
Rapport sur le mémoire de thèse de Anke Brock intitulé

« Interactive Maps for Visually Impaired People:
Design, Usability and Spatial Cognition »

(Le manuscrit est en anglais donc il est préférable de rédiger le rapport en anglais. La conclusion générale est en français)

The candidate's doctoral research represents an all-out effort toward the improvement of tactile maps for use by the Blind by augmenting the paper substrate with computerized interactive maps that respond with a synthesized voice to touch inputs. However, the thesis encompasses a scope that is much larger than the design of this type of map. It also investigates some of the fundamental questions that are connected to this idea, namely spatial cognition, spatial memory, space without vision, the nature of maps, haptic perception, and design theory. It is quite a comprehensive document that, in the opinion of this reader, could easily be turned into a book of interest to many in the field of interactive maps, in particular (not necessarily limited to their use by the Blind), but also to those interested in adaptive technologies for the Blind in general, and even to those interested in perception and design in the large.

Because the document is quite long, the author has had the wisdom to introduce it in the form of a list of research questions that are indicated upfront and then addressed in the subsequent chapters: map design space, map collaborative design, and non visual interaction, complemented by a document "walk-through".

The Chapter 2, called 'Theoretical Background', treats the basic questions including a description of the visual impairments, their causes, their consequences, the respective roles of vision, audition and touch. There is a discussion on the topic of spatial cognition to recap the main results that have been obtained in terms of way finding, navigation, recall, mental imagery, place recognition, types of spatial knowledge and their use, frames of reference, individual differences, mode of knowledge acquisition. Then follows a discussion of these aspects when one is deprived of the benefits of sight. There is an interesting discussion looking at the factors of discrepancy, of how space is dealt with in the absence of vision, and an important section on how spatial knowledge can be assessed. Then comes a detailed description of the state of art in tactile maps, their design, their use, the question of orientation and view point, how they are read, how they relate to spatial cognition, how they can be produced, designed, and Braille annotated. This chapter continues with an introduction to the so-called 'interactive maps', the devices to mediate them, tangible approaches, and the methods of interaction including touch and gesture, leading to the

question of accessibility. There is also an in-depth review of auditory interaction techniques such as earcons, speech, and spatialization and a review of tactile interaction techniques including vibrotaction, force feedback, pin arrays, and laterotactile systems and others. The chapter terminates with a discussion on user studies, usability and spatial cognition issues raised by these techniques. There is a considerable amount of material collected in this chapter.

The research begins in earnest with Chapter 3 which is concerned with the design of the aforementioned interactive maps. It is argued that the accessible design process is not exactly like other design process since users are not in a position to participate in the same manner as sighted people. To this end, the four stages of the design cycle, analysis, design, prototyping, and evaluation are revisited in this particular context, looking at communication, logistics, analysis, and compatibility issues. Interactive maps must also account for what technology has to offer in terms of input techniques that are compatible with paper overlays. These technologies are evaluated when possible. The adaptation of the design process comes next, discussing in particular the Wizard of Oz technique. Then comes the adaptation of the prototyping stage and integration of the raised map with speech technology. Interaction and evaluation is then described in detail.

The next Chapter, 4, investigates the question of interactive maps usability. This chapter is written in the form of a scientific article, going from background and goals to methods, results, and discussion. The study draws some of its originality from dividing the study into the investigation of short and long-term effects and selecting efficiency, effectiveness, and satisfaction as dependent variables when comparing ordinary raised maps to interactive maps. It was found after detailed analysis of the results of 24 subjects that concerning better spatial learning, shorter learning time, and higher user satisfaction, interactive maps — accounting for the complex effects of individual differences — held important advantages in that they would be more usable to a larger population, for instance a population of non Braille readers.

Armed with the prototype developed in Chapter 4, Chapter 5 dwells into the problem of optimizing the tactile map exploration which requires to measure the user's motor behavior during reading and exploration. To the end the Authors developed a system cleverly combining an overlying Kinect device with a 3M projected capacitive multi-touch screen. With this system the hands and fingers can be tracked during behavior giving new means of analysis but also new interaction options, for instance, accounting for gestures and not touch static contacts. Although this work is still preliminary, it opens many new avenues for non visual interaction that are discussed in turn.

The Conclusion recaps the whole work and revisits the four research questions posed at the outset. It then lists the thesis principal contributions and proposes avenues for future work aimed at overcoming the limitations of the current interactive maps, including for example their automatic generation and annotation. Future work also needs to take into account emerging technologies such as surface tactile displays. A final Glossary was an excellent addition to already excellent piece of work.

Qualité de la présentation

Le candidat a fait un travail très complet sur le plan conceptuel et sur le plan pratique qui démontre une excellente maîtrise du sujet et par extension de la conception d'interfaces personne-machine utilisables. Elle forme une base solide sur laquelle des développements futurs seront possibles. L'abondant travail est présenté clairement et de façon organisée. Le manuscrit est remarquablement exempt de défauts tels que coquilles ou figures peu claires.

En conclusion je suis très favorable à ce que Anke M. Brock présente son travail afin d'obtenir le titre de docteur de l'université de Toulouse 3 Paul Sabatier.

Le 3 novembre, 2013

A handwritten signature in black ink, appearing to be 'Vincent Hayward', written on a light-colored background.

Vincent Hayward
Professeur, Université Pierre et Marie Curie

**DEPARTMENT FÜR
INFORMATIK
MEDIENINFORMATIK
MULTIMEDIA SYSTEME**

ED MITT - ED 475
- Soutenances -
UNIVERSITE DE TOULOUSE
UT3 Paul Sabatier - Bât. 1R1
31062 Toulouse Cedex 9
France

PROF.
SUSANNE BOLL

TELEFONDURCHWAHL
(0441) 97 22 - 2 13
Sekretariat - 2 01
FAX - 2 02

EMAIL
susanne.boll@informatik.uni-oldenburg.de

INTERNET
medien.informatik.uni-oldenburg.de

OLDENBURG
6. November 2013

**Review for the doctoral thesis „Interactive Maps for Visually
Impaired People. Design, Usability and Spatial Cognition“
submitted by Anke Brock**

Background and motivation for the thesis

Millions of people worldwide and also in Europe are blind or visually impaired. One central issue for these individuals is that they travel less. Supporting them in their daily activities and the participation in society Anke Brock has designed, developed and evaluated a multimodal interactive map as a means to better support the acquisition of spatial knowledge of urban environments for visually impaired.

Review of the chapters and contributions of the thesis

The first and comprehensive part of the thesis is the related work section. In *Chapter II – Theoretical Background* Anke Brock presents the work related to her approach from several perspectives, from psychology, computer science and human-computer interaction. This chapter is extremely substantial and covers the wide scope of work that is related to interactive maps for visually impaired people. The different areas presented here are not only very impressive and comprehensive. They are also presented in very much detail and with much care to really cover all aspects that are needed to understand and underpin the contribution of the thesis. It is

such an excellent multi-perspective survey of related work that I strongly recommend that Anke Brock is considering a submission of this chapter to ACM Computing Surveys. The only thing – if at all – missing here is an introduction why the different areas are relevant for the field and a systematic overview of the approaches in the field in the sense of a classification of the approaches such as done in Table II.1 or Figure II.2. One little reference that might be added here would be the work of Kevin Lynch from 1960, *The Image of the City*, that is often referred to when talking about mental maps of people and their surroundings. It is very nice to see that this chapter also includes a set of original prototypes and devices that illustrate the state of the art in the field. The number of work cited and embedded into the context of her work is really impressive. So when Anke Brock writes at the end of Chapter II that “In this chapter we presented the broad theoretical context that concerns interactive maps for visually impaired people.” I can only say that this is absolutely true and the elaboration of the fundamentals has been very well done.

In *Chapter III*, Anke Brock reports about her design choice, and present methods that have been employed during the design cycle as well as the resulting prototypes. She introduces the motivation and the process of a participatory design for an interactive map system for visually impaired. This is a challenge and also a great contribution to involve this special user group into the design process. Her goal was to really understand the user needs “for orientation and mobility, challenges that they face when traveling, and the reading of tactile maps.” For this she advanced the methods from the participatory design process towards working in this process with visually impaired people. In her work, Anke worked with 38 visually impaired people, which is a really big number in the sense of user studies and a wonderful asset for her work. In addition to the contribution to the actual participatory design process she carefully describes the working and communication with the visually impaired participants and relates her own experiences excellently with related work and experiences in the research literature. For her approach of interactive maps she motivates the use of auditory and tactile output modalities for the map design. Table III.1 summarizes the motivated design choices for her work. The chapter reports on the iterative design and evaluation process for the tactile/auditory map from first design sketches to Wizard of Oz experiments and a refined design and experimental prototype.

In *Chapter IV*, Anke Brock is investigating the effects on the interactive map design for visually impaired people on spatial cognition. In user studies Anke compared the usability of two different map types for visually impaired people: a raised-line paper map. Even though results on the effectiveness (scores for the different types of spatial knowledge) of the interactive map prototype was not measurably better than the paper map, other variables such as the satisfaction were actually better and the learning time of the interactive map was shorter. Anke also further looked into the effect of the map type on the learning of the different components (landmark, route and survey) of spatial knowledge.

Chapter V on Designing Non-Visual Interaction to Enhance Tactile Map Exploration Anke Brock presents her work on how spatial cognition can be improved by employing systematic exploration strategies. With a design of tracking the fingers of the individual to following the tracking of the map and touch events of the multi-touch surface. She elaborates the technical set up but also details the tracking performance of the two different sources and the visualization of the movements. Based on observations how visually impaired people read maps, Anke developed basic gestural interaction techniques for fundamental interaction (such as to provide supplementary information such as distances or details on specific landmarks) with the interactive map for visually impaired.

The thesis concludes with a summary of the contributions and the answers to the research questions that were raised in the first chapter. Anke also gives clear paths towards future work in different areas of her work.

Summary

The thesis is a real pleasure to read and presents very clearly and focused the scientific contribution of her work. All of the chapter are very detailed and carefully guide the reader through the motivation, background and the contributions of the thesis. The research contributions are competitive and original in the field of human computer interaction. Anke Brock has substantially contributed to the field of interactive maps for visually impaired people.

With her thesis and the underlying research work Anke Brock has shown that she has scientifically mastered the challenge of designing interactive maps for visually impaired people. The design methods as well as the evaluation methods are very well grounded in the state of the art and are very sound for her work. Anke has implemented all of her work in substantial prototypes, both low fi prototypes for first tests and pilot tests as well as experimental functional prototypes in software and hardware.

The research results of Anke Brock have been published very at competitive venues such as CHI, ITS and IHCCP. The different conference venues also show that she was able to successfully make her work visible not only in the human computer interaction community but also in the research community of the International Conference on Computers Helping People with Special Needs.

I am looking forward to an interesting discussion with Anke Brock during the defense of her thesis.

Sincerely,

Prof. Dr. Susanne Boll

