

# Indoor cartography and usability

PhD Project Outline — Alexander Salveson Nossum  
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## 1 Background

Technological advances have enabled new methods of creating, using and distributing maps for electronic devices, in contrast to their traditional paper versions. Maps are no longer bound to be static two-dimensional representations. Highly interactive, dynamic and personalized maps are increasingly becoming the de-facto standard for representing geospatial information. Up till now, the focus in geospatial visualization has been in outdoor environments. This projects aims at contributing to adapting and extending the mentioned methods in indoor environments. The field of cartography is believed to experience a demand for indoor visualization as well as location aware systems in near future. Cartography and visualization in indoor environments have previously received some attention (Muller et al. 2006, Klippel et al. 2006, Butz et al. 2001, Radoczky 2007, Ruddle et al. 1997). However, the earlier work has been lacking proper technology and are all conducted in an ad-hoc fashion. As a result of this the outcomes of this work have not gained wide success, nor impact on the cartographic community. This project recognizes the current availability of technology as well as expected technological advances are now ready for successful research on indoor visualization.

Earlier studies on indoor visualization have focused primarily either on static, printed emergency maps or maps on early prototypes of mobile devices (Muller et al. 2006, Klippel et al. 2006, Ciavarella and Paternò 2004). The latter work on mobile devices has not gained apparent wide success due to the technological capabilities and especially availability. The current situation is different, with technology advancing rapidly. This is especially recognized on mobile platforms where “smart” mobile devices have fast processors, medium sized screens, multi-tactual interfaces as well as an array of

sensors ranging from accelerometers to (A)GPS. In addition to the fact of technological advances – previous research has mainly concentrated on traditional visual representations of indoor environments, namely floor plans. New visualization methods are needed in order to satisfy future user requirements and most importantly to adhere to the current change in cartography for interactive, highly dynamic geospatial visualization systems currently receiving attention for outdoor scenarios.

In order to develop successful new maps and map systems for indoor environments it is of utter importance to include concern on the usability issues. Thus reflecting the topics in the research agendas currently accepted in the research community (Virrantaus et al. 2009, MacEachren and Kraak 2001). This project aims at taking great care in the usability of the proposed innovations. In order to do so a focus and objective of the project as a whole will be to investigate evaluation methods for cartographic systems and designs.

Evaluation of proposed visualization methods is a common method of assessing their quality (Fabrikant et al. 2008, Coltekin Arzu and Irina January 2009, Dillemath 2005, Pugliesi et al. 2009, Muller et al. 2006) – however, new methods of conducting evaluations are being made possible, for instance through the use of eye-tracking equipment, web experiments and alike. Additionally the field of usability and human-computer interaction (HCI) has developed and still develops new evaluation methods suitable for new user interfaces. Adapting and integrating well-known methods from this field is of importance to the project. With respect to this, the project will potentially contribute to developing new evaluation techniques in cartography and make comparisons against the traditional evaluation techniques already present within cartography.

Methods of development of cartographic visualizations generally follows a linear process, where an initial idea is development, implemented and evaluated against prospective users. Similarities of the development processes and challenges in software engineering are evident. Following a linear process may limit the success of the result as the feedback from the users is available only at the end of the project and refinement based on user feedback are either to costly or to time consuming to be implemented. In this project we will investigate the feasibility of adapting agile development methodologies from software engineering into development of cartographic visualizations. This will enable iterative and user-involved development which leans very well towards development of innovative visualizations which this project aims at. This will contribute to the scientific community and directly address the current research agenda (Virrantaus et al. 2009).

## 2 Objectives

The overall objectives of the project are (1) to develop several new indoor visualizations targeted at specific usage scenarios, (2) adapting evaluation and development methodologies from software engineering and human-computer interaction to cartographic development and evaluation, (3) develop guidelines based on the results from (1) and (2) suitable for generic cartographic development of visualizations. The latter can be perceived as the main scientific outcome of the project.

The following lists the most important tasks identified for the fulfillment of the overall objectives.

1. Investigate further state-of-the-art in evaluation and design methodology in human-computer interaction and usability.

*Primarily through courses taught at IDI as well as through literature*

2. Develop several innovative indoor visualizations

*Targeted at specific usage scenarios*

3. Evaluate the visual representations developed through both new and traditional methods.

*Adapting and integrating traditional methods from HCI and usability into a cartographic context*

*Discuss the outcome of this adaptation and integration.*

4. Disseminate the research through relevant channels

*International peer-reviewed journals*

*Presentation and contribution to conferences*

*Popular science channels where appropriate*

5. Establish collaboration with other relevant researchers and research groups.

*COSTT-project<sup>1</sup>*

*IDI at NTNU*

*ICA commission on Use and User issues*

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<sup>1</sup>COoperation Support Through Transparency

### 3 Scope

The project will keep a strong focus on the development of visual representations of primarily indoor cartography. Thus limited efforts will be put into issues such as implementation of software which does not contribute specifically to the innovations of the visual representations. Neither will the project focus on issues that are adjacent and related to indoor cartography such as indoor positioning. Focus will be given to different screen sizes and available technology - however it is expected to move beyond the current state of the art in technology and predict technological advances in the future and adapt the visual representations without technological constraints.

Concerning the evaluation methodology it is not expected to adapt and integrate all methods found in HCI and usability. Primarily a focus will be on the most prominent methods. Thus it is not likely that genuinely new evaluation methods will be proposed, rather integration and application of known methods into new contexts is expected. The main goals of the project will be of a cartographic nature and thus the scope will not stretch into general HCI and usability.

Due to the limitations of a PhD project the visual representations developed are likely to have specific applicability such as limited to specific usage scenarios, contexts, technology and alike.

### 4 Research method

Several new methods for indoor visualization will be developed. Each visualization method will target specific user scenarios, particularly user tasks and device capabilities in different environments. Evaluation of the proposed visualization methods will be employed in order to ensure high quality results. Results from intermediate evaluations will guide future work and refinement of the methods. The evaluation methods will range from traditional methods within cartography to novel methods from the field of human computer interaction and usability.

The experience and results from each visualization method will contribute to the development of frameworks for developing and evaluating indoor visualizations.

A literature study will form the basis of assessing the state of the art within indoor visualization. Emphasis will be put in exploring different visualization techniques suitable for indoor environments. The relevance and support for different tasks and user groups in indoor environments will additionally be in focus.

The context affects greatly the quality of visualizations. This is hypothesized to be of even greater importance for indoor visualizations. Thus, the project will develop several different indoor visualization methods for specific pre-defined scenarios, including user tasks, user groups and environments. Collaboration with the COSTT project will enable easy access to suitable case study areas, including usage scenarios. The development of visualization methods will be performed in tight collaboration with prospective users and will be iteratively refined based on results from intermediate evaluations. It is envisaged that case studies will be conducted on St. Olavs hospital, NTNU's campus areas as well as large commercial buildings. Evaluation methods will be varied in order to assess the quality of the evaluation methods themselves as well as to gain a broad insight into the quality of the proposed visualizations. Methods from traditional cartography, human computer interaction and usability will be extended and adapted to suit the task at hand.

Following are the major tasks relating to the development of indoor visualizations:

- Elicit suitable case study areas, usage scenarios, involved user groups and potential user tasks. Will be done in collaboration with relevant partners and user groups.
- Develop indoor visualization methods targeted at specific scenarios:
  - Navigation and orientation
  - Coordination and overview purposes
  - At-a-glance usage (support situational awareness)

The tasks described above will be structured as projects. Each project will contribute to the guidelines previously mentioned. The project methodology will be dependant on the usage scenarios identified. Nevertheless, it is envisaged that the general methodology will adopt an iterative approach (Nielsen 1993) involving prospective users for rapid feedback and refinement of results.

This means that experiments and simulation will be the core methodology of assessing as well as develop the results of the project. Each project is envisaged to encompass several smaller experiments involving few, but focused participants. In addition to this, larger experiments will be conducted for final evaluation of results which will strengthen the results with statistical founding. Several experimental methodologies have been identified and selected as suitable for the project. This includes eye-tracking experiments, adapted paper prototyping for both design and evaluation, device

prototyping and web-experiments. All of these methods will inevitably require analysis of their output. Analysis of eye-tracking results in relation to cartography has still no established methods (Fabrikant et al. 2008) - thus, new methods will be developed for analyzing the data. Paper prototyping is a well known technique from human-computer interaction for initial design of user interfaces. For visualizations that relies on dynamics as well as interaction the traditional method may not be sufficient. An adaptation of the method is believed to be required. Prototyping on devices will enable a close to real-life environment where user behaviours in relation to the user interface (including hardware) can be evaluated. Device prototyping will be employed after initial design and testing has finished in order to maximize the contribution of the needed effort of this task.

Web-experiments in cartography are currently in the phase of being established. This will be applied when suitable for reaching larger sample population, if and when the visualization under evaluation can be evaluated through web interfaces. In addition, different observations of participants can be applied when suitable.

It is emphasized that the above mentioned experimental methodologies will be the basis for the research. However, if technological advances open for other experimental methods - these will be applied in combination or as a replacement of the above mentioned methods.

The research approach described above is chosen due to timespan of a PhD, where rapid feedback and refinement of results are of utter importance. An additional benefit is the potential of rapid dissemination of intermediate results which opens for feedback from the scientific community *during* the development of the project.

## 5 Expected results

The main result from the project will be an increased knowledge in indoor cartography and usability, its application areas and suitable contexts. Secondary results is believed to be affecting primarily the field of HCI and Usability in new insights on evaluation methods for this particular application.

Adjacent to the theoretical contribution the projects aims at contributing to interaction with other relevant projects which have a more practical approach. Fruitful collaboration with for instance master thesis and student projects could result in implementation of the new knowledge gained through this project.

Dissemination of results will be of great importance to the project. Primarily it will be on the form of scientific papers - preferably published or

accepted in international scientific journals appropriate for the project conducted. Additionally, effort will be put into dissemination of results in non-scientific channels - such as through the internet, popular science magazines and similar. Attendance and presentations on conferences and similar scientific gatherings will be essential to both the dissemination but also for the possibilities of attracting new collaborating partners. It is expected that each sub-project will result in at least one paper ready for publishing in one or more of the above mentioned channels.

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# A Appendix

