Context-Enhanced Interaction Techniques for More Accessible Mobile Phones

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Abstract

Modern mobile phones enable users to access a wide variety of information and communication services anytime and anywhere. In order for people with disabilities to benefit from these services, mobile devices must provide accessible user interfaces. Currently, users with motor and visual impairments often have difficulty using mobile devices due to issues such as screen readability and small controls. These problems may be exacerbated when attempting to use such devices in crowded, noisy or otherwise distracting environments. We are developing accessible mobile interaction techniques that adapt the mobile device interface to the user by leveraging information about the user's current location, activity, and level of ability.

Introduction

While relatively uncommon even 10 years ago, today mobile phones are used daily by people of all ages, occupations and abilities. As mobile phones have become more ubiquitous, they have also gained features such as e-mail, web browsing, and global positioning system (GPS) capabilities, thereby providing access to additional information and services while on the go. This access is beneficial to all users, but may have special significance for some people with disabilities. For these users, mobile phones offer a constant connection to friends, family, and caregivers, allowing them to act independently in the world while remaining connected to essential support and services [1].

Despite the ubiquity of mobile phones, many commercially available phones remain inaccessible to people with disabilities. Users with visual or motor impairments may encounter difficulties using these devices due to issues such as small screens, small controls that are difficult to manipulate, and a lack of multimodal feedback [9]. Furthermore, because mobile phones may be used in a wide variety of contexts, such as when walking down the street or riding public transportation, environmental factors such as ambient noise, unsteady surfaces, and inclement weather may further impair a user's ability to interact with the device [9].

Although mobile phone accessibility issues may be exacerbated by environmental factors, understanding the effects of these factors makes it possible to develop user interfaces that can adapt to these limiting situations, thereby improving overall accessibility. We are currently investigating mobile interaction techniques that use information about a user's context, location, and activity to adapt to the user's abilities and increase accessibility.

Related work

Modern mobile phones often feature on-device sensors such as accelerometers, light sensors, and GPS devices. Prior studies have explored using these sensors to detect a user's context and change the user interface accordingly. Hinckley et al. [4] explored interaction scenarios that used on-device sensors to augment a user interface, but focused on novel interactions rather than increasing accessibility. For example, their prototype rotated its on-screen display when the device itself was rotated, and began audio recording when the device was held near the user's face. Dey and Mankoff [2] developed a prototype augmentative and alternative communication (AAC) device that used information about the user's location to populate a word menu. This was intended to improve usability by populating the menu with likely candidates, but a pilot evaluation of the prototype did not show significant benefit over existing AAC systems. Our research extends this prior work by exploring new adaptive techniques that use contextual information to increase accessibility.

This research also extends our prior work in developing accessible and adaptive mobile user interfaces. Barrier Pointing [3] introduced an alternative target selection method that increased pointing accuracy on touch screen-based mobile devices for users with some types of motor impairments. Slide Rule [5] introduced gestural input and audio output techniques that enabled visually impaired people to use a touch screen-based mobile device. These interfaces improved accessibility for users, but did not adapt to the user's context or level of ability. In another study, we developed a prototype walking user interface (WUI) that increased the size of touch screen targets while the user was in motion. Our current research extends this prior work to explore how accessible interaction techniques can be combined with context-driven interface adaptation to provide accessibility support when it is needed most.

Situational factors in mobile accessibility

While many mobile phones are difficult to use for people with disabilities, these people may encounter further accessibility issues when attempting to use a device in a busy environment or while moving. A mobile phone button that is difficult to press while sitting at a desk will likely be even more difficult to press when the user is on a moving train or is walking down the street. This negative effect on performance caused by environmental factors can be thought of as a situational impairment [8], since it effectively impairs the user's ability to interact with the device. Situational impairments may affect mobile device users with and without disabilities. Situational impairments can be caused by a range of factors, including user movement, inclement weather, impeding clothing, or user fatigue [6]. These impairments affect user performance in various ways, including reducing reading speed [7] and target acquisition speed [6].

User interfaces that can adapt to the user's context may reduce the effects of these situational impairments. These situational accommodations [6] may overcome the effects of situational impairments by adapting the user interface so that it is easier to use in a given situation. For example, a user interface might make text larger while the user is moving in order to make it easier to read, or might increase text contrast when the lighting conditions are poor. These accommodations may be triggered automatically when needed, thereby reducing the effort required to interact with the device in a distracting or impairing situation.

Proposed solution

We are developing a system of interaction techniques that leverage contextual information about the user to reduce accessibility issues during mobile use. These techniques draw on multiple types of contextual information, including the user's location, movement, and current activity. This information can be detected by sensors on the mobile phone itself. The system can also monitor the user's current performance, and can take action if the user's performance is significantly lower than normal. For example, the system might detect that the user is pressing the BACKSPACE key significantly more than usual and infer that the user is having difficulty typing. The user may also set explicit preferences for adapting the user interface. Once a potential accessibility issue is detected, the user interface can adapt to allow for more accessible interactions. The proposed system is illustrated in Figure 1.

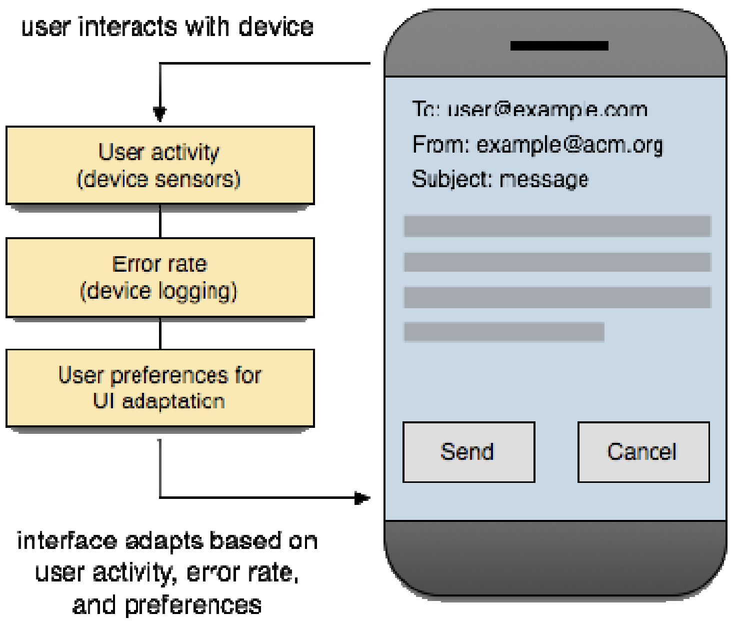

Figure 1. Accessible mobile interaction techniques leverage contextual information about the user, such as their location, movement, and error rate, to adapt an interface to the user's current needs and abilities.

The proposed system consists of three primary components. First, the system must determine the user's context using sensors on the mobile device. Prior research has shown that it is possible to determine a user's location [2] and movement [4] using on-device sensors. Data can be combined from multiple sensors to create a model of the user's current activity and capabilities.

Second, the system must provide a set of interface adaptations that can address potential accessibility issues as they arise. These adaptations may take a number of forms, including: (1) rescaling or reordering a user interface to accommodate interaction difficulties, (2) automatically performing contextually appropriate actions to reduce required effort, (3) activating an alternative interface that is optimized for a given context, or (4) activating typing or pointing correction to reduce errors. Examples of some typical mobile use situations, potential situational impairments, and adaptations to address these impairments are listed in Table 1.

Finally, because each user may have different needs, the system must allow users to customize accessibility features. Users should be able to choose which accessibility features they want to use, and determine when they will be activated. Users may also further customize the adaptations, for example by choosing minimum and maximum sizes for on-screen targets. These customization features must be easy to use and accessible to people with a range of abilities.

Situation	Impairing effects	Interface adaptations
User is in motion	Reading ability is reduced	Text size increased; text-to-speech activated
User is in a busy bus station	Attention is reduced; crowded space impairs movement	Bus schedule application automatically launched
User is riding on a bumpy bus	On-screen targets are difficult to hit while moving	On-screen target size increased; keyboard error correction activated
Phone is in pocket	User cannot see the screen	Voice output activated; touch screen gestures enabled

Table 1. Mobile usage situations, potential impairing effects, and interface adaptations that address these effects.

Future work

We are currently conducting a qualitative investigation of mobile device accessibility, with an emphasis on accessibility issues that occur while moving around in the world. We will interview people with disabilities about the mobile devices that they use and about the accessibility issues that they encounter when using these devices. This investigation will reveal what accessibility problems are experienced by mobile device users with disabilities, how environmental factors can affect these problems, and how users adapt to these problems.

Following this investigation, we will develop an initial set of accessible, adaptive interaction techniques for mobile phones. These techniques will be refined through participatory design and iterative prototyping involving users with visual and motor impairments.

Finally, we will conduct a field study to evaluate the effects of these interaction techniques on mobile phone usability and accessibility. When possible, we will deploy prototypes to the mobile devices that the participants are already using, rather than requiring them to adopt new devices for the experiment.

The expected contributions of this research include further understanding about mobile accessibility issues in the field, a set of new accessible mobile interaction techniques, and a framework for integrating and managing these interaction techniques. These contributions may significantly increase the accessibility of current mobile phones, and will help ensure that future mobile devices are accessible to users with disabilities.

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