The History and Future of

TOUCHSCREENS

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Touchscreens

Introduction

A touchscreen is a electronic visual display that enables a user to interact directly with information by touching areas on the display. The touching can occur with a finger/hand or objects such as stylus pens. Many of the first touchscreens required a more active object such as a light pen to work properly, however contemporary ones are designed with only the need for touch from a finger. Although touchscreens have been around for almost 40 years, the recent explosion in popularity and development is often attributed to the 2007 launch of Apple's iPhone. The success of the iPhone proved that touchscreens could be developed elegantly, affordably, and be received with massive public excitement. This success was a catalyst for growth and investment in the application and deployment of touchscreen technologies. Global shipments of touchscreen display modules are expected to more than double from 2008 to 2012, and investments in the development of new touchscreen technologies are also expected to increase significantly (Colegrove, 2008).

The touchscreen has evolved in reaction to computing applications that require this medium to be present. The form factor of digital devices have drastically changed in the last few years. We now carry with us multi-tasking microcomputers that have evolved from cell phones. The new use protocols that have turned phones into mobile computers, rather than just voice communication tools, presented a need to evolve the hardware. Spacial issues, that are caused by the shrinking size of these devices, have forced the device applications to become context aware. It simply

isn't efficient or sustainable to have full sized keyboards or other intermediary devices as the primary input for these microcomputers. Touchscreens solve this problem by allowing the display to act as the primary method of inputs, and thus overcomes the limitations of input flow though digitally creating context based interfaces.

The most important aspect of touchscreens is in its contributions to the evolution of the user interface. In an age dominated by information, improved methods of interacting with information are both coveted and necessary. One of the greatest advancements in improved information interaction in the digital age was the advent of hypertext. Hypertext allows for the ability to cut through linear connection, which allows the reader to participate more actively with information and connect with it in more meaningful ways. It demands an active reader by blurring the distinction between author and reader.(Landow, p.178-79) We now expect the same non-linear approach of hypertext to be available in any devices that we use to interact with information. The touchscreen adds this non-linear navigation to the user interface, through a physical method of direct control of the user interface.

History and Cultural Impacts

From a usability standpoint, touchscreens extend Harold Innis' concept of "time bias of communications", as discussed in his book *The Bias of Communication*. Technology can often have a barrier of entry due to the complexity of use. Simplifying the method of information consumption breaks down the monopoly of knowledge held by the technology savvy, because it increases accessibility for a greater population.

The imbalance of knowledge control has been ongoing in computing since its invention. It wasn't until the late 1970's that anyone other than IT Professionals and hobbyists used computers (Allen, p.14-15). This is because access was limited and computing complexities created a barrier to entry. When the personal computer (PC) boom of arrived in 1980s, thanks in part to the development of the desktop graphical user interface (GUI), a wider mass of people could comprehend computing and thus have access to a new wealth of information. As Harold Innis states, "Enormous improvements in communication have made understanding more difficult" (Innis). Bridging information through simplified interface design makes understanding easier, and thus broadens the availability of information to greater masses.

"There would be no transformation of the great society into the great community by way of disinterested technology but only in terms of the ways in which knowledge and culture were monopolized by particular groups" (Innis, p.152)

Improved ability of technology usage throughout the masses, by way of accessible access and improved interfaces, results in an increase in knowledge transfer (brought about by increased access to information). What should not be dismissed, however, is the important aspect that knowledge and culture are still being monopolized by other groups. These groups include those designing the interfaces, developing the hardware, and managing the information networks. These groups are the filters which control the flow of information. Innis discussed how cuneiform script, one of the first complex writing systems, resulted in the formation of an exclusive group of scribes. This group of scribes had a a monopoly on the knowledge on the written word. Today we have a new groups of scribes in the form of business groups. We are dependent on these "new

scribes" to provide us methods to consume information, and we empower them with an unquantified amount of trust that the information isn't being manipulated (in form or content).

The Emergence of Touchscreens

Touchscreen displays are now showing up in a plethora of computing environments, including ATMs, kiosks, and a variety of mobile devices. The surge of new touch-enabled devices is being fueled by a large growth consumer demand. While there are concerns from consumers over the durability and precision of touchscreens, the vast majority of people find this technology as a simple and intuitive way to engage with technology.(Gownder, 2009) This interest is especially high, and most likely to see the most initial grow, in the PC and Mobile market. There are a variety of reasons that explain the immediate excitement and embrace of touchscreen technologies. One small aspect can be attributed to the futuristic appeal. As Steven Johnson describes in Interface Culture, "For centuries, Western culture had fantasized about its technology in prosthetic terms, as a supplement to the body, like a wooden leg or telescope. The great industrials rhapsodized about the gotten gin as a miraculous extension of the hand-weaver's finger…This tradition continued well into the twentieth century" (Johnson, p.23). Technology has advanced our outlook of this concept, and evolved the ideal state from "machine-as-prosthesis" to one of "augmentation" (Johnson, p.24). Machines can be presented as a space or environment rather than a physical extension of ourselves. This allows society to virtually broaden space, which gives us a greater sense of control over technology through an individual's illusionary state of information control.

Another major appeal of touchscreens is in the enhanced user interface – especially in regards to improvements the new interfaces bring to information interaction. Touchscreens bring the user one step closer to information through Direct Manipulation, defined as "human-computer interaction style which involves continuous representation of objects of interest, and rapid, reversible, incremental actions and feedback".(Shneiderman,1983) This sort of interaction allows for a more experiential interaction with information, rather than just passive consumption.

The goal of Direct Manipulation is to allow a user to manipulate digital objects, using processes similar to real-world action. The first demonstration of a direct manipulation interface, where a pointing device was utilized, was in 1963 by Ivan Sutherland in his Sketchpad application. The software allowed the manipulation of objects using a light pen, where objects could be grabbed, moved, and scaled in size. The lightpen had been used since 1954, but this was the first development where it interacted in conjunction with a touch based software applications. These basic interactions were extended with the creation of AMBIT/G, which was developed at the Massachusetts Institute of Technology's Lincoln Labs in 1968. This system first introduced icon representations, dynamic menus with item selection, and gesture recognition. In 1975 David Canfield Smith coined the term "icons" (in a doctoral thesis on Pygmalion), and later popularize the concept of icons when he became a chief designer at Xerox Star. Xerox would later become a prime researcher and developer in the field of direct manipulation techniques such as object and text manipulation.

Douglas Engelbart involved the principal of Direct Manipulation when he invented the mouse in 1965 at Stanford Research Laboratory. The device was made famous as a practical input device by Xerox PARC in the 1970's, and became available commercially by Xerox Star (1981), the Three Rivers Computer Company's PERQ (1981), the Apple Lisa (1982), and the Apple Macintosh (1984). As Steven Johnson describes in his book "Interface Culture", the mouse interaction with the interface creates a "tactile immediacy that seems to make information closer at hand (even though in reality the graphic interface has added another layer separating the user from his information). You feel as though you are doing something with the data, rather than telling the computer to do it for you."(Johnson, p21) Touchscreens remove the button from the equation of information retrieval. They enhance tactile immediacy by eliminating the mouse-click step, which brings the user one step closer to the information.

Engelbart's mouse wasn't his only contribution to Human Computer Interactions, as he also was the first to introduce hyperlinks, live text editing, interactive computing, and Network Improvement Communities. An overlaying theme in all Engelbart's inventions was his non-linear approach to how we navigate and explore information. Engelbart once said that "content represents concepts, but there is also a relation between the content of concepts, their structure, and the structure of other domains of human thought that is too complex to investigate in linear text. The computer is a tool for navigating through those structures and examining them in ways that would be too complex otherwise." (Kirsch, 1995) This non-linear approach to accessing infor-

mation was the basis of Hypertext, which is defined as electronic information as nodes and link networks forming non-linear paths. Hypertext has created a method for users to get instant access to information. The more direct the path to the information, the more efficient and gratifying. This method of engaging is a freeing experience for the user. As George Landow remarks in his book "Hypertext and De-Centering", "All hypertext systems permit the individual reader to choose his or her own center of investigation and experience. What this principle means in practice is that the reader is not locked into any kind of particular organization or hierarchy." (Landow, p13)

The most prevalent metaphor in computing, since the advent of the Graphical User Interface (GUI), has been the use of the desktop model. This metaphor was an understandable choice, considering how most concepts in computing were quite foreign to consumers during the introduction of personal computers. Understanding action triggering, file / memory management, and data storage, without metaphors would have been be quite a daunting task. However, the use of iconic representations of folders, files, and applications as representational "desktop" tools, brings a sense of familiarity. Familiarity brings about natural intuitiveness, which is a method of judging the quality of an interface. And the more natural we can interact with digital objects, the more intuitive the experience becomes.

Time and technology are making the desktop paradigm obsolete. Most computing performed in today's applications display metaphors first presented in the desktop model. We are presented with a metaphor of the metaphor of the desktop, so to speak, where iconic representations and actions attempt to resurrect familiarities of the desktop GUI. The introduction of the touchscreen interface has brought about a way to break away from what has become a forced metaphor, and move into new grounds of organic interaction with digital objects. The advent of the desktop model was necessary for presenting new concepts to a market. It was a method of minimizing fear and confusion, by presenting the familiar. However, as technology has become interwoven into the daily practices of our society, computing has become ubiquitous. Data is becoming increasingly more managed by outside parties (in the "Cloud"), and most digital objects are becoming more application centric. This ubiquity has made actions of computing invisible, which in turn, has furthered intuitiveness. The touchscreen furthers the natural interaction by applying physical familiarity, to an otherwise static experience. No longer is just representational imagery available to simulate a natural experience, but representational movements are also reproduced.

Predicting the Future

2 Years in the Future

The next two years will bring with it the emergence of many new tablet-type devices. These computing hybrids (that blend aspects of both mobile and personal computers) will be integrating the same touchscreen technologies that have persevered in the smartphone industry over the last three years. The intended use protocol of these tablet devices is for the purpose of media consumption. They will be marketed specifically for the use of textual reading (books,magazines,etc.) and multimedia use (music, video), however, convergence is leading them to function for multi-purpose computing (i.e.,internet and applications use) as well. The first of these multi-purpose devices is the Apple's iPad. This full color, multi-touch, tablet computer, was introduced as a competitor to the Amazon Kindle. The Kindle's initial functionality was as an e-Reader. However, with Amazon's recent purchase of touch-screen technology company Touchco, all signs point to this device eventually integrating touchscreen capabilities.(Bilton, 2010) The Touchco touchscreen technology is different than Apple's capacitive touchscreens, in that it involves interpolating force-sensitive resistance, which allows different touch sensitivities. This allows for the use of non-skin based touching, opening up the ability for use with gloved hands and even stylus devices.

As companies begin to differentiate their products based on touchscreen capabilities, it will advance the evolution of touch technologies. New peripherals will be introduced to leverage the enhanced touch features, which will change the use protocols for these devices. Components such as stylus' will allow for a more organic process of inputing data. Products such as Micro-

soft's “Courier”(Patel, 2010) are already showing signs of this sort of integration. It allows for greater control in areas such as note taking and illustration, but also opens the door for a resurgence in handwriting recognition software (the re-introduction of Graffiti).

As analog media, such as books, try to find a place in a digital world, these new devices are attempting to recreate the experience previously provided by these mediums, through the practice of simulation. This is having a large impact on the evolution of user interfaces. For books, digital interfaces are incorporating multi-gester (multi-touch) interaction, which allow for a physical mode similar to that of the offline book experience. This basis for this technique follows the same tactic used by the desktop metaphor in its utilization of “memory palaces”. This idea was originated by the ancient Greeks, where by a spatial place is associated with concepts or memories in order to facilitate understanding and memorization. (Heden, p.457-464) The interface metaphor is evolving though, going beyond the broad and outdated spacial settings, such as that of a desktop (or office environment), and turning into an application centric metaphor that recreate the familiar physical interactions experienced with non-digital media.

Prototypes are already in the works for the development of digital magazines, which will be used on touch-based tablets(example 1 / example 2). While the interaction retains the non-linear mode of hypertext, there is also an attempt to create an intuitive experience by way of layout design, and physical motions. This same sort of techniques will available modes of information production, where digital pen peripherals will take the process of writing to the digital area. Much like the metaphor of the desktop GUI was necessary for the introduction of the personal computer,

these new media specific simulations will aid in a transition from analog input and consumption into a digital experience.

5 Years in the Future

Advancements in haptic technologies, a field dedicated to providing tactile sensation, will provide physical sensations such as vibrations which will further the simulation experience. This sort of capability is already seen in modern gaming experiences, where vibration response is coordinated between the controller and game context. (Wilson, 2008) For example, shooting a gun in a video game will re-create the pulsating sensation held by the users controller. There are limitations to the control of haptic feedback that can be made on the flat surface of a touchscreen. However, combining haptics with external peripherals that interact with the screen will allow for greater feedback capabilities, and further extend the simulated experience analog motions into the digital realm.

An unexplored area in touchscreens is the role it can play in the future of marketing and commerce. A frequent complaint of consumers in regards to modern touchscreens is with the unpleasant effect that fingerprints can have on the aesthetics of a touchscreen device. The ability to easily capture such vital identification (the finger print), in a natural process of interacting with these interfaces, could be of massive assistance to marketers. By leveraging current fingerprint recognition technologies with the touchscreen interface, and further integrating touchscreen devices into to commercial spaces, would allow for a plethora of improved marketing opportunities. Applications such as "interactive sign-ins" (evolution of the "information kiosk") in retail

storefronts, could allow consumers to check-in through simple swipes of the finger. This would have a huge impact on data mining (“the application of database technology and techniques-such as statistical analysis and modeling-to uncover hidden patterns and subtle relationships in data and to infer rules that allow for the prediction of future results.”) (, 2004). Data mining operations would have access to meta-data that would include location, time, and even spending behavior -- combined with individual statistics that contained personal information. This would bring about a massive amount of privacy issues, however, the success of modern applications that perform these tasks on a smaller level (see: 4Square, Facebook) tell a story that citizens are willing to compromise privacy in exchange for improvements in social and personal experiences.

15 Years in the Future

In his book "New Philosophy for New Media", Mark Hanson discusses a separation between image and "digital image", stating that it "demarcates the very process through which the body, in conjunction with the various apparatuses for rendering information perceptible, gives form to or in-forms information." Hanson argues that this sort of image (the "digital image") can't be restricted to the simple 'surface appearance', but must be extended to encompass the entire process by which information is made perceivable through embodied experience" (Hanson, p.8). The claim he makes is one that immersion works beyond screen, and that we internalize the digital space (or as he describes as the "digital images") as a space in our body. These claims supports a prediction that the touchscreen and its related interfaces will evolve from mechanisms for easy information consumption, into environments that deliver immersive and experiential spaces of participation.

A technology that builds off of these concepts, and is likely to evolve into a prevalent interface in 15 years is "Skinput". This technology works by using 'body acoustics' to turn your skin into an interactive touchscreen, by which “different bone densities, tissue mass and muscle size, unique acoustic signatures can be identified for particular parts of the arm or hand (including fingers), allowing people to literally control their gear by touching themselves."(Savov, 2010) These same practices could be extended by modifying the identification process to inanimate objects other than the body. Such advancements would allow a touchscreen to be projected onto any shape, form, and texture. This will present the opportunity for touchscreens to depart from the restrictive flat experience, and develop into a "touch environment". Simulation efforts will be further evolved, as sensations in this touch environment can be combined without physical limits. The addition of physical sensation to computing will revolutionize methods of information interaction. Users will not only be able to manipulate data in virtual spaces, but this evolved interface will allow users to physically experience information too.

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