Introducing Usability Heuristics for Mobile Map Applications

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Abstract. In this paper, a set of heuristics for evaluating the usability of mobile map applications is introduced. We developed the heuristics by exploring the present generic heuristics and then forming new theory-based heuristics. Usability specialists tested the heuristics by evaluating the usability of a mobile map application with both generic and domain-specific heuristics. As a result, more usability problems were found with the proposed domain-specific heuristics. In addition, based on the evaluators' views the initial domain-specific heuristics were further developed. We conclude by proposing domain-specific usability heuristics for evaluating the mobile map applications.

Keywords: mobile map applications, domain-specific heuristics, heuristic evaluation, cartography, usability, visual design

1. Introduction

Mobile map applications (MMAs) are a current trend of today. Nowadays not only IT oriented people, but also almost everyone who has a smart phone uses MMAs. However, currently usability problems concerning MMAs are not taken in proper consideration. One typical reason for these problems is that there are not enough resources, such as knowledge, time or money, to put into the usability engineering of a map development project.

Analyzing the application's usability with usability heuristics during the development phase is a low-cost and easily implementable way to improve usability. The problem though is that the currently existing usability heuristics are too general to be applicable for evaluating the usability of MMAs. Many research reports (e.g., Bertini et al. 2006) state that domain-specific usability heuristics have been more suitable for evaluating the usability of special applications than general heuristics such as Nielsen's set of usability

heuristics (Nielsen & Molich 1990, Nielsen 1994). Domain-specific usability heuristics have been introduced for example to evaluate computer games (Pinelle et al. 2008), children's e-learning applications (Alsumait & Al-Osaimi 2009) and IT security management tools (Jaferian et al. 2011). Still there are no suitable heuristics for MMAs. To additionally evaluate, support and improve the usability of MMAs there is the need to develop domain-specific usability heuristics.

In this study, we test and propose a new set of usability heuristics to support the development of MMAs. Firstly, the heuristics were derived via a theoretical-conceptual procedure based on theories from cartography (MacEachren 1995, Van Laar 2001, Nivala & Sarjakoski 2005, Tyner 2010, Krygier & Wood 2011) and visual design (Mullet & Sano 1995, Lidwell 2003) in relation to the Nielsen's (1994) general heuristics. Special attention was paid towards the visual design of the user interface (UI) of map applications. This is due to the fact that mobile maps deploy specialized visual elements rendering it essential that the user understands their meaning. The proposed heuristics also cover information about the user's location, unambiguous route guidance, map scalability, adaptability of visible information depending on the device's screen size, up-to-date maps, application customizability to support user's personal interests and use of shortcuts to save important locations.

The rest of the paper is organized as follows. First, we discuss the background of the topic, including the previously indicated usability problems and the usability inspection methods of MMAs. Additionally we highlight the gaps of current general usability heuristics. Second, we describe our research method. Third, we discuss the resulting initial domain-specific heuristics in detail. Finally, we conclude by describing our findings.

2. Background

The usability of MMAs is not trouble-free. The problems are related to, for example, the small screen size of the mobile device, interaction limitations of the device, connection speed and limited battery life. This is in addition to several visualization related issues, such as choice of level of detail, enhancement effects, color choices, hierarchy in the use of symbols and visualization of off-screen information (Looije et al. 2007).

Although the problems have been pointed out, they typically still exist in the mobile map services. There are some reasons for this. For instance, map application developers are often not very familiar with usability related issues. Nivala et al. (2007) maintain that although usability is seen as an ad-

vantage in the competition to be successful on the map application market, companies often fail to implement the usability engineering approach due to lack of knowledge and resources. Moreover, one problematic issue still is that usability has not played an important role in product development (Jerome & Kazman 2005).

Heuristics evaluation (HE) is a discount method for evaluating usability, as HE can be conducted with low resources in a short timeframe (Nielsen 1992). Another advantage is that although the best results can be achieved with usability professionals performing HE, also non-professionals can use the method to evaluate product usability with some success (Baker et al. 2002). HE has gained criticism for example concerning the variability and in-depth results depending on the evaluator's expertise and commitment (Hertzum & Jacobsen 2003). De Kock et al. (2009) emphasize the type of information HE conveys compared to empirical user testing in that HE is focusing on identifying errors, whereas empirical user testing is determined by effectiveness, efficiency and user satisfaction. They also point out that as empirical user testing deals with the questions such as what and how, HE focuses on a meta-level which considers the questions why and when.

The applicability of Nielsen's heuristics (1994) is limited in terms of evaluating MMAs. This is because the heuristic set does not cover the specific aspects of MMAs such as location awareness, mobility and interruptions. The visual design of mobile maps comprises multiple viewpoints to visual design (e.g., Tyner 2010). Further, Nielsen's heuristics which relate to visual design do not properly take into account cartographic visual design principles. Therefore, these existing heuristics lack many essential viewpoints to effective visual mobile map design, and novel domain-specific heuristics are needed.

3. Research Method

The study was implemented in four phases. First, we explored the generic heuristics (Nielsen 1994) and pointed out their limitations for evaluating the usability of MMAs. Second, we familiarized ourselves with current domain-specific heuristic sets (Pinelle et al. 2008, Alsumait & Al-Osaimi 2009, Jaferian et al. 2011) and explored which methods were used to develop these heuristics. The third phase was to formulate the new heuristics. We derived the initial usability heuristics from Nielsen's (1994) generic usability heuristics by using a conceptual-theoretical approach suitable for the evaluation of MMAs. A similar approach has also been used in the development of other domain-specific usability heuristics (Alsumait & Al-Osaimi 2009, Inostroza et al. 2012).

Finally, the applicability of the initial usability heuristics for MMAs was tested. We asked four usability specialists to evaluate an MMA by completing specific map-related tasks (self-locating, searching address, exploring the map, wayfinding and using POIs). Similar to Jaferian et al. (2011) half of the evaluators were asked to use the original Nielsen heuristics to do the evaluation and half were asked to use our initial heuristics that are presented in *Table 1*. The evaluated application was NavFree (Navmii Holding plc. 2013). The application was chosen because it was not familiar to the evaluators, but is still widely used, offering common MMA functionalities. All four evaluators used a smart phone to do the evaluation: Apple iPhone 3GS (3), and an Android phone Samsung Galaxy Nexus (1). After completing the evaluation, we asked the evaluators to rate the applicability of the heuristics for evaluating the MMA and the intelligibility of each of the heuristics. We also asked for specific feedback of the heuristics.

Jakob Nielsen's Heuristics	Proposed Heuristics for Mobile Map Applications
1. Visibility of system status The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.	**1. Visibility of the contextual map functions** The map application should always keep the user informed about what is going on, through appropriate feedback within a reasonable time. The map functions should be visible.
2. Match between system and the real world The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.	**2. Match between the system and the physical surroundings of the user** The map application should show clear indication of the user's current location on the map and of the possible target location. It is essential that the map compares in an understandable way with the physical surroundings of the user. The map should be up-to-date.
3. User control and freedom Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.	**3. User control over map functions and locations** Allow the user to take control over map application when interruptions (from the mobile device: phone call, message, other applications' notifications, from the concrete surroundings: traffic, weather, traffic lights) happen.
4. Consistency and standards Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.	**4. Consistency and standards** Follow platform conventions. Use clear, intuitive, commonly known map symbols.
5. Error prevention Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.	**5. Error prevention** Even better than good error messages is a careful design, which prevents a problem from occurring in the first place. If errors still happen, make sure to offer the possibility to recover from them.

6. Recognition rather than recall Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.	**6. Recognition rather than recall** Make sure that the main functions of the map application (e.g. search, route guidance, zooming, panning) are easily accessible. Use short menu paths for the main functions or keep the main functions visible at all times.
7. Flexibility and efficiency of use Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.	**7. Flexibility and efficiency of use** Offer flexible options for the main map functions. Allow the user to save locations to be used as shortcuts (e.g. home) and support POI information. Give easy access to additional information (metadata, links, user-generated content). Make sure the user interface is scalable for different screen sizes of mobile devices.
8. Aesthetic and minimalist design Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.	**8. Balanced and simplistic visual design** Harmonious overall appearance should consist of clear contrast between visual elements, balanced layout and informative colors. Avoid visual clutter.
9. Help users recognize, diagnose, and recover from errors Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.	**9. Help users recognize, diagnose, and recover from errors** Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution. Indicate clearly the reasons if the searched locations are not found. Save the user's previous searches for fast repetition.
10. Help and documentation Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.	**10. Help and documentation** Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Provide both: fast guidance focused on the user's task and a more detailed guide with search functions.

Table 1. General and domain-specific heuristics

4. Results

The testing of the proposed MMA heuristics compared to the Nielsen (1994) heuristics pointed out that with the MMA heuristics more usability problems (19, of which 6 were severe) were found than with the Nielsen heuristics (15, of which 5 were severe). On a scale from 1 to 5, where 1 is the least suitable and 5 is the most suitable, the suitability of the MMA heuristics was rated twice as 4 and the Nielsen heuristics as 2 and 3.

The initial heuristics (*Table 1*) have been further elaborated by feedback of the applicability of the heuristics given by the usability specialists. In the following list we introduce the proposed usability heuristics for MMAs and present the justification for each of the heuristics.

1. **Visibility of the contextual map functions and important locations.** The map application should always interact with the user by giving informative feedback within reasonable time. The map functions should be visible. The map view should constantly stay visible when the map application is in use.

The limited display size of the mobile devices causes challenges for both setting map functions and making important map locations visible (Burigat et al. 2008). The power saving mode should not turn on if the user is in constant need of the map application's assistance.

2. **Match between the system and the physical surroundings of the user.** The map application should show clear indication of the user's location and other important locations (e.g. destinations and POIs) on the map. It is essential that the map corresponds in an understandable way with the physical surroundings of the user. The map should be up-to-date.

Oulasvirta et al. (2008) have compared the embodied interaction of 2D versus 3D mobile maps and summarized that 3D maps present realistic representation of objects, variable views from first-person perspective and more degrees of freedom in movement. 2D maps guide users into using environmental cues like street names and crossings. Meilinger et al. (2007) point out that different map types suit different tasks.

3. **User control over map functions.** Allow the user to take control of the map application when interruptions (from the mobile device: phone call, message, other applications' notifications, from the concrete surroundings: traffic, weather, traffic lights) happen. Allow multitasking.

Interruptions such as incoming emails, SMSs and phone calls influence interaction with mobile devices. When such interruptions occur, the application should save its current state and still be able to give the needed navigation instructions. As the use of a MMA is often concurrent with other tasks (Tamminen et al. 2004), allowing multitasking is essential. The MMA should also be context-aware, i.e. adapt to the surrounding conditions as that may enable more efficient uses of mobile applications (Häkkilä et al. 2009). For example, the MMA should adjust the visibility of screen size according to the lighting conditions and time of day.

4. **Consistency and standards.** Follow platform conventions in the user interface design. Be consistent within the use of interaction gestures, controls, functions, elements of user interface and map features. Use clear, intuitive, commonly known map symbols.

Symbols for mobile maps are designed for small screen size in which it is essentially important to consider clarity, intuitiveness and map symbol conventions. In order for the map symbols to be clear, simplification and abstraction are essential (Mullet & Sano 1995). Krygier and Wood (2011) emphasize that map symbols should work through resemblance, relationship, convention, difference, and standardization.

5. **Error prevention.** Make the map application free of errors. If errors still happen, be sure to offer the possibility to recover from them. Prevent the user from getting lost.

Careful testing of the MMA should be performed in order to reduce the amount of errors. Wayfinding support prevents users from getting lost (Schmid et al. 2010) – as long as the wayfinding instructions are correct. Besides visual and audible instructions, also tactile feedback can be given to the users (Pielot et al. 2009). Tversky (2003) emphasizes the use of local environmental cues.

6. **Recognition rather than recall.** Minimize the user's memory load. Make sure that the main functions of the map application (e.g. exploring, route guidance, zooming, panning, POI selection) are easily accessible. Use short menu paths for the main functions or keep the main functions present all the time.

Mayer and Moreno (2003) discuss cognitive overload in the context of multimedia learning. To avoid overload, they suggest solutions, such as offloading by using different multimedia channels to present information, providing cues about how the user can select and organize the data and aligning the content in a balanced way.

7. **Flexibility, scalability and efficiency of use.** Offer flexible options for the main map functions. Allow the user to save locations to be used as shortcuts (e.g. home) and support POI information. Give easy access to additional information (metadata, links, user-generated content). Make sure the user interface is scalable for different screen sizes of mobile devices.

Setlur et al. (2010) present three types of optimizations implemented to enhance the usability of specific MMAs. They emphasize the rendering techniques, interaction paradigms and optimizing the system's performance.

8. **Balanced and simplistic visual design.** Harmonious overall appearance should consist of clear contrast between visual elements, balanced layout and informative colors. Visual elements should guide users gaze to important elements. Avoid visual clutter.

In harmonious overall appearance all elements should work well together and complement each other (Tyner 2010). Harmony plays an important role in evaluating the overall appearance of mobile maps (Nivala & Sarjakoski 2005). According to Tyner (2010), balance, clarity and contrast are important in effective map design. The composition of a map should be balanced. Clarity of the map is mainly achieved through contrast, which can be created with opposites, such as dark and light. Visual clutter should be avoided. MacEachren (1995) states that the distinction between insignificant and significant visual elements needs to be made clear in order to guide attention to specific details. Color is beneficial in the context of locating and searching information (Van Laar 2001) and for grouping elements (Lidwell 2003). Krygier and Wood (2011) point out that colors should be more intense because of varying lighting conditions in use contexts of mobile maps.

9. **Recognizing, diagnosing and recovering from errors.** Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution. Indicate clearly the reasons for why the searched locations are not found. Save the user's previous searches for fast repetition.

When errors occur, recovering from them should be straightforward. Haklay and Nivala (2010) state: "Actions that are reversible are important for relieving anxiety because it is clear to the user that errors can be undone and they should not feel that they will 'break' the system by one mistaken action."

10. **Offering help.** Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Provide both: fast guidance focused on the user's task and more detailed documentation with search functions. Pay attention to the understandability of the help.

Skarlatidou (2010) emphasize the careful design of help and documentation based on the purposes of the application and the user context. He points out that it is essential to offer instructions for the description and use of the tasks that are included in the application. Moreover, he states that as the majority of map application users are not familiar with the special terminology of the field, the vocabulary and instructions should be simple.

5. Conclusion

We propose domain specific heuristics for evaluating the usability of MMAs. Four usability specialists tested initial, theoretically derived MMA heuristics versus the general Nielsen (1994) heuristics to evaluate the usability of MMA. As a result, more usability problems were found with the initial domain-specific heuristics. Also, the initial heuristics were rated more applicable for the MMA domain. The proposed heuristics also include in-depth insights to the heuristic evaluation of visual mobile map design. Based on the results of this study it can be summarized that domain-specific usability heuristics are needed in order to properly evaluate MMAs.

A limitation in this study is the small amount of evaluators for testing the proposed heuristics. The results of HE are also known for being dependent on the evaluators (Hertzum & Jacobsen 2003). Also, the generalizability of the heuristics is uncertain at this stage, as the field of MMAs is wide. We will further validate the proposed MMA heuristics. Future steps will include testing the proposed heuristics with a larger data collection.

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