Adaptive User Interfaces on Tablets to Support People With Disabilities

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Abstract

With the advent of tablet computers, touch screens, gesture-based interaction and speech recognition, sophisticated applications with Natural User Interfaces (NUIs) become state of the art. NUIs have the potential to support people with disabilities, e.g., in their daily activities or in acquiring specific skills. Yet, one main challenge is that this user group has diverse abilities and handicaps so that an interaction design must be highly configurable to make NUIs beneficial. The introduction of adaptivity might be promising in order to overcome configuration complexity and effort. This paper presents an approach to adaptive user interfaces on tablets to support people with disabilities.

1 Introduction

The WHO estimates that about 10% of the human population have disabilities. According to the latest US Census data (~2007), 15% of the American population are classified as (physically, mentally or developmentally) disabled. Natural User Interfaces (NUIs) allow the use of existing skills for the interaction with applications. Such NUIs are getting increasing attention in recent years and are applied in many fields, e.g., mobile computing, healthcare or ambient assisted living (John et al., 2012). The recently started related research project *Assistive Technology Laboratory* has several goals: *i)* development of a software framework for NUI-based tablet apps, *ii)* integration of specific hardware (e.g., Microsoft Kinect, IntegraMouse, external switch buttons), *iii)* application and content development support, and *iv)* evaluation of concepts and apps according to users' limitations. The project examines the integration of existing knowledge about the use of assistive technologies and software and User Interfaces (UIs) design referring to tablet computers. Further, there are new control and interaction opportunities through multi-touch technology and the concept of NUIs.

In our approach, tablets play a crucial role due to the following advantages: tablets *i)* are relatively cheap compared to specific hardware for people with disabilities, *ii)* offer new input methods, and *iii)* are portable and easy to handle. The great opportunities offered by NUIs come with the drawback that people with disabilities must learn to interact with them. Our approach is guided by the hypothesis that specific tablet games could help these people to learn interaction patterns, so that they are later better able to use other tablet applications.

A main challenge faced by the development of NUI-based applications for people with (especially motor or cognitive) disabilities is the exceptionally high degree of required variability. This challenge can partly be overcome by offering a high level of configurability, but only at the cost of high effort for developers and users. To tailor the interaction with an application to the needs of a disabled user, the system must be continually updated about the user's skills, handicaps and progress – data predestined to be organized in a user model. The user model could then serve as a basis for adaptive behavior to reduce configuration efforts.

Our work covers the development of accessible tablet games. This paper provides an overview of different kinds of impairments, discusses related work, and presents our intended approach to adaptive UIs on tablets to better support people with disabilities.

2 Related Work

According to (Bierre, Hinn, Martin, McIntosh, & Snider, 2004), the limitation of a person can be divided into visual, hearing, motor and cognitive as follows:

Visual impairment includes (color) blindness and low vision. For this group a game should provide a voice interface and customizable fonts and color schemes. *Hearing impairment* includes (all degrees of) deafness. For this group a game has to provide speech and sounds as text/subtitles. *Motor impairment* includes disabilities like paralysis, neurological disorders or repetitive stress injury. Here, a game should give more time to react. According to (Yuan, Folmer, & Harris, 2010), an accessible game for this group should also support a variety of input devices, like switch inputs, brain wave controllers, head trackers, or eye or mouth controllers. *Cognitive impairment* includes memory loss or Attention Deficit (Hyperactive) Disorder. Games should be simple, provide instructions and give the user time to react.

(Wobbrock, Kane, Gajos, Harada, & Froehlich, 2011) propose the concept of ability-based design, where a system considers users' abilities, provides a fitting UI and allows users to interact according to their individual skills. (Gajos, Wobbrock, & Weld, 2008) describe tests with ability- and preference-based UIs for motor impaired users. An ability model based on the results of a performance test is the foundation of the ability-based approach, whereas the preference-based one is grounded on preference statements. As tests showed, "participants were both significantly faster *and* more accurate with the ability-based interfaces".

As discussed by (Miñón & Abascal, 2011), adaptive systems commonly use previously created UIs as a starting point for adaptation, which might not be the best solution for people with disabilities. The authors discuss an approach introducing an abstraction layer between the description of a UI and its concrete appearance, so that abstract interface elements can be transformed into different concrete ones, resulting in highly generic UIs.

3 Reflections on Adaptivity

As a first step in designing an adaptation unit for our framework, we try to answer the major questions of adaptation: *Why* is adaptation needed, *Where*, *When*, *How* can adaptation take place, *What* can be adapted and *To What* can it be adapted (Knutov, De Bra, & Pechenizkiy, 2009). People with disabilities are extremely diverse and differ in their learning approaches, skills and handicaps more than other people do. Also, health- or progress-wise setbacks have to be considered. Such conditions make it difficult to continuously offer the optimal NUI configuration without a lot of effort – an adaptive interface could take a main part of these endeavors. A user's current visual, auditory, motor and cognitive skills must be included in the user model, as these are the most distinctive characteristics impaired users exhibit. Skills can be further divided into *alterable* and *non-alterable* ones (e.g., vision is less likely to change over time than motor skills). Next, concrete manifestations of adaptive behavior for our application area have to be identified. Here, the following options seem most promising:

Adaptive selection of input and output modalities: Users might be visually or auditory impaired and not be able to perceive all forms of system feedback. Further, users might be dependent on additional input devices.

Adaptation of game speed and level of difficulty: Users might differ drastically regarding their reaction time and cognitive capabilities.

Adaptation of guidance: Some users might require additional accompanying hints regarding not only the game itself but also the interaction with the device, etc.

Adaptive presentation of UI components and dialogs: If not tailored to a user's needs, the UI might become impossible to interact with (e.g., a motor impaired person would probably not be able to perform a very precise tap on a small UI element).

Adaptive presentation of game elements and their behavior: A high amount of animation and a lot of details in a game might appear appealing to one user but be distracting for another.

In our case, an adaptation approach should be a holistic one, i.e., adaptivity would not be limited to specific system components but enhance interaction in all areas: *i)* at the level of interaction with the device (in our case tablets, potentially in combination with assistive input equipment), *ii)* at the level of the UI, and *iii)* at the level of the respective game.

4 Discussion

In this paper we presented an approach to introduce adaptivity to NUI-based games for people with disabilities. The target group is highly diverse, making it almost impossible to design games that fit all users' needs. A high level of configurability would be required to ensure that a game can be played by people with different kinds of impairments. Aiming at reducing the efforts to configure such applications, adaptivity seems to be a promising concept. Yet, some issues have to be considered. People with certain disabilities might react particularly sensitive to non-replicable changes in the UI or game behavior. Thus, adaptation causing such changes (e.g., a system's decision to offer the next level of difficulty of a game or to reduce the size of UI elements if a user improved tapping precision) could also result in a negative experience. An option to tackle the acceptance problem would be to generally offer a non-adaptive version of all games. Another consideration would be the introduction of the concept of a recognizable message (e.g., in form of a symbol) informing the user that something has changed in the system's behavior or appearance. A challenging change might be easier to accept if it is made obvious that it happened on purpose. Yet, this and other, similar concepts might again not be suitable for all users with different kinds of impairments. In order to prevent unpleasant situations, users have been so far and must further be integrated in the full development process, including the design of adaptive behavior.

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