comes into contact with a PCT panel, it distorts the local electrostatic field at that point. This is measurable as a change in capacitance. If a finger bridges the gap between two of the “ tracks,” the charge field is further interrupted and detected by the controller.

The capacitance can be changed and measured at every individual point on the grid (intersection). Therefore, this system is able to accurately track touches. Due to the top layer of a PCT being glass, it is a more robust solution than less costly resistive touch technology. Additionally, unlike traditional capacitive touch technology, it is possible for a PCT system to sense a passive stylus or gloved fingers. However, moisture on the surface of the panel, high humidity, or collected dust can interfere with the performance of a PCT system. There are two types of PCT: mutual capacitance and self-capacitance.

Mutual capacitance

This is common PCT approach, which makes use of the fact that most conductive objects are able to hold a charge if they are very close together. In mutual capacitive sensors, there is a capacitor at every intersection of each row and each column. A 16-by-14 array, for example, would have 224 independent capacitors. A voltage is applied to the rows or columns. Bringing a finger or conductive stylus close to the surface of the sensor changes the local electrostatic field which reduces the mutual capacitance. The capacitance change at every individual point on the grid can be measured to accurately determine the touch location by measuring the voltage in the

other axis. Mutual capacitance allows multi-touch operation where multiple fingers, palms or styli can be accurately tracked at the same time.

Self-capacitance

Self-capacitance sensors can have the same X-Y grid as mutual capacitance sensors, but the columns and rows operate independently. With self-capacitance, the capacitive load of a finger is measured on each column or row electrode by a current meter. This method produces a stronger signal than mutual capacitance, but it is unable to resolve accurately more than one finger, which results in “ghosting”, or misplaced location sensing.

Infrared grid

Infrared sensors mounted around the display watch for a user's touchscreen input on this PLATO V terminal in 1981. The monochromatic plasma display's characteristic orange glow is illustrated.

An infrared touchscreen uses an array of X-Y infrared LED and photodetector pairs around the edges of the screen to detect a disruption in the pattern of LED beams. These LED beams cross each other in vertical and horizontal patterns. This helps the sensors pick up the exact location of the touch. A major benefit of such a system is that it can detect essentially any input including a finger, gloved finger, stylus or pen. It is generally used in outdoor applications and point of sale systems which can not rely on a conductor (such as a bare finger) to activate the touchscreen. Unlike capacitive touchscreens, infrared touchscreens do not require any patterning on the glass which increases durability and optical clarity of the overall system.

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Infrared touchscreens are sensitive to dirt/dust that can interfere with the IR beams, and suffer from parallax in curved surfaces and accidental press when the user hovers his/her finger over the screen while searching for the item to be selected.

Infrared acrylic projection

A translucent acrylic sheet is used as a rear projection screen to display information. The edges of the acrylic sheet are illuminated by infrared LEDs, and infrared cameras are focused on the back of the sheet. Objects placed on the sheet are detectable by the cameras. When the sheet is touched by the user the deformation results in leakage of infrared light, which peaks at the points of maximum pressure indicating the user's touch location.

Microsoft's PixelSense tables use this technology. Optical imaging

Optical touchscreens are a relatively modern development in touchscreen technology, in which two or more image sensors are placed around the edges (mostly the corners) of the screen. Infrared back lights are placed in the camera's field of view on the other side of the screen. A touch shows up as a shadow and each pair of cameras can then be pinpointed 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 piezoelectricity in the glass that occurs due to a touch. Complex algorithms

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then interpret this information and provide the actual location of the touch.

[23] 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.

Acoustic pulse recognition

The key to this technology is that a touch at any one position on the surface generates a sound wave in the substrate which then produces a unique combined sound after being picked up by three or more tiny transducers attached to the edges of the touchscreen. The sound is then digitized by the controller and compared to a list of pre-recorded sounds for every position on the surface. The cursor position is instantly updated to the touch location. A moving touch is tracked by rapid repetition of this process. Extraneous and ambient sounds are ignored since they do not match any stored sound profile.

The technology differs from other attempts to recognize the position of touch with transducers or microphones in using a simple table look-up method, rather than requiring powerful and expensive signal processing hardware to attempt to calculate the touch location without any references. As with the dispersive signal technology system, a motionless finger cannot be detected after the initial touch. However, for the same reason, the touch recognition is not disrupted by any resting objects. The technology was created by

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SoundTouch Ltd in the early 2000s, as described by the patent family EP1852772, and introduced to the market by Tyco International's Elo division in 2006 as Acoustic Pulse Recognition. The touchscreen used by Elo is made of ordinary glass, giving good durability and optical clarity. APR is usually able to function with scratches and dust on the screen with good accuracy. The technology is also well suited to displays that are physically larger.

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:

Top polyester coated with a transparent metallic conductive coating on the bottom
Adhesive spacer
Glass layer coated with a transparent metallic conductive coating on the top
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

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 use of touchscreens, the marginal cost of touchscreen technology is routinely absorbed into the products that incorporate it and is nearly eliminated. Touchscreens now have proven reliability. Thus, touchscreen displays are found today in airplanes, automobiles, gaming consoles, machine control systems, appliances, and handheld display devices including the Nintendo DS and multi-touch enabled cellphones; 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 also advancing with the emerging graphics tablet/screen hybrids.

TapSense, announced in October 2011, allows touchscreens to distinguish what part of the hand was used for input, such as the fingertip, knuckle and

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finger nail. This could be used in a variety of ways, for example, to copy and paste, to capitalize letters, to activate different drawing modes, and similar.

Ergonomics and usage

Fingernail as stylus Pointed nail for easier typing. This concept—using a pointed fingernail to specifically use as a stylus for writing-tablet communication—appeared in the 1950 science fiction short story “ Scanners Live in Vain”.

The 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 tip of a fingernail can be used instead. This method does not work on capacitive touchscreens.

The fingernail’s hard, curved surface contacts the touchscreen at one 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,[citation needed] 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). Alternatively, 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, or oleophobic coatings as used in the iPhone 3GS, which lessen the actual amount of oil residue, or by installing a matte-finish anti-glare screen protector, which creates a slightly roughened surface that does not easily retain smudges, or by reducing skin contact by using a fingernail or stylus.

Combined with haptics

Touchscreens are often used with haptic response systems. An example of this technology would be a system that caused the device to vibrate when a button on the touchscreen was tapped. The user experience with touchscreens lacking 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 and more recently Hogan] 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 touchscreens for prolonged use. By this proposition the human arm held in an unsupported horizontal position rapidly becomes fatigued and painful, the so-called “ gorilla arm”.[29] It is often cited as a prima facie example of what not to do in ergonomics. Vertical touchscreens still dominate in applications such as <https://assignbuster.com/apple-microsoft-ibm-and-others-the-touchscreen-comes-of-age/>

ATMs and data kiosks in which the usage is too brief to be an ergonomic problem.