Model Based Simulation and Evaluation of Mobile and Web 2.0 Applications for Users with Special Needs

Philip Ackermann

Fraunhofer Institute for Applied Information Technology FIT
Schloss Birlinghoven, 53757 Sankt Augustin Germany
philip.ackermann@fit.fraunhofer.de

Abstract. The accessibility of modern Web 2.0 applications for people with disabilities continues to be a problem [1,2,3]. Recent research has shown that even the Web Content Accessibility Guidelines 2.0 only cover half of the accessibility problems that users encounter when interacting with those kind of web applications [4].

Those guidelines do not consider the fact that people with disabilities use special interaction patterns when interacting with web applications [5]. Analysing these interaction patterns and integrating them into the development process of web applications by providing tool support seems promising to help improving the accessibility of those web applications and also to reduce the time and costs for user trials [6,7].

The purpose of this thesis is to simulate interaction patterns of people with disabilities and to analyse how those interaction patterns have effects on the time and efficiency to complete given tasks in web applications. It will also analyse how effective this simulation will be in helping to design web applications, both accessible and usable.

To achieve this, a model based simulation framework will be designed that take into account different models involved in the interaction of users with web applications. A software tool will be developed that implements these models and the simulation.

Keywords: Web Accessibility, Web Usability, User Interactions, Web Simulation, Interaction Patterns, Model Based Simulation.

1 Problem Statement

Over the last years the web has evolved from a static hypertext system into a platform for rich internet applications [8,9] that emulate the functionality of desktop applications. However the accessibility of such applications for people with disabilities continues to be a problem [1,2,3]. Recent research has shown that even the Web Content Accessibility Guidelines 2.0 only cover half of the accessibility problems that users encounter when interacting with those kind of web applications [4] and that implementing them does not guarantee the usability of a web application [10,11].

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One example of rich internet applications are social networks like Facebook[1]. Those social networks are intended to build relationships with other people on a private or a professional level [12]. Participating in such communities would be important especially for people with disabilities. However a recent survey by WebAIM on the usage of screen-readers revealed that Facebook is avoided by most of the screen-reader users because of accessibility issues[2]. One user commented that

> *"Facebook is becoming especially annoying. I can force it to work, but it's TOTALLY inefficient and not a pleasure to use. It's becoming critical for business visibility, though."*

This comment highlights the problem that users with disabilities are currently excluded from participating in social network activities, because of inaccessible and unusable design of web applications. This problem is not limited to social networks and is observed in other rich internet applications as well [13].

Another observation is that users with disabilities have developed different interaction patterns when interacting with web applications [14,11,15,5], partly to compensate some of the accessibility problems they encounter. Those interaction patterns are not taken into account in current accessibility guidelines. The interaction patterns that an user applies depend on different components like the task the user wants to perform, the assistive technology and device she is using and the application itself.

Analysing those interaction patterns can reveal how people with disabilities interact with web applications. It is important to analyse them to understand the behaviour of those user groups on web applications and how they effect the time and efficiency to complete tasks in web applications. Integrating them into the development process of web applications by providing tool support for web developers seems promising to help improving the accessibility of those web applications and to reduce the time and costs for user trials [6,7].

2 Purpose Statement and Research Questions

The purpose of this study is to simulate interaction patterns of people with disabilities in the context of mobile and Web 2.0 applications and to identify the effects of those interaction patterns on the time and efficiency to complete given tasks in web applications. It will also analyse how effective this simulation will be in designing web applications that are both accessible and usable. The work will try to answer the following research questions:

1. How effective is model based simulation to simulate interaction patterns of users with disabilities?

[1] `http://www.facebook.com`

[2] WebAIM. 2009. Survey of Preferences of Screen Readers Users, Retrieved July 30, 2012, from `http://webaim.org/projects/screenreadersurvey/`

   - What components need to be taken into account to simulate interaction patterns?
   - How can those components be integrated into the simulation?
2. How does simulating user interactions support web developers in designing accessible and usable web applications?
   - How can the simulation be integrated to work on real HTML based web applications instead of an abstract application model?
   - What kind of feedback is effective to explain accessibility and usability problems to the web developer?

The proposed simulation framework will take into account the following models: (i) the user model, (ii) the device model including user agents and assistive technologies, (iii) the application model under test, (iv) the tasks model and (v) the interaction patterns model. A proposal for the user model and the device model has been published by the author in [16]. The application model that is going to be used is the *Document Object Model* (DOM) [17] extended by the specification for *Accessible Rich Internet Applications* (ARIA) [1]. All those models have to be taken into account, because they influence the interaction patterns that an user would and could apply. Another reason is that the efficiency of performing tasks can differ significantly between different versions of an application, for example between the smartphone version and the desktop version [18].

3 Literature Review

This section describes different relevant existing approaches for simulation of interaction patterns and/or model based simulation in the context of accessibility and usability evaluation. The state of art in user preference and device modelling has been briefly described by the author in [16]. Due to space restrictions this section does not represent a complete review of the state of the art. Instead it highlights the most relevant existing work, their limitations and how the proposed work will differ.

Biswas [19] created an environment to simulate the interactions of people with low vision or motor impairment with a graphical user interface. The approach focus on graphical user interfaces in general and does not consider interactions that are specific to web applications. Furthermore instead of a real application the input for the simulation consists of a sequence of bitmap images and information about the location of different objects in that interface.

Schrepp [6] proposes models for (i) keyboard navigation in web sites, (ii) keyboard navigation in web applications and (iii) interaction of blind users in web pages. The models are based on the GOMS (Goals, Operators, Methods and Selection rules) model but extend it to take into account random errors made by the user. The approach has not been implemented in a software tool, although the author mentions that it would be an important part of future work, because performing a GOMS analysis without tool support would be time consuming and also not trivial from a technical point of view.

Tonn-Eichstädt [20] proposes an extension of GOMS to model the user interaction patterns and uses it to calculate the task execution time on a web page. The model has not been verified and it does not take into account parameters like speech rate of a screen-reader or Braille reading times. A tool that visualizes the interaction patterns is not provided but mentioned as future work.

Trewin et al. [14] observed different patterns that screen-reader users apply when interacting with web applications. Their goal is to create a tool for developers that simulate screen-reader users and report usability problems. Later the same authors [7] uses CogTool [21] as a start point to build a KLM (Keystroke Level Model) for one task and one user using JAWS[3] as screen-reader. Because CogTool only uses storyboards for simulation the goal remains to have a tool that works on a real web application. Until now no such software has been implemented.

MeMo tool [22] is a workbench for conducting semi-automatic usability evaluations by simulation. It simulates an user interacting with the *system interaction model* implemented by the software developer. The system consists of different models including those for the tasks and the user interactions. However MeMo does not focus on the following aspects that the proposed work will address: (i) interactions of users with disabilities and (ii) simulation on real web applications.

Based on the use of skip-links and heading tags the Accessibility Designer tool [23] calculates the time to navigate to an element on a web page using a screen-reader. Colors are used to visualize how fast a region on a web page can be reached by screen-reader users. However this tool does not take into account new semantic tags like those introduced in the HTML5 [24] or the ARIA [1] specifications. Newer screen-readers like JAWS 12[4] are able to interpret those semantics as well. Therefore the interaction patterns of screen-reader users have changed accordingly. This change must be considered when creating the models for the simulation.

4 Research Methodology and Research Plan

Based on existing studies about interaction patterns of users with disabilities the requirements for modelling such interaction patterns are collected. According to those requirements the model will be developed in an iterative process. The task and goals model and the simulation framework itself will be developed in iterative processes as well. The plan is to finish a first prototype of the simulation and the models after different iterations until November 2013.

The interaction of users with disabilities with web applications is quite complex, therefore we foresee the need to validate the prototype with user testing.

[3] Freedom Scientific. 2010. JAWS, Retrieved July 31, 2012, from `http://www.freedomscientific.com`

[4] Freedom Scientific. 2010. Features and Enhancements in JAWS 12, Retrieved July 31, 2012, from `http://www.freedomscientific.com/downloads/jaws/JAWS12-previous-enhancements.asp`

Based on those user tests the models and the simulation will be calibrated as necessary. The plan is to finish the user testing and the validation until April 2014.

After the simulation framework has been validated a software will be designed that implements the framework. The purpose of this software is (i) to verify the applicability of the simulation framework and (ii) to provide tool support for web developers. According to the plan a prototype of the software will be finished in September 2014. The software will be validated with user tests until December 2014. The plan is to defend the thesis in January 2015.

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