Methodology for designing, implementing and evaluating assistive mobility technology to enable the social inclusion and independence needs of an ageing population

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Abstract. Seamless mobile navigation will reinforce social inclusion of people with Mild Cognitive Impairment (MCI) and will lower their anxiety levels when mobile in their usual habitats as they have at hand a means to support them in cases such as where they lose their way or forget where they were going. We have continued development from existing studies of vibrotactile displays (Van Erp, 2007), for our first prototype of a wearable assistive navigation device that gives a range of sensitive haptic feedback as part of an intended larger project. The larger project will develop methods and technology that provide "companion navigators", which are of significant importance for social inclusion for people with navigation problems (Hansen et al, 2009). In addition, we add the concept of *PeerCare* as developed by Riche & MacKay (2010) in order to create a system that enhances the ability of elderly peers to communicate with and care for each other (Hutchinson et al, 2003). We describe here our methods for observing participants operating in their homes and usual habitats in order to design for their specific needs and to build a scalable living lab method (Winthereik et al, 2009) for urban and regional environments. As the prototypes become more robust, the repertoire expands and the user group is enlarged meaning a triangulation of design and testing methods is required.

A Scalable Model: Ethnographic evaluation of the mundane needs of individual senior citizens

The development of navigational concepts for support of people with MCI is based on participatory studies of MCI people in their immediate environments and evaluation with future users divided into four phases.

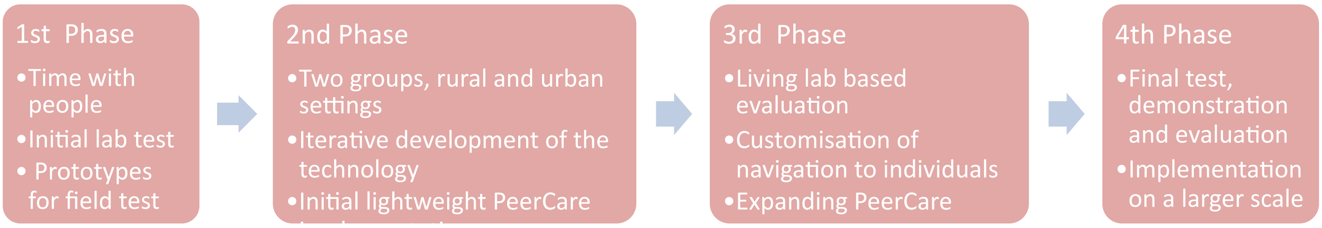

Figure 1. The four phases of Iterative Design, Integration, Test and Evaluation methodology

In the first phase we work directly with a small group of people with MCI to get direct and specific input in the early plan, design and experiment phases. This small group and their everyday situation will form the focus of the kinds of navigation activities that we develop support for. Understanding everyday challenges of this group will inform the design of components. Initial lab testing of individual components aims at developing integrated prototypes that are robust enough for field evaluations with a small group of people with MCI (Riche & MacKay, 2010, Morrison, 2010)

In the second phase we study two groups of participants with MCI in both urban and rural settings based on their everyday activities. Through field evaluations, relevant activities are identified by the participants and/or those we have observed as challenging (Riche & MacKay, 2010). We can then improve the underlying technology, the interaction design and the general capabilities for individual solutions. With iterative development of prototypes during phase two, we can add more complex tasks to the repertoire of navigational activities. In addition, we add low-fi awareness prototypes, for example, MarkerClock by Riche & MacKay (2010) into paired test-subjects' houses (friends) to begin integration of these types of systems with assistive navigation devices.

In phase three we do Living lab based (Winthereik et al, 2009) evaluations with both groups of participants. The participants perform mundane tasks in their home and daily life environments using the prototype for week-long periods at a time. This phase involves iterative development of the prototype in order to allow the navigational concepts to be customised to the individuals' needs. The concept of *PeerCare*, where elderly neighbors develop small social networks that involve both social and care exchanges as developed by Riche & MacKay (2010) will be incorporated into the system with paired instances having been introduced and tested iteratively with MarkerClock in phase two, and larger group instances in phase three and four. This adds a more socially mediated element with low-fi probes becoming integrated as an information stream both in the home and as vibrotactile information on the wearable devices. We add this component in order to create a system that not only enhances independence with surety about mobility and navigation, but also integrates and extends the ability of elderly peers to communicate with and care for each other.

In phase four user evaluations from phases two and three are added to technological results from the development of mobile computer vision, the decentralised backbone structure, and seamless navigation support and are integrated into a robust prototype which can be tested on a larger group of participants from both rural and urban areas. Both quantitative logging methods and qualitative observation and interview methods will be applied to evaluate use qualities of the navigational support in the final evaluation phases (MacKay, 1998).

Underlying technology and rationale

One of the major challenges of assistive navigation for people with MCI is to make an interface that is adaptive and proactive when support is needed. First, the interface has to allow for user input of wanted support. Next, it has to adapt and give support to the user according to the context and the person's action and behaviour. Embarking in state of art human navigation models (Van Erp, 2007) the project will enhance these to deal with the special needs of MCI users for seamless navigation outdoor and indoor. The project approach is to combine globally and locally operating localisation methods facilitating indoor and outdoor navigation. To this end, the project will develop new modalities for mobile navigation support using concealed wearable tactile displays giving direction by input from GPS and mobile computer vision for recognition of natural landmarks for indoor navigation and outdoor. The computer vision method will support the GPS based systems when satellites gets occluded or dropout a frequent problem especially in urban environments.

The mobile computer vision landmark detection will be on based natural local features using a newly introduced method suitable for mobile devices with limited processing power (Nguyen & Andersen, 2011) A distributed server solution will be designed with both a desktop and mobile interface that will allow the users (people with MCI, relatives, staff etc.) to upload images and other sources of information when problems are encountered, such as finding an entrance and/or tagging information. To support distributed processing the servers will rely on state of the art dynamic virtual machine technology, such as Snowflock (Lagar-Cavilla et al, 2009). Development of the tactile navigation interfaces for MCI users will be based on recent findings in the area (Elliot et al., 2010, Pielot et al, 2010). These results will be mapped into the MCI domain. For implementation of user modeling the project will use learning from memory techniques as case-based reasoning which compared to reinforced learning has proven to be a good method to handle situations with significant uncertainties.

Summary

The project will assist in appreciating a rich and meaningful life for all and enable people with MCI (and the elderly generally) the possibility to continue to act as a resource in society. To set a price on the value of social inclusion is extremely difficult. For the individual, the project will facilitate the possibility to take a more active part in their local community and society generally lowering the risk of isolation, which easily can lead to the development of depression which in turn increases the probability for sickness and need for care. To break this spiral as early as possibility is important for an increased quality of life and for the society's ability to offer an appropriate level of service to senior citizens who need assistance.

The methodology ensures that the individual needs are taken into account, small care networks are developed and independence through mobility is supported. In addition, the design and evaluation methods ensure the prototypes can be adapted to include additional features as they come to light through use of the prototypes at each stage and that they are able to be incrementally scaled up to include customising for incoming individuals needs and to support and provoke small and larger social groupings.

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Bios:

Ann Morrison:

Ann Morrison is trained in Visual Arts, Humanities, Digital Media Design Science and Interaction Design. Ann's main research contributions lie in tangible and urban computing for mobile and cultural environments focusing on play and activating participation. Ann has collaborated as a researcher-designer on a wide range of projects including locative, mundane technologies, social & mobile, urban surface display systems, mobile augmented reality applications designing pervasive games for field tests, a re-configurable iRoom, national ICT crisis response systems and educational environments. Prior to working as a researcher in Interaction Design, Ann worked as an interactive installation artist with a 20-year exhibition history, and for eight years in the multimedia industry working with design, visual arts and education.

Hans Jørgen Andersen:

Associated Professor Hans Jørgen Andersen research interest lies within media technology with focus on use of computer vision for support of human-computer and human-robot interaction. He is involved in development of computer vision methods supporting physical and mobile devices. These activities are supported by his experience with development of adaptive computer vision methods for use in indoor and outdoor unconstrained environments.

Lone Malmborg:

Lone Malmborg is an Associate Professor at the IT University of Copenhagen. Since 1995 her research interests have been related to aspects of interaction design, participatory design and embodied interaction. She has participated in and headed national and international research projects. Her research takes place in close collaboration with users, industry and organizations, in a variety of different fields and settings. Currently she is doing research in the area of interaction design and everyday aging together with research colleagues at the IT University. Since 1998 she has been a co-editor of the international journal Digital Creativity

Dan Witzner Hansen:

Dan Witzner Hansen has conducted research within image analysis, machine learning. His specialty is theory and applications on eye and gaze tracking with a direction towards mobility and human eye movements and attention for people with dementia. He is the technical leader of the gaze group at ITU, the first group to make a low cost and freely downloadable eye tracker. He is working on location-based services involving cameras and on design of rehabilitation and domotics for the elderly.

Lars Knudsen:

Lars Knudsen is completing his master's thesis at Aalborg University working with Wearable tactile displays and navigation. Lars' research interests include the use of interaction design, programming and electronics to expand human abilities and to inform and actuate environments.