Interactive Maps for Cognitive Disabilities

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Abstract
This paper outlines the early phases of a project that aims at supporting people with dementia in orienting and moving in urban spaces. The project is part of a wider framework whose main goal is to make our cities accessible not only to people with physical disabilities but also to those with cognitive ones like autism, spatial agnosia, and, precisely, dementia in the form of Alzheimer’s Disease. By leveraging crowdsourced maps we also aim at empowering patients and increasing their sense of private and social agency, allowing them to contribute to the wellness of the urban spaces in which they live.

Author Keywords
Interactive urban maps; dementia; Alzheimer’s disease.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
The increase of life expectancy of the world population is judged by the World Health Organization a triumph of modern society. However, it poses important challenges to institutions and infrastructure, as outlined by the Societal Challenge of Horizon 2020, which aims to "keep older people active and independent for longer

and support the development of new, safer and more effective interventions" [2]. Ageing is associated with like the reduction of processing speed and working memory, and other cognitive changes, e.g. in executive functions [16]. These changes can be sped up by a variety of degenerative diseases that jeopardize the independency and autonomy of the affected population.

Spatial orientation declines early in patients with Alzheimer's disease (AD), which is one of the main causes for institutionalization of these patients. Lithfous et al. [9] provide an overview of orientation abilities that are impacted by AD. Visual deficits and lower self-motion perception yield a reduced recognition of landmarks, while the impairment of short-term memory affects the capability of learning new routes. The deterioration of spatial representation impacts on the ability of moving in familiar environments, as much as the decline of the capability of remembering landmarks affects navigating even previously familiar routes [11].

Also persons with Mild Cognitive Impairment (MCI), which is characterized by slight impairments in one or more cognitive domains but of insufficient severity to constitute dementia, may suffer from orientation functioning decline [5]. MCI prevalence in European countries is 25.9% among people older than 65 years. MCI may convert to to AD in a percentage estimated to be 12-15% (Petersen, 1998) or higher [17], depending on the specific diagnostic criteria and markers used. It has been highlighted that both kinds of patients tend to find difficulties with spatial orientation in everyday activities and in outdoor environments [5, 15]. Persons with AD and MCI may fail to find their way in unfamiliar environments, and in more advanced stages they may be disoriented even within familiar ones [5].

In this project we aim at supporting people with spatial orientation impairment, especially those with AD in the early stages of the disease and MCI, to improve their daily living by supporting their everyday movements in the urban environment. Focusing on the early stages of cognitive decline facilitates the design of future personalized interventions in older persons, preventing or postponing the cognitive impairment or its consequences and improving the well-being and quality of life in the elderly. By making our cities more accessible we can make such people more autonomous and independent. Moreover, by providing crowdsourced maps we can empower their sense of citizenship, supporting their contribution to a collective goal that may benefit other people as well as themselves.

Related Work

Over the past years, a number of strategies for reducing spatial orientation disorders in people with AD have been proposed. Such strategies may be classified as compensatory or restorative [1]: while the former employ new ways of performing cognitive and behavioral tasks bypassing cognitive deficits, e.g. by using spatial cues [13, 14], the latter aim to restore skills in specific domains with the purpose of returning the relevant functioning to pre-disease levels or slowing deterioration, e.g. by employing reality orientation training [3]. Assistive Technology programs belong to the first group and aim at supporting AD patients in their daily living with technological interventions, providing them with the highest possible degree of independence and autonomy [1]. For example, verbal cues [7] and light cues [8] have been used to orient AD patient towards a target spatial destination. Hettinga et al. [4] conducted an exploratory research with people with mild dementia to study the effects of two different types of audio instructions. Navigation instructions spoken by a familiar voice appeared to positively impact on the effectiveness of the navigation system, while the employment of warning sounds appeared to have the opposite effect. Kaminoyama et al. [6] developed a walk navigation system using photographs of landmarks to benefit people with dementia and their families. The system provides a photograph of the next target landmark to the user's mobile devices also identifying points where they are likely to get lost. On this vein, we aim at providing support to people with MCI and early AD to increase their autonomy in their everyday movements.

Interactive urban maps for cognitive disabilities

The project aims at helping people with cognitive disabilities to live within cities by means of a new digital service providing interactive maps. Cognitive urbanism [10] studies how the characteristics of human cognition and the features of the city interact in building a subjective spatial representation of urban areas, volumes, routes, and landmarks. This project is situated in this context with the twofold aim of understanding how people with signs of cognitive decline (particularly with MCI and early AD) represent urban spaces, and provide them with support for their daily transportations and activities. While most of the current maps addressed to increase accessibility to urban spaces are focused on physical disabilities, we want to address cognitive ones.

Our first goal is to understand how people with MCI and AD represent urban spaces. We will explore cognitive maps by inviting the subjects to draw sketches of their city and positioning themselves within them, in order to collect information on how they represent urban environments and routes, where they position meaningful landmarks, etc. The first phase of the project is addressed to understand their specific modes of spatial representation, also exploring their habitual pattern of movements, their daily transportation routines , and their recurrent activities in the urban spaces. The second goal is to design digital interactive urban maps with the following general functionalities, to be tailored to the patients' specific needs on the basis of the information gathered during the first phase of the research:

1) Agenda-maps. To support the users in their everyday movements (e.g. home-relatives, etc) by allowing them to plan routes and by providing personalized aids for coping with unexpected events (e.g. a bus line is canceled in that day). Maps will be personalized on the basis of their habits and cognitive skills, in relation to the severity of their impairment.
2) Crowdsensed interactive maps. Maps will be populated with comments, reviews, trails by people with AD and MCI. They will be able to suggest places, routes, services, and activities that could make life more comfortable in their city of residence as well as in other cities.
3) **Remote support**. When the patient gets lost, the system could provide means for contacting a trustworthy person that could guide her toward a secure place through a shared map (visualized both on the caregiver's mobile phone and the patient's smartphone) and an audio communication channel.

While the "agenda-maps" and the "remote support" are addressed to help AD and MCI patients during their daily living, crowdsensed interactive maps are also aimed at empowering their sense of agency, allowing them to contribute as citizens to the wellness of their city as well as to be recognized for the value that they can bring to the community. This might make their voices truly heard, giving them the opportunity of signaling issues and opportunities, as well as recommending and advertising services tailored to them in the urban spaces where they move and live. Crowdsourced maps might then increase the sense of inclusion of people with dementia: such maps would enable them to "act" on the local communities which they belong to, by participating in public discussions and actively providing useful information, making their needs evident to the wider population, as well as showing that they are capable of being the creator of their own wellness.

This part of the project builds upon FirstLife (http://www.firstlife.org), a social network based on interactive maps, which provides a flexible platform that can be tailored to different aims. FirstLife's architecture is composed of an interactive geographical map interface as a frontend and a backend for managing and searching geographical information. The interactive map is based on AngularJS, Ionic, Leaflet and OpenStreetMap. It allows to insert and manage different kinds of Points Of Interest directly from the map, favoring the gathering of crowdsourced data. The platform also provides social networking functionalities such as the user's profile and activity stream, connections with other users, a dashboard with notifications, messaging, and groups.

The project aims to design the interactive maps through participatory design techniques: people with dementia will be involved in the design of the interactive maps, confronting our design decisions with their needs, as well as incorporating their feedback in the design. Participatory design has been used previously with people with dementia [12]. Finally, to evaluate the solution we will carry out a field trial, where patients with an impairment of spatial cognition could try the maps in a real context of use.

Conclusion

This project is an evolution of our interest in making urban spaces accessible to cognitive disabilities. To this aim, we are also designing interactive maps for people with Autism Spectrum Disorder (ASD), who have a tendency to social withdrawal, a reduced capacity of extracting a Gestalt from a collection of details, and a strong need of finding reassurance in repetitious routines. Such characteristics entail peculiar modes of spatial representation. With the prosecution of the project we aim at further extending the cognitive disabilities covered by our maps, supporting people who might encounter difficulties in orienting and moving in urban environments, also by giving them an increased agency to impact on the spaces in which they live.

Acknowledgments

This project is funded by the ICxT Innovation Center.

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