Indoor Navigation for the Visually Impaired Using the Apple iPhone®

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Developing smartphone technology for the visually impaired depends on more than just adapting current technology available to the fully sighted. One demonstration of implementing assistive technology for the visually impaired is an indoor navigation system.

Introduction

Navigating a new indoor location is a challenge for the visually impaired. Global Positioning System (GPS) technology does not have the appropriate accuracy for indoor applications. Apple iPhones® are the smartphones of choice for the visually impaired due to their disability accommodations and design rules. The objective of the Yellow Team was to create a device that used Apple's technology without using GPS technology.

Indoor Navigation

What Has Been Done

The Yellow Team's research revealed that a visually impaired person felt comfortable returning to a room once they were shown the path. An indoor navigation system for the visually impaired would only need to direct users to and from a location one time. Blind walkers tend to be more hesitant to move forward than sighted walkers (Flores, 2014).

GPS technology is ubiquitous and available on many smart phones applications (Jain, 2014). However, it is not sufficient for indoor settings because satellite signals are blocked by walls and the resolution is not fine enough.

One option that Yellow Team considered was using Apple iBeacons™. An iBeacon device uses Bluetooth Low Energy (BLE) to signal an iPhone when the phone enters into the "region" surrounding the iBeacon. The strength of the connection between the beacon and the phone yields the proximity of the devices. However, beacon signal strength is attenuated by walls, human bodies, and how the user holds the phone (Apple, 2014).

It should be noted that many of the sources collected for this Tech Note were conference papers and were often written by authors outside of the United States. This suggests that not many American researchers are publishing work focused on mobile phone technology for the visually impaired.

What We Will Do

The Yellow Team's design will measure the user's acceleration and rotation. A sensing device will send this information to the user's phone, which will determine the user's location on a pre-existing map. The iPhone will suggest the next action to the user. The design should value the safety of the user as much as its functionality [see related Tech Note by Yellow Team member Steven Santos].

Designing for the Visually Impaired

Many developers design first for healthy, able-bodied users and then adapt their design to accommodate disabled users (Sierra, 2012), as shown in Figure 1a. This is in contrast to universal design, also called inclusive design, which is defined as "the design of products and environments that can be used … by people of all ages and abilities … without adaptation." (Story, 1998, p. 4). Accessibility is considered simultaneously with the rest of the design process, as shown in Figure 1b.

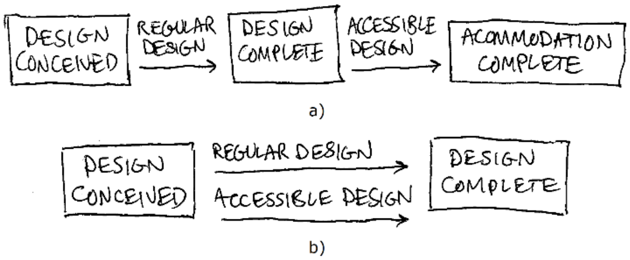

Figure 1. Universal Design versus Regular Design for Accessibility

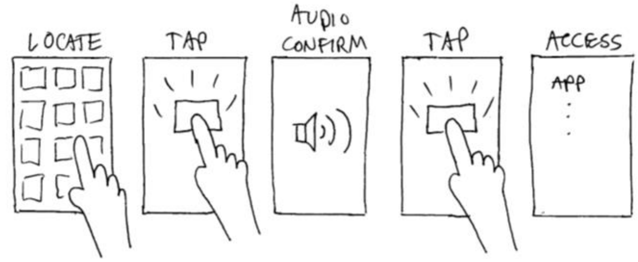

Figure 2. Apple VoiceOver Identification and Confirmation Sequence

For our project, the intended user is visually impaired or blind, and we must consider universal design. We will save time and resources at the end of development if we plan on implementing accessibility for both sighted and non-sighted users at the beginning of the project.

Desirable app designs are practical, accessible, fast, and easy to use (Kornowski, 2012). One priority for the Yellow Team's project is that the app should be quick to open and use.

Apple's VoiceOver

Three visually impaired advocacy groups, The American Foundation for the Blind, the Royal National Institute of Blind people, and the National Federation of the Blind, agree that the iPhone is the smartphone of choice for the blind (Fakrudeen, 2014). Blind users favor the quick setup time and simple steps of the iPhone.

In 2009, Apple implemented a built-in screen reader for their devices called "VoiceOver." Apple claims that VoiceOver audibly describes everything happening on screen. Users can customize VoiceOver's speech rate and pitch, language, and screen darkness (Apple, 2015). VoiceOver meets some of the criteria of universal design and is compatible with all Apple-designed apps. Apple has online guidelines for designing third-party apps to work with VoiceOver (developer.apple.com).

One key aspect of VoiceOver's operation is the two-step process of identification and confirmation (Mascetti, 2012). When users want to identify an element on an iPhone screen, they must locate the element on the screen, tap it to receive audio identification, and tap the element again to confirm selection of the desired element, as shown in Figure 2. This process takes time, depends on a spatial understanding of the virtual layout on the screen, and is prone to error.

VoiceOver adapts the standard Apple input interface, which displays both the field where text is being entered and the virtual keyboard on the touch screen. VoiceOver's focus shifts between the virtual keyboard and the input element as a user inputs character. Because a sighted user can see where each key is, they can press the next key and receive visual confirmation. A visually impaired user must locate each key each time they input a character, and it is easy for a user's finger to slip in the confirmation stage, requiring another identification cycle (Mascetti, 2012).

In addition, VoiceOver's need for audio playback is awkward in loud public spaces and quiet private ones.

Implementing the Yellow Team's Project

Some of the barriers for accessible design with Apple technology comes from their choices of user input and interface layout.

Application Layout

A static layout, as demonstrated in Figure 3, should be used rather than a dynamic layout since blind users cannot remember where elements are located in a dynamic layout (Fakrudeen, 2014). Keeping elements in the same location makes it easier for users to remember where the elements are and ensures that VoiceOver will not read information in a non-sequential fashion (Leporini, 2012). VoiceOver does not alert the user when a new section of text has been selected and cannot

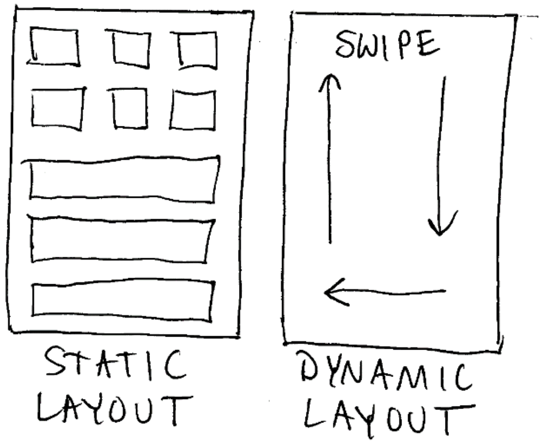

Figure 3. Sample Sketch of Difference Between Static and Dynamic Layouts

distinguish between interactive and non-interactive elements.

iPhone applications that require a fixed interface resembling a visual layout should use the physical boundaries of the iPhone, such as the border and the home button, to frame button locations. This gives users a reference and helps them locate elements, as in Finger Based Technique.

Gesture-Based Input

If an application requires an interactive input, it should implement an alternative to VoiceOver. The VoiceOver method of text entry involves locating keys and confirming inputs, which is prone to error and time consuming (Leporini, 2012). If an application takes a long amount of time for accurate entry, it can deter use (Kornowski, 2012). Proposed solutions such as Finger Based Technique can improve speed or accuracy but require use of a full hand, rather than just a thumb (Fakrudeen, 2014).

If possible, developers should implement gesture-based interfaces instead of layouts that simulate sighted-accessible apps (Leporini, 2012). This was demonstrated with Everyware Technologies' TypeInBraille™, which uses a static layout that splits the screen into two halves, but that is controlled with distinct gestures such as taps and flicks (Mascetti, 2012). Apple's VoiceOver includes a "rotor control" that mimics a physical dial. By rotating two fingers, play back settings and scroll speeds can be adjusted (Apple, 2015).

Appropriate Feedback

One consistent feature of visually impaired applications is audio feedback. In the case of Apple's VoiceOver, this takes the form of a human male voice with over 30 languages and dialects (Apple, 2015). Finger Based Technique also depends on audio feedback for confirmation and operation (Fakrudeen, 2014). TypeInBraille claims independence of audio feedback, but visually impaired users would want some final confirmation of what they entered, especially with TypeInBraille's decreased accuracy compared to VoiceOver (Mascetti, 2012).

The Yellow Team does not propose a complete replacement for audio feedback. Environmental noise and privacy concerns will continue to be a problem for visually impaired users unless they rely on noise-cancelling headphones. The Team's design will depend on some form of audio feedback.

Conclusions

Applications and devices designed for the visually impaired should use Apple technology due to its principles of universal design and preference among the visually impaired. However, some of the built-in features, such as VoiceOver, are not sufficient by themselves, and an application should utilize static layouts, gesture based commands, and appropriate feedback.

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