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RESEARCH PROJECT

Assistive Technology to Support the Mobility of Senior Citizens

Overcoming Mobility Barriers and Establishing Mobility Chains by Social Collaboration

Christoph Schlieder · Ute Schmid · Michael Munz · Klaus Stein

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Abstract Maintaining mobility despite the bodily, mental, or monetary challenges which often come along with advanced age is a relevant aspect of the quality of live. The collaborative research project EMN-Moves provides assistive technology for initiating and coordinating mobility support in residential districts. Mobility support is seen as a social task involving the interplay of housing societies, social organisations and residents of different age groups—with and without special needs. The project focuses on two aspects: (1) a Geo-Wiki for documenting temporary mobility barriers and for generating proposals for alternative routes, (2) a matchmaking service for bringing together (elderly) people who need support with volunteers.

Keywords Assistive Technologies · Collaborative Mapping · Geographical Information Systems · Match-making · Similarity

1 Introduction

Maintenance of mobility in old age is a crucial factor of the quality of live because many activities of daily living require being mobile [7]. Indoor mobility is important for independent living in ones own home, outdoor mobility is a prerequisite for activities such as shopping, visiting friends, and participating in social events [13]. Impairments of mobility result from different causes: old age often entails bodily handicaps such as restricted ability to walk or reduced eyesight. However, mobility can also be affected by monetary or mental constraints such as the fear of falling [20] or the fear to travel alone with public transport [11].

Research in assistive technologies for mobility in later life mostly addresses one or more of the following aspects: specific hardware design such as smart walkers [3, 12] or phones [24], personal assistance such as guides for travel planning [23] or personal reminders [16], or ergonomics and interaction design for elderly people [4, 10]. In this context, mobility assistance has been mainly studied at a regional scale (e.g., trip planning assistance) or at the scale of the individual home (e.g., robotic assistance). However, empirical studies show that senior citizens leisure mobility is mainly focused on the near neighbourhood [21]. Furthermore, research mainly concentrates on bilateral assistive relations between a needful individual and the (intelligent) technology.

In contrast, the collaborative research project EMN-Moves addresses outdoor mobility on the *intermediate spatial scale* of residential districts. Mobility assistance is conceived mainly as a *social task* which involves not only the person in need but depends on collaboration with neighbours, family members, and social organisations. We argue that collaborative approaches to mobility need to succeed on this mesoscale to be truly effective.

Given this context, providing assistive technology to support the mobility of senior citizens is mainly directed at mobility support in residential districts with interfaces to mobility from the living quarter into the district and from the dis-

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C. Schlieder · U. Schmid (✉)
Faculty Information Systems and Applied Computer Science, University of Bamberg, 96045 Bamberg, Germany
e-mail: ute.schmid@uni-bamberg.de

C. Schlieder
e-mail: christoph.schlieder@uni-bamberg.de
url: http://www.emn-moves.de

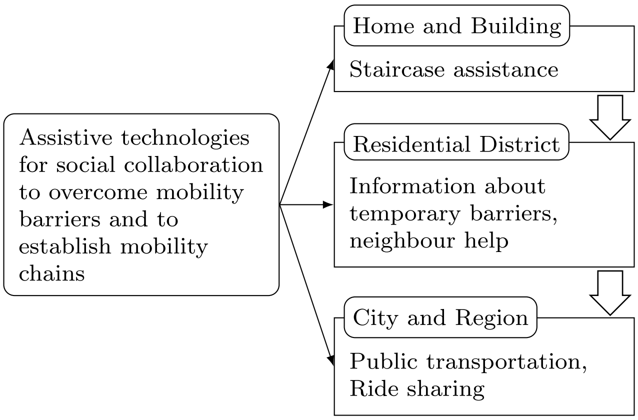

Fig. 1 Services for mobility in a residential district

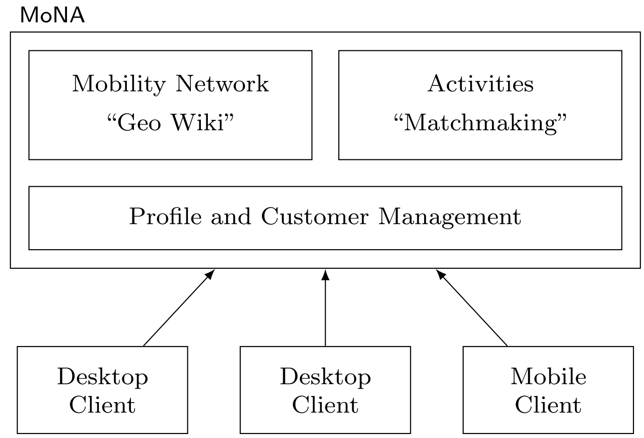

Fig. 2 Architecture of the mobility assistance system

trict in the larger area (see Fig. 1). The assistive technology provides support for (1) identification of permanent and temporal barriers together with proposals for alternative routes and (2) finding volunteer support for overcoming mobility impairments and finding partners for joint outdoor activities. What constitutes a barrier is dependent on individual impairments. Besides typical obstacles such as construction sites or high boardwalk borders, a barrier could be a route from the home to the bus stop which is not adequately lighted in the evening. Even the absence of benches may constitute a barrier for some people. Volunteer support can help to overcome some of such barriers. For example, a neighbour might help to navigate a staircase or accompany a person to the bus stop in the evening.

The EMN-Moves consortium consists of two university partners—the project group "Assistive Technology" from the University of Bamberg and the Institute of Psychogerontology of the University of Erlangen—and of three communal housing societies,[1] and of SOPHIA living network GmbH. The later is a provider of technology which supports independent living at home including activity monitoring and 24/7 reaction to emergency calls. SOPHIA differs from other providers by offering regular personal social contacts as obligatory component of its services. These social contacts are based on a network of volunteers. The volunteers are integrated in the work-flow of the company and work from offices in the company. Quality control is maintained by regular screening and training.

Different from a number of other AI related research projects in the area of ambient assisted living, EMN-Moves focuses on a present-day application scenario and not on a vision of how assistance might look in decades from now. Our assistive system is developed in tight cooperation with SOPHIA. At the end of the research project, SOPHIA will add outdoor mobility support to its portfolio. In consequence, the development of the assistive system has to take account of requirements from the application context from the beginning. The project addresses the following research questions:

– How should a mobility assistive system be designed to deal with uncertain information in such a way that on the one hand users do not receive erroneous information and on the other hand are not alienated?
– Can an intermediate range mobility system which is embedded in a social context contribute to sustainable development of supportive and caring neighbourly relations?

The system is realised on a joint framework—MoNA—described in Sect. 2. The two components, barrier identification via Geo-Wiki (see Sect. 3) and mobility support via match-making (see Sect. 4), rely on different technologies and methods. However, as illustrated in the example above, the components interact: if a mobility barrier is identified, volunteer support can be requested to overcome this barrier.

2 The Social Collaboration Framework

The Mobile Neighbourhood Assistance platform MoNA is a location-based social network with a focus on an intermediate spatial scale. The inhabitants of a district collaboratively collect and edit information about spatial configurations and outdoor activities to increase their mobility.

MoNA (Fig. 2) is a Rails[2]-based web application accessible by any modern web browser. The Geo-Wiki component (Sect. 3) provides the map-centred spatial services, whereas the matchmaking component (Sect. 4) coordinates activities and mobility partnerships.

The target user group in the EMN-Moves project are senior citizens, many of them without computer and Internet access. Service providers like SOPHIA provide telephone

[1] Josef-Stifung Bamberg, GewoBau Erlangen, WBG Nürnberg.

[2] http://rubyonrails.org/.

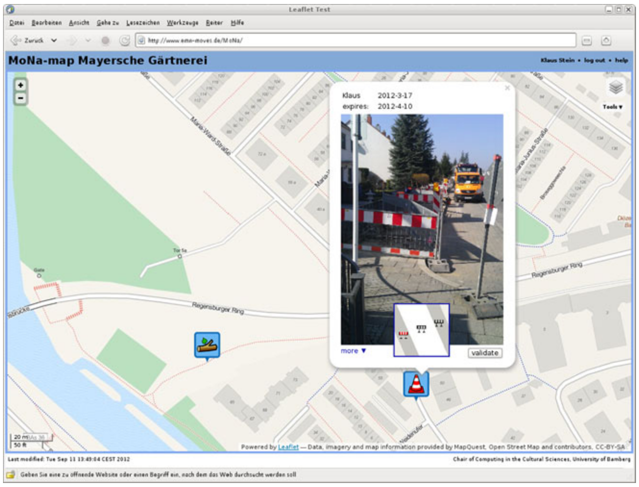

Fig. 3 MoNA-map

support for their customers on a regular basis. This means that a relevant group of users will not directly interact with the system but use the help of some employee or volunteer acting as a proxy.

This is modelled by the profile and customer management component which distinguishes between the *user* which is identified by login and password, and the *profile* which holds the personal data and everything else. By default, a user only has access to her or his own profile, but special users, e.g. the volunteers giving telephone support, may be allowed to switch to the profiles of their customers and act for them. Seniors can also allow access to their relatives. For each edit the system logs both: the user and the current profile, so it is traceable *who* did *what* for *whom*.

3 A Geo-Wiki for Overcoming Mobility Barriers

Exchanging information about the changes in the spatial environment is maybe the most important geospatial information need at the level of residential districts. Since the local residents know about their surroundings most viable information is about temporary mobility barriers like road works or snow piles. However, these and other obstacles that influences mobility could not be mapped in a topographic base map because of their temporary character.

Temporary geographic objects constitute a special challenge insofar as they are known to cease to exist in near future which means that they need continuous monitoring and updating. In principle, collaborative mapping approaches based on volunteered geographic information (VGI) could provide a solution [6, 8]. While most VGI applications focus on data collection, GeoWikis provide means to address change [17, 19]. However, current GeoWikis provide no specific mechanisms to deal with temporary objects.

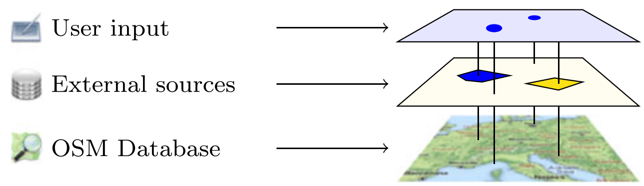

Fig. 4 MoNA-map layers

The Geo-Wiki component of MoNA (Fig. 3) is an OSM[3]-based VGI system which allows users to map temporary spatial objects. Using OSM data for the base map (Fig. 4) provides an adaptable detailed map with good quality [9].

Collaborative mapping of temporary objects raises a number of research questions:

- aging, i.e. temporary barriers should be removed from the map by the system after some expire time. Maps of temporary objects have to deal with *false positive errors* (a barrier is shown on the map but has ceased to exist in the environment) and *false negative errors* (a barrier which still exists is removed from the map). Monitoring approaches need to balance the two types of errors.
- attention: dedicated users are notified about barriers or areas which need to be checked.
- strong binding: barriers are mapped on top of the base map layer and connected to underlying base map objects without being part of the base map database. Therefore changes on the base map layer may invalidate barriers and the system has to provide an unintrusive solution.

These issues are addressed by a mechanism of automatic aging which models and tracks different barrier states (Fig. 5, for a detailed description see [22]). Barriers in *set* state are shown to all users. Interested users can opt in to see also icons of the other states: planned barriers, e.g. planned road works known from third sources. This draws attention to this spot and increases the probability of the barrier to be mapped as soon as possible. When a barrier is mapped it is assigned an expire time. Some period before this expire time is reached, the creator and other interested users are actively notified to be able to re-validate the barrier. Without revalidation, the barrier switches to state *unvalidated* and is shown only to the interested users. It will get removed completely after a second time span without further revalidation.

Setting the expire times depends on various constraints. If the expire time is not explicitly set by the user or inferable from background information (e.g. for some scheduled road works), a time span is chosen automatically dependent of the type of barrier. A manual revalidation of a barrier will expand this time-span for *some* types of barrier, but only if the expire time was not set explicitly in the beginning.

[3] OpenStreetMap, http://www.openstreetmap.org/.

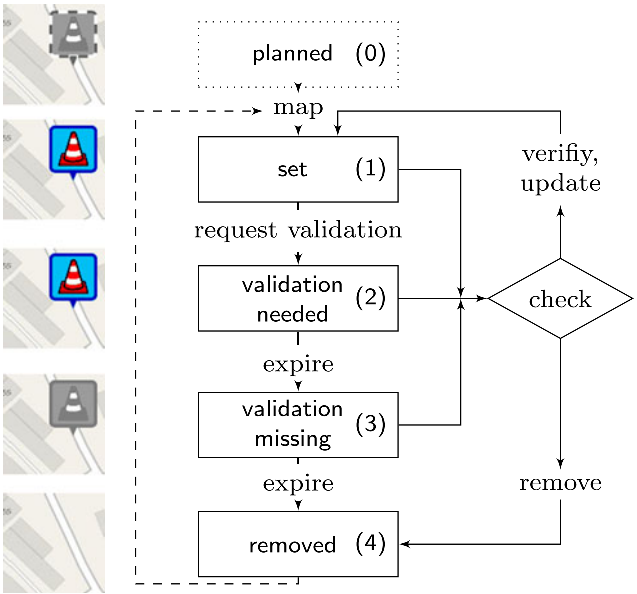

Fig. 5 Barrier states

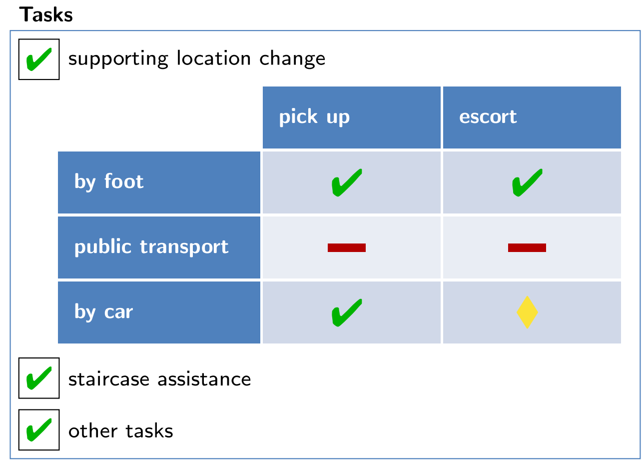

Fig. 6 Screen for entering tasks a volunteer is willing to undertake

Additionally, generalisations based on the barrier type can be modelled. If a number of paths is reported to be free of snow one could assume this may also hold for the others.

Spatial objects on the map may refer to additional information like the barrier in Fig. 3 which shows a photograph of the road works. The Geo-Wiki also supports associations in the reverse direction: Wiki pages have a map included and Wiki text can refer to mapped objects. This works like a hyperlink, that is, words in the text are marked as map links, but instead of opening another Wiki page the map scrolls and zooms to the corresponding spatial object and highlights it. This allows housing associations as well as residents to provide additional mobility information about their neighbourhood.

Finally the mapping component is also available for the matchmaking service to provide spatial constraints and a visual feedback for these.

4 A Matchmaking Service for Establishing Mobility Chains

Approaches to matchmaking typically rely on similarity measures to asses how good a case fits to a matching request. Applications aim at identifying people with similar interests, profiles or skills in social networks [1, 25]. Furthermore, matchmaking is applied in technical domains such as distributed resource management [18] and web services [5].

In the context of the project, there are two different kinds of requirements for matchmaking: (1) asymmetric matching of persons with needs and volunteers, and (2) symmetric matching of persons who want to engage in joint activities away from home. Exemplary user stories, the basic system architecture, and the requirement specification is described in [15]. In the following we give an overview of the matchmaking approach, focusing on asymmetric matching.

Asymmetric matching is a service offered to a restricted set of users. Volunteers are recruited via SOPHIA and social organisations, mobility impaired seniors are personally known by the same agencies. Volunteers as well as seniors can use the system via their home computer or smart-phone. Alternatively, employees of the social organisations or designated relations or friends can use the system as proxies.

Information about a match case is a collection of data gained from the profiles of registered users and from current requests. Profiles of volunteers contain information about gender and the type of tasks she or he is willing to undertake. A screen-shot of the mask for selecting tasks is given in Fig. 6.

Tasks can involve a chance of location (e.g., escort to a performance of the city theatre) or not (e.g., escort to the local supermarket and back). Assistance with a staircase might be needed. In general, tasks are classified by means of transport (by foot, public transport, car) and whether only a pickup or transport is needed or whether an escort is necessary or wanted. For example, a person might need a transport by car to the physician and only wants to be taken there and back an hour later. On the other hand, a person might want that the volunteer stays with him or her. Volunteers fill in the mask by selecting and excluding tasks in the matrix. Help seekers characterise their need in the same way, adding a textual description of the activity for which they want support.

Besides the task characterisation, a help seeking request contains information about (1) startend location (typically the home address given in the profile), (2) the target location if a chance of location is involved, (3) startend time, and

(4) additional wishes, such as gender or age group of the volunteer. Start and end times can be marked as fix or variable. For example, if a helper for shopping is needed, it can be irrelevant if the help is given before or after noon. However, if a visit to the physician or to a theatre performance is scheduled, the time needs to be fix.

Given these requirements, matching of volunteers to seniors involves hard and soft constraints. Hard constraints are matched using simple binary values where each correspondence returns value 1 and each disagreement returns value 0. Matching with respect to time takes into account the availability times of a volunteer and the time requested by the help seeker. For fixed times, the match is calculated by a simple interval logic based on the start and end times. If the time interval for the help is included in the time interval given by a volunteer, the match is 1, if the time intervals are not overlapping, the match is 0. If time intervals are overlapping on one side, the match is 0.5, if the time given by the volunteer is included in the time interval for help, the match is 0.25. If the requested time is variable, e.g., "an hour on Tuesday somewhere between 9 am and 4 pm", the matching is reversed, that is, it is checked whether the availability time of a volunteer falls into the interval given by the help seeker.

Currently, the match of the location is not taken into account, since the prototype system currently is only implemented in one residential district. In general, the system should prefer to match such volunteers and help seekers who are living near each other. On the one hand, this is more convenient for volunteers because it minimises the journey, on the other hand, thereby the establishment of an informal support network in the neighbourhood is facilitated. Ideally, volunteer and senior can arrange future support in person, without the help of the system. We plan to define the location match not only based on Euclidean distance between the starting locations of volunteer and help seeker but take into account topological information such as "same residential district" or "same side of the river".

The total match is calculated as weighted sum. Because asymmetric matchmaking is provided for preselected sets of users only, the total number of volunteers and help seekers will be small (e.g., between 100 and 500 users), all results with a fit above 0 are presented to the help seeker in ranked order. If the user selects a volunteer, the volunteer is informed by email or SMS. He or she has to respond to the request before a fixed time. If there is no response, the help seeker or proxy is requested to select another person. During the next six month, it is explored whether and how often it happens that no volunteer can be found. The involved social organisations have to decide how they will deal with such cases. One possibility would be that an employee of the organisation will fill the gap.

Symmetric matching aims at involving senior citizens in a given residential district in common activities such as walking, shopping, going to church. For symmetric matching, we plan to rely on an ontology of leisure activities for senior citizens, similar to approaches in personalised recommendation systems [14]. We are currently working on an approach to ontology-based matchmaking which is based on self-extending ontologies [2].

The matchmaking component can be interleaved with the Geo-Wiki to find volunteer support to help to overcome temporal barriers. From the practical perspective, the most critical point is on what temporal scale a decision should be made by the system that the best match is found or that no match can be found for a time-constrained request. When a match-case is closed to early—especially for symmetric matching—a more suitable partner to share an activity who enters his/her interest later might be overseen. On the other hand, a person who seeks an escort to a time critical event might prefer to know two days in advance whether a helper was found. As a first step, we solve this problem by requesting that the user specifies a time limit. Alternatively, we plan to explore user- and request-adaptive strategies.

5 Conclusions and Further Work

We presented the design of an assistive system for mobility support for senior citizens which takes the perspective of mobility support as social task. The focus of our research is *information design*, that is, which information can be requested from and given to the users in such a way that he or she can easily overcome mobility barriers and establish mobility chains. Current research addresses the problem how the system handles insecurity. In the Geo-Wiki, insecurity exists for temporal barriers. In matchmaking, insecurity exists for the decision whether the best match is found or whether no match can be found. For both domains, we explore different heuristics. Besides many practical considerations which have to be taken into account to implement such a system, the topic allows us to explore how AI technologies can be brought to use to provide for intelligent assistance. The used technologies involve temporal and spatial reasoning and the use of ontologies for similarity assessments.

Currently, the prototype system is exemplarily implemented at SOPHIA serving one residential district. We are conducting an empirical study with members of senior citizen councils and social organisations to assess which types of barriers people are confronted with and which kinds of mobility assistance people are wishing. We are hoping that the introduction of our assistive system in this residential district will help senior citizens to enhance their mobility and thereby their general well-being. It remains to be seen whether the introduction of the mobility assistance system will be accepted and used not only by seniors but by many people in the neighbourhood and contributes to the development of social awareness and neighbourhood support.

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Christoph Schlieder is professor and Chair of Applied Computer Science at the University of Bamberg where he heads the research group on Computing in the Cultural Sciences. He holds a doctoral degree and a habilitation degree in computer science, both from the University of Hamburg. Before coming to Bamberg, he teached computer science at the University of Bremen. His primary research interest are approaches for semantic information processing and their application to problems from the cultural sciences, especially to problems involving spatial data. With his research group he has developed software solutions that assist, for instance, preservation scientists mapping built heritage.

Ute Schmid is professor of Cognitive Systems at the Faculty Information Systems and Applied Computer Science of the University of Bamberg. She received a diploma degree in Psychology as well as a diploma degree in Computer Science. She holds a doctoral and a habilitation degree in computer science, both from Technical University Berlin. During her doctoral and post-doctoral time she worked as assistant at TU Berlin, as research stipend at Carnegie-Mellon University, and as lecturer at the University of Osnabrück. Her main research interest are approaches to learning on the knowledge-level and application of methods of cognitive AI to various domains.

Michael Munz is research assistant in the BMBF project EMN-Moves. He received his bachelor degree in Applied Computer Science in 2009 and his master degree in 2012, both at University of Bamberg.

Klaus Stein is research assistant in the BMBF project EMN-Moves. He received a diploma degree in Computer Science at University of Technology München (TUM) in 1998 and his doctoral degree in computer science from TUM in 2003. He works at the Chair of Computing in the Cultural Sciences in Bamberg since 2004.