Usability of Modern Display Technologies

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October 16, 2014

Abstract

This study aims to examine how interaction design concepts specifically map to the usability of modern display technology. //TODO: write a better abstract

Contents

1 Introduction

Electronic screens are the devices through which information is transferred between users and the interface. Although electronic displays have been around for roughly a century,[1] they are still transforming and evolving in a multitude of ways. Screens are diversifying in order to tackle the limitations that have presented themselves over the years. [8] Screen devices have been changing in size, shape, flexibility, and resolution in order to improve usability for specific tasks. For example, *focus plus context screens*, which are wall-size low-resolution displays with an embedded high-resolution display region, are currently a proposed solution to working with visual documents too large to fit standard screens. [4] Another kind of screen that is emerging is the *BiDirectional (BiDi) Screen*, which is a thin, depth-sensing liquid-crystal display (LCD) that allows for 3D interaction using light fields. [12]

Though each kind of screen has its merits, this study will focus exclusively on touch sensitive screens. In a study from Linköping University, researchers articulated how "interaction on touch sensitive screens is literally the most 'direct' form of HCI, where information display and control are but one surface." [3] Though it is clear that a connection between modern touchscreen devices and the field of interaction design exists, this study aims to investigate exactly *how* interaction design concepts specifically map to the usability of touch screens.

2 Background/ Prior Work/ Literary Review

2.1 Limitations/Proposed Solutions

There exists a fair amount of previous work pertaining to the the limitations of touch sensitive screens. One limitation that is discussed in the literature is how typing on flat surfaces—with no physical keys to guide the fingers—requires heightened visual attention. A study by Hussain Tinwala and Scott MacKenzie suggests that since the visual demand on the user is increased, concentration is diverted from the thoughts being expressed. [19] The lack of tactile features not only diverts attention from thoughts being expressed, but moreover, it makes the devices extremely difficult to use for Individuals with Blindness or Severe Visual Impairment (IBSVI). A study from Virginia Polytechnic Institute and State University examined how, even with the use of *VoiceOver*[2] functionality, touch screens do not provide sufficient support for IBSVI. These users are only able to "develop a spatial mental model for the interface or the screen through dead reckoning" as there is an "absence of any landmark other than the boundary of the device." [9]

One purposed solution to this limitation is a physical overlay, developed by researchers specifically to help IBSVI engage their spatial cognition, perception, and sensing resources while interacting with touch screens. [9] The tactile overlay covers the touch device screen. An IBSVI can use the tactile patterns of the overlay to locate the text, icons, or buttons in the touch device interface. A study examining the efficacy of this physical overlay suggested IBSVI who used it were typically more efficient than those using voice-over technology or 'trail-and-error' exploration. [9]

Another limitation of touchscreen devices that is examined in the literature is how the human finger as a pointing device has "very low resolution." [3] With mobile touch screens in particular, research has illustrated the difficulty in pointing at targets that are often smaller than the width of the user's finger. A notable technique was created by Schneiderman, Sears, and colleagues to specifically address this problem. [16] Their basic technique provides a cursor

[1] One of the earliest electronic displays, the cathode ray tube (CRT), was first made commercial in 1922. [17]
[2] *VoiceOver* for OS X tells users what is on the screen and walks users through actions. [2]

above the user's finger tip with a fixed offset when touching the screen. The user drags the cursor to a desired target and then lifts the finger to select the targeted object. Although this technique generally allowed a user to perform precise movements with less errors, the user's efficiency tended to suffer. [16]

Many studies have purposed using a stylus (pen) to interact with touch screens instead of using a bare finger. A stylus has better "resolution" than a finger tip and recent studies have demonstrated that pen input is emerging as a promising interaction modality for touch screens. [5] A study by Forlines and Balakrishnan, which evaluated multiple forms of stylus input, articulated that one drawback of this approach is the occlusion of other elements on the screen by the pen. [10]

Zooming is also found in the literature as a proposed solution to increase precision of touchscreen interaction. It is possible to use zooming to enlarge the information space of the touchscreen enough so that the user can comfortably point at the target with a bare finger. However, a study by Pär-Anders Albinsson and Shumin Zhai asserted that zooming has a fundamental drawback since "when zoomed to a sub area of interest, one loses the contextual global view that can be important for the user's task." [3]

2.2 Advantages

Previous work on the subject of touchscreen display devices not only discusses limitations and proposed solutions, but also examines advantages of touchscreen displays. Ben Schneiderman's essay, *Touch Screens Now Offer Compelling Uses*, argues that touchscreen devices can be advantageous for multiple reasons: they are forms of direct manipulation, they are easy to learn, they are the fastest pointing device, no extra workspace is required to use them, etc. [18] Many experiments have been conducted that provide evidence supporting Schneiderman's reasons. For example, the results from an experiment by Robert Hardy and Enrico Rukzio suggest that finger interaction is, in fact, faster than alternative pointing devices in most situations. [11] Schneiderman's assertion that touchscreen display devices are generally more learnable was also supported by an experiment that examined the learnability of a touchscreen electronic medical record system. [7]

3 Methods

There exist several input entry methods, however, that attempt to address this problem. For instance, Tinwala and MacKenzie present a system that includes auditory and tactile feedback to guide eyes-free entry using speech and non-speech sounds. [19] Another proposed solution comes from Tactus Technology, a company in Fremont, California. Employees from Tactus Technology are creating a keyboard with shape-shifting keys that pop up from the screen's surface when needed and recede again when no longer necessary. [1] Craig Ciesla, the co-founder of the company, said that the keyboard will be offered later this year.

Though literature on the subject of touchscreen display devices have presented many limitations, the most relevant and important seems to be the lack of tactile features and the requirement for heightened visual attention. For people who are blind, accessing touch screen interfaces is nearly impossible. Some accessibility features are beginning to be developed though.

"Touch screen interfaces have been popular for over 20 years, and concerns about touch screen accessibility have remained active throughout this time. [6] Touch screen accessibility research has considered various device form factors. These techniques relied upon hardware modifications, such as augmenting a touch screen with physical buttons or placing a physical overlay atop the screen. Such approaches may be expensive to install, may limit the flexibility of the underlying software (by imposing physical structures), and may interfere with use by sighted

Figure 1: A Tactus keyboard

people; unsurprisingly, such techniques have not been widely adopted. More recent efforts have focused on using gestures to provide blind users with access to touch screens without modifying the underlying hardware. For example, Slide Rule [13] used multi-touch gestures to allow blind users to browse and explore content on a touch screen-based smartphone. Researchers have also explored techniques to address specific aspects of blind touch screen interaction, such as text entry and gesture selection [14]. However, these techniques have often focused on small, mobile phone-sized screens. Furthermore, many of these techniques change the fundamental layout of the screen to improve accessibility. Thus, our current work addresses interaction with larger touch screens, and explores methods to preserve users understanding of the screen layout.

The principle of feedback feedback —sending back to the user information about what action has actually been done, what result has been accomplished— is a well-known concept in the science of control and information theory [15] "In the good old days of the telephone", "telephones were designed with much more care and concern for the user. Designers at the Bell Telephone Laboratories worried a lot about feedback. The push buttons were designed to give an appropriate feel—tactile feedback. When a button was pushed, a tone was fed back into the earpiece so the user could tell that the button had been properly pushed. When the phone call was being connected, clicks, tones, and other noises gave the user feedback about the progress of the call." "All this changed." "Why are modern telephone systems so difficult to use? Basically, the problem is that the systems have more features and less feedback"

3.1 What Work is Most Relevant/Important?

LaTeX has support for up to three outline levels (`\section`, `\subsection`, and `\subsubsection`). It also recognizes `\paragraph` and `\subparagraph` directives, though those don't show up in the table of contents. All of these directives expect a title.

Note also the use of the `\verb` directive for inserting code-like labels or symbols. It was particularly needed here so that we can include the backslash character in the text.

4 Discussion

Though there is awareness, nothing has been widely accepted yet. More research should be devoted to this problem. LaTeX is very good at providing clean lists. Examples are shown below.

- Bulleted items come out properly indented and spaced, every time.

  - Sub-bullets are a virtual no-brainer: just nest another `itemize` block.
  - Note how the bullet character automatically changes too.
- Just keep on adding `\item`s...
- ...until you're done.

Numbered lists are almost identical, except that you specify `enumerate` instead of `itemize`. List items are specified in exactly the same way (thus making it easy to change list types).

1. A list item
2. Another list item
3. A list item with multiple nested lists
   - Nested lists can be of mixed types.
   - That's a lot of power and flexibility for the price of learning a handful of directives.
     (a) Like nested bullet lists, nested numbered lists also "intelligently" change their numbering schemes.
     (b) Meanwhile, all *you* have to write is `\item`. LaTeX does the rest.
4. Back to your regularly scheduled list item

We may as well include a second figure also, shown in Figure **??**. The same image file is used, but note how it can be resized. Again, observe how the positions of the tables and figures do not necessarily match their positions in the source file, reiterating the aforementioned LaTeX functionality for deciding where these items go in the final document. You provide an approximate location, and LaTeX does the rest.

5 Conclusions

Wrap up your paper with an "executive summary" of the paper itself, reiterating its subject and its major points. If you want examples, just look at the conclusions from the literature.

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