Mobility Impaired Pedestrians Are Not Cars: Requirements for the Annotation of Geographical Data

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Abstract. Mobility is one prerequisite for carrying out an autonomous and independent life. As mobility impaired pedestrians impose very heterogeneous requirements regarding the calculation of optimized routes and the provision of navigation instructions, currently available navigation systems do not offer sufficient support. The main drawback is due to inadequate map data which is mostly optimized for car navigation. To overcome these limitations, the technique of multimodal annotation of geographical data has been developed for which additional requirements have been gathered by conducting a survey including 88 visually impaired respondents. Within this paper, the results of the survey are presented. Requirements for multimodal annotation are derived and discussed.

Keywords: Mobility impaired, annotation, navigation systems.

1 Introduction

The group of mobility impaired as defined in detail later in this paper includes a broad range of disabled such as wheelchair users, blind and visually impaired, as well as people who suffer temporary or situational mobility restrictions. Activities and tasks such as accessing the work place, meeting daily consumer needs, reaching health professionals' offices, meeting friends and relatives are not possible without a minimum level of mobility. Hence, mobility is one prerequisite for carrying out an autonomous and independent life. As mobility impaired travellers are restricted regarding their ability to move independently and autonomous in known as well as in unknown environments, they are consequently also restricted in terms of carrying out an independent life without the support of other people.

Vehicle navigation systems have become miniaturized and affordable for the mass market, and their application has widened towards pedestrian navigation. Additionally, navigation software for mobile phones and other small devices capable of integrating GPS sensors has become widespread over the market. People without mobility restrictions benefit greatly from currently available navigations systems as inaccuracies regarding positioning and data limitations are compensated easily. In contrast, many requirements of mobility impaired pedestrians are only partially or not fulfilled.

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For instance, wheelchair users are often guided via inaccessible routes including high curbs or stairs leading them into dead ends [6]. Regarding visually impaired pedestrians, routes often include dangerous locations such as street crossings without traffic lights, or routes without sufficient orientation features that are sensible without the use of vision. Currently applied route calculation algorithms mostly optimize for route length or for time needed to pass a route. In contrast, blind travellers try to avoid big, noisy, and crowded cross-ways and consequently accept a longer but safer route.

Since the fundamental work reported in [5], many research projects have been conducted to develop navigation systems tailored to the needs of mobility impaired travellers such as the MOBIC project [11], Drishti [9], Pontes and Odilia [7, 8], or work specific to the group of wheelchair users reported in [3]. Although all these projects resulted in promising approaches and prototypes, one of the main problems remaining is the acquisition of geographic datasets that are needed to support different groups of mobility impaired travellers more adequately, as most drawbacks of current navigation systems are due to an inadequate basis of the underlying geographical data. Information such as the exact location of pavements and their condition (i.e. amount of cracks and holes), the location of lowered curbs, the location of tactile guide strips and traffic signals eligible for blind pedestrians etc. is not available [2]. Even commercially available navigation systems developed specifically for visually impaired such as Humanware's Trekker [4] or Sendero GPS [10] do still rely on map data previously optimized for car navigation. Although these systems provide an accessible interface, they do not offer optimized routes or the generation of other than turn-by-turn instructions similar to those used for car navigation.

As the financial effort necessary to acquire the additional data is beyond available funding by public institutions, we developed the technique of multimodal annotation of geographic data to enable users of such navigation systems to enrich existing geographical data using a semi-automatic method and share this data with other users of the specific user group [13, 14]. The technique of multimodal annotation is described briefly in section 3 after the target group of mobility impaired pedestrians is introduced in section 2. To gather additional requirements for the annotation of geographical data from the group of visually impaired, we conducted a survey including 88 visually impaired participants from Germany and Switzerland. The results of the survey are presented in section 4. Requirements for the multimodal annotation of geographical data are then discussed in section 5. Finally, a conclusion is drawn and an outlook is given in section 6.

2 Mobility Impaired Pedestrians

The group of mobility impaired pedestrians is very heterogeneous as it includes people with a wide variety of both temporally restricted and temporally unrestricted impairments. However, in most cases mobility impairment is solely defined as a restriction of the locomotion system limiting persons in their ability to change their location independently [12]. We will thus elaborate this definition during the following discussion to suit the context of navigation systems. In particular, an expansion is necessary to include pedestrians such as visually impaired and blind persons. We will thus rely on the following definition for mobility impairments derived from previous work [14]:

Mobility impairments include all functional limitations which affect the ability of a person to reach a remote destination independently. A physical, cognitive, or sensory impairment or a combination of them may lead to mobility impairment.

The cited definition allows for an inclusion of pedestrians with a broad range of restrictions. For example, visually impaired and blind people are not restricted regarding their locomotion system. However, due to the restriction to sense their environment visually, visually impaired and blind people are consequently mobility impaired. They rely upon the use of assistive means such as high-grade glasses, long canes, guide dogs, or even navigation systems such as mentioned in the previous section. Furthermore, most blind persons are limited to routes previously learned with the assistance of orientation and mobility instructors.

Additional groups of mobility impaired pedestrians include people with cognitive impairments, deaf people, wheelchair users and elderly people. People with cognitive impairments such as Alzheimer's disease face orientation problems due to short-term memory loss. In contrast, congenitally deaf people often have reading deficits as sign language is their first language particularly imposing additional requirements regarding the presentation of navigation instructions. Wheelchair users need paths without inaccessible structural barriers such as stairs or high curbs. Finally, elderly people normally can be assigned to one or more of the mentioned groups as diverse diseases and restrictions emerge with increasing age. As a consequence, elderly people may suffer visual impairments such as cataracts or macular degeneration or suffer diseases regarding their locomotion system hence being assigned to the corresponding groups.

3 Multimodal Annotation of Geographic Data

Within this section we give a very brief introduction of the technique of multimodal annotation of geographical data. Details can be found in previous publications such as [13] and [14]. The technique of multimodal annotation is intended to provide supplementary data for the calculation of personalized and hence optimized routes as well as for the generation of better suited navigation instructions for the targeted user group. Annotations are acquired either by direct user input via an appropriate navigation system or semi-automatically by analyzing the user's LOM-Modality which combines the user's location, orientation and movement into one modality. This allows for drawing conclusions using arbitrary combinations of all three spatial dimensions to annotate the underlying geographical data. The acquisition of additional data by concerned users offers many advantages as the perception of actual obstacles, hazards and characteristics of the environment differs strongly between mobility impaired and non-impaired travellers [15].

Annotations acquired by direct user input include information about the ground surface, the slope of a path section, specific points-of-interest (POI), the location of barriers and obstacles, small sound samples, or even images. Additionally, annotations can include user ratings for routes or specific route sections such as safety or convenience ratings. Automatically derived annotations using the LOM-Modality include specific convenience weights for path sections indicating the suitability for specific user groups. For example, measures include the frequency of use or the average time to pass a route section by users of a specific user group.

To enable a broad usage of acquired annotation data, datasets are transmitted to a central database where the annotations of all users are assembled and associated with the user groups of the corresponding user. As the association only relates to the user group, no relation of annotation data and user can be reconstructed, hence ensuring basic privacy requirements. However, a traveller navigating in unknown environment is then able to access specific data associated with his user group remotely to broaden his map data. The acquired additional information then enables the calculation of an optimized route based on multiple criteria and enabling the generation of navigation instructions with respect to his specific requirements.

4 Survey

4.1 Goals

Questions were related to navigation and orientation in both known and unknown environment. In particular, the outcome of the questionnaire should reveal how visually impaired pedestrians navigate and orientate and which environmental orientation features are used frequently and could therefore be a natural target for annotations. Additionally, the questionnaire should reveal which features of paths have positive or negative effects upon navigation and orientation and weather visually impaired pedestrians would accept a longer route if suited better to their specific requirements. Finally, expectations regarding the use of navigation systems should be exposed by the survey.

4.2 Subjects and Procedure

A total of 88 persons from Germany and Switzerland participated in the survey. The questionnaire was distributed online via various mailing lists such as the main information list of the German Blind Union. Respondents were asked to fill out a MS Word document which was pre-tested by two blind persons regarding its accessibility and structuring. Alternatively, respondents were given the possibility to conduct a telephone interview.

The questionnaire consisted of three sections with a total of 30 questions using both quantitative and qualitative question types. The first part included six demographic questions about gender, age and the specific type of visual impairment. The second part included twelve questions regarding navigation and orientation in known environment followed by the third part including twelve questions about navigation and orientation in unknown environment. The questionnaire also included questions about assistive devices used for daily navigation including questions about experiences with navigation systems if applicable. At the end of the questionnaire, respondents were asked to state their ideal vision of mobility and navigation systems' support. Regarding the distribution channel, a total number of 5 respondents asked for conduction of a telephone interview. As shown in Table 1, respondents represent a broad range of different ages:

Table 1. Age of Participants

Age	20 - 35	36 - 50	51 - 65	> 65
Participants	22 (25%)	37 (42%)	18 (20.5%)	11 (12.5%)

44 (50%) of the participants are blind whereas the other 44 respondents declared that their remaining vision allows for at least minor use for navigation and orientation. 58 (65.9%) of the respondents are congenitally visually impaired and accordingly 30 (34.1%) reported a later commencement of the visual impairment. As the questionnaire was distributed online, the group of possible participants was limited to the technically more experienced visually impaired. However, visually impaired people belonging to this group are most likely to adopt navigational support provided by navigation systems.

4.3 Results

Within this section we briefly describe the results of the second and third part of the survey. We mainly concentrate on results which only indirectly relate to the annotation of geographical data and present directly related results in section 5 where corresponding requirements are then directly derived.

Only 20 (22.7%) of the respondents need assistance when travelling, the great majority or 68 (77.3%) travels without the assistance of another person whereas 47 (47.7%) learned routes within mobility training sessions. Although the group of respondents is not representative, the results show a significant improvement regarding mobility of visually impaired compared to earlier studies such as [1]. Regarding the use of mobility assistance, the long cane was named by 74 (84.1%) of the respondents as exclusive or primary mobility aid. The long cane is used in conjunction with other vision aids by 12 (13.6%), with tactile maps by 12 (13.6%), with a guide dog by 6 (6.8%), and with a navigation system by 3 (3.4%) of the respondents.

Regarding the effort needed to learn a new route, respondents reported a mean necessary amount of three to four repetitions. The majority of respondents (67 or 76.1%) reported a great interest in travelling in unknown environment regularly. Concerns were mainly related to a possible loss of orientation, although most respondents (81 or 92%) reported positive experiences when asking other people for help. 81 (92%) of the participants are interested in using navigation systems tailored to the needs of visually impaired whereas 27 (30.7%) already experimented with such a system. Three-fourths of the respondents would use functions to store and use additional personal geographic data such as points-of-interest or other specific annotations such as small audio snippets. Only two respondents denied such a function completely, leading to a conclusion that most users of the targeted group would use functionalities for the annotation of geographical data if provided by navigation systems. Finally, most respondents reported great expectations regarding the development of novel navigation solutions satisfying specific needs of visually impaired pedestrians. The prevalent vision can be précised as navigation systems should enable visually impaired pedestrians to reach most locations independently of help provided by other people. Most respondents expect a great improvement of mobility and independence. However, many respondents declared that specific navigation systems must become more affordable as otherwise their potential distribution will be limited.

5 Requirements for the Annotation of Geographical Data

Currently used map data for navigation systems both for in-vehicle use and pedestrian use includes mostly roads and areas that are accessible for vehicles. However, as pedestrians are not bound to this network, a higher resolution of geographical features is required for pedestrians and in particular for mobility impaired pedestrians [2]. Consequently, an enrichment of available map data is necessary to provide appropriate navigational support. This conclusion is supported by the great amount of environmental features for orientation named by respondents of the survey. Examples include tactilely sensible features such as curbs, stairs, fences, balustrades, ground composition, and changes of ground composition. Additionally, acoustically sensible features included traffic noise, the sound of stores and restaurants, and the echo from building fronts aroused by panning the white cane. Moreover, respondents reported the use of smells from restaurants, bakeries, and snack bars as an orientation aid. Regarding wheelchair users, important information include the location of lowered curbs, stairs, missing ramps, condition of pavements, or too small traffic islands. Similar features are also applicable for elderly pedestrians. As most of these environmental features are not included in currently available map data, techniques for multimodal annotation of geographical data must consequently provide methods for the annotation of the cited environmental features.

As the group of mobility impaired pedestrians is very heterogeneous, requirements for rating routes are much diversified. For example, a route for a wheelchair user must not include sections exclusively traversable by stairs whereas this restriction does not hold for visually impaired pedestrians. Lowered curbs are facilitations for wheelchair users entering a pavement. In contrast, lowered curbs may impose additional risks for blind pedestrians as the transition between pavement and street cannot be detected using the haptic sense. Additionally, a wheelchair user benefits from a slightly longer route of much of it contains a decreasing slope. Security considerations are important criteria for blind pedestrians. Not surprisingly, 43 (48.9%) of the respondents reported to explicitly avoid large cross-ways or big plazas. Furthermore, 83 (94.3%) of the respondents would accept a longer route in case this route would conform better to specific requirements compared to shorter routes. Consequently, a route optimized solely regarding its length might not be of optimal choice. Annotations acquired from mobility impaired pedestrians must therefore provide required information to be used for multicriteria routing algorithms which consider diverse needs of the respective user.

Besides the requirements imposed by the need to provide orientation and navigation information, to generate navigation instructions, and to calculate optimized routes based on multiple criteria, also temporal requirements must be taken into account. Geographical attributes and annotations are due to change over certain time spans. For instance, construction sites and road works are obstacles which only last for a specific time. Events such as large fairs also affect the accessibility of certain areas only for a specific time span. Furthermore, also annotations are affected by temporal constraints as an older user rating might be weighted less than a newer one when calculating a mean value for a given route section. Subsuming the discussed requirements, annotations must contain specific relations, namely an association with one or more user groups, an association with location information as well as a temporal relation. An association with user groups is necessary for determination of an applicability of annotations within route calculation and generation of navigation instructions for specific users. Additionally, a relation to location information derived from the annotating user's LOM-Modality is necessary as otherwise no spatial application would be possible. For instance, a usage of photos for navigational instructions would not be possible without knowing the exact perspective necessary for guiding a pedestrian. Finally, temporal relations are important for rating annotations as older annotations might be of less validation than newer ones. Additionally, annotations might also be only valid within specific temporal intervals as for instance illuminated advertising will only be noticed if the light conditions are adequate (implying availability only at nighttime).

6 Conclusion and Outlook

Within this paper, requirements for the annotation of geographic data are discussed. The requirements are derived from a survey including 88 visually impaired people. We conclude that geographic annotations acquired by mobility impaired and particularly visually impaired pedestrians must be usable to annotate various types of points-of-interest such as obstacles or environmental orientation features to enhance currently existing map data. Additionally, annotations must include a relation to specific user groups, a spatial reference derived from the annotating user's LOM-Modality, and temporal relation respectively. By providing all cited relations, annotations are eligible for application within multicriteria routing procedures as well as for the generation of better suited navigation instructions as additional orientation and navigation information can be included. After the provision of a theoretical foundation, multicriteria routing algorithms are currently being developed incorporating requirements of different groups of mobility impaired pedestrians. Finally, an evaluation of the described technique of multimodal annotation is planned and will be conducted shortly after simulations of the developed routing algorithms have been finished.

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