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Crowdsourcing-Based Mobile Application for Wheelchair Accessibility

Zhan Liu, Nicole Glassey Balet, Maria Sokhn, Eline De Gaspari

Institute of Information Systems, University of Applied Sciences and Arts Western Switzerland

Institute of Social Work, University of Applied Sciences and Arts Western Switzerland

zhan.liu@hevs.ch, nicole.glassey@hevs.ch, maria.sokhn@hevs.ch

eline.degaspari@hevs.ch,

Abstract

Creating an optimal travel plan is not an easy task, particularly for people with mobility disabilities, for whom even simple trips, such as eating out in a restaurant, can be extremely difficult. Many of their travel plans need to be made days or even months in advance, including the route and time of day to travel. These plans must take into account ways in which to navigate the area, as well as the most suitable means of transportation. In response to these challenges, this study was designed to develop a solution that used linked data technologies in the domains of tourism services and e-governance to build a smart city application for wheelchair accessibility. This smart phone application provides useful travel information to enable those with mobility disabilities to travel more easily.

Keywords

Linked data, crowdsourcing, wheelchair accessibility, mobility disabilities, semantic web, mobile application

Introduction

Travelling to have dinner with friends in a restaurant, shop, or visit a museum should not require too much time or advanced planning, and for most people, these outings are simple. However, even simple trips can be extremely difficult for people with mobility disabilities, who may need to plan their travel days or months in advance. In fact, the market for accessible tourism is tremendous (Darcy and Dickson, 2009; Buhalis et al. 2005). According to the World Health Organization (2015), over a billion people, approximately 15% of the world's population, have some form of mobility disability. In Switzerland, the number of people with mobility disabilities reached 780,000 in 2012 (Swiss Federal Statistical Office, 2012). Disabilities (physical, sensory, or cognitive) limit people's long-term ability to participate in daily life activities and interact with their environments (family, profession, schools, means of transport, etc.).

Information systems consist typically of multiple databases with independent data stored on different computer systems and in different data models, many of which commonly contain overlapping and inconsistent data. Although there are many ways to make the data useful, the most fundamental is to enable anyone to access and use it without formatting or licensing restrictions. However, traditional web technologies do not allow people to obtain information easily from different databases, as the data are usually stored in a variety of formats. To link the data and obtain useful information, users must spend considerable time collecting and comparing the adaptive information from different sources and databases to understand to what the data refer, and the way in which the information is interrelated. Semantic-based, linked data technologies make data more meaningful and useful. By providing identifiers (URIs) in datasets, such as places, transportation, and geographic areas, we applied linked data to individual data items and statistical observations. Thus, our algorithms were able to identify crowdsourcing data with semantic-based, linked data technologies, which then can be used to link information that is more useful. For example, once a user collects data about a point of interest, or POI (e.g., longitude, latitude, and the accessibility criteria), our application identifies whether the POI is a restaurant or museum. Further, the linked data technologies also allow us to provide additional information when it is available on the Web, such as its hours of operation, telephone number, or menu and prices. To provide context descriptions and location information, the mobile application links each POI to some external ontologies, including DBPedia (Auer et al., 2007) and Geonames (Wick and Vatant, 2012). By applying standardized ontologies, our semantic-based solutions offer another significant contribution that makes information easy to share, publish, and reuse as structured data and domain knowledge. The use of linked data is ideal in helping people with mobility disabilities make their travel plans; it also provides complementary services for tourism businesses simultaneously.

Therefore, the main objective of this research was to use crowdsourcing data to design and develop a visualized travel accessibility system in the form of a mobile application for people with mobility disabilities. We referred to this as WEMAP, and created a User Story to illustrate our solution (Figure 1). We adopted a design science approach that would answer the following research questions:

- When making travel plans, what are the real needs of people with mobile disabilities?
- How does one design and develop a mobile application by applying new approaches for semantic-based, linked data technologies and information visualization?

- How does one build a solution that can generate door-to-door routes automatically to avoid obstacles to wheelchair accessibility and make the journey easier for people with mobility disabilities?

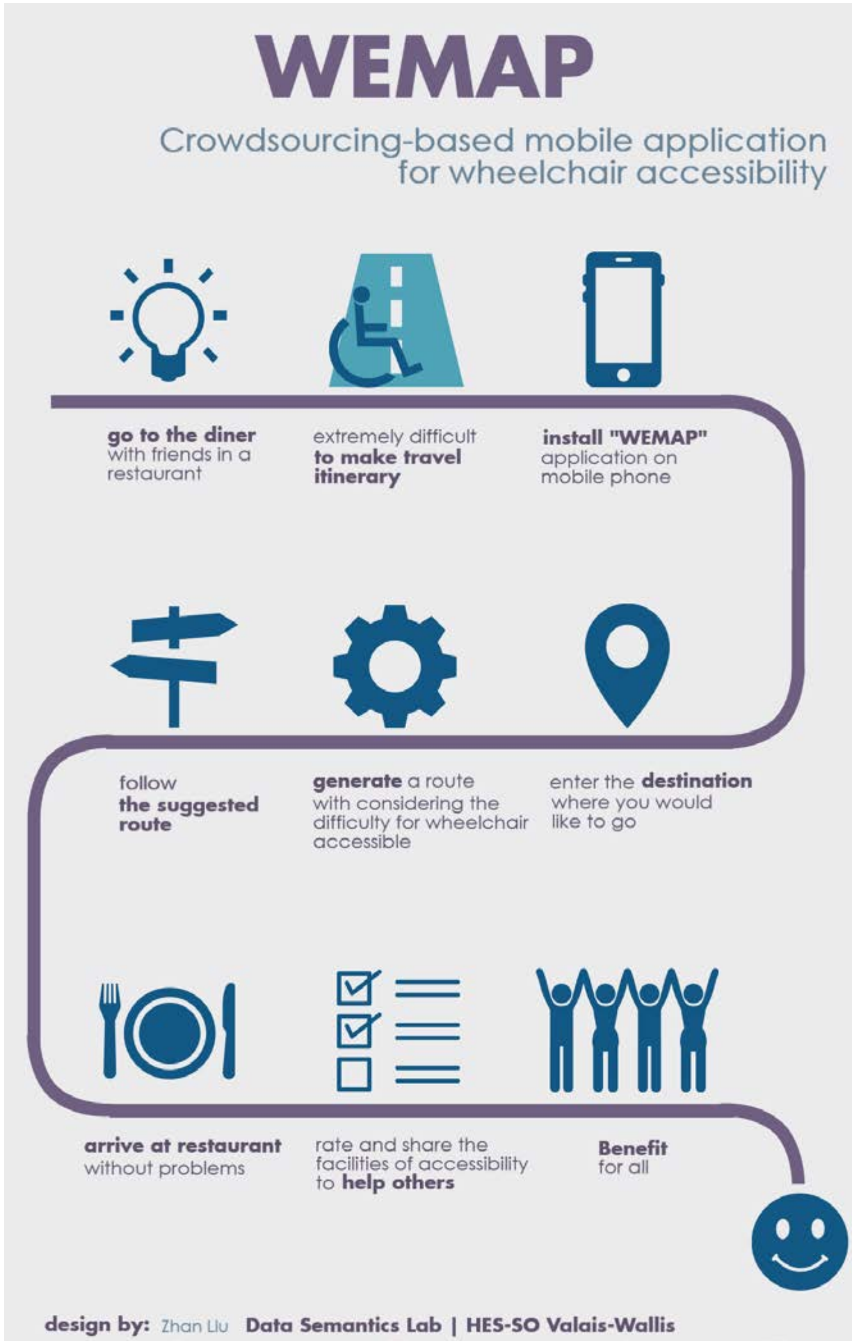

Fig. 1. User Story of WEMAP

Discussion

In this section, we first introduce the methodology we used in the study. Then, we highlight the key findings from online surveys that describe the business needs of travelers with mobility disabilities. Next, we present the process with which we designed and developed the mobile application and relevant functions. Finally, we discuss the results of evaluation obtained in focus group interviews, including the application's usefulness and effectiveness for people with mobility disabilities.

Methods

This project adopted the framework of information systems research presented by Hevner et al. (2004), as illustrated in Figure 2. First, we spoke with people with mobility disabilities and asked them to complete an online survey to identify their business and tourism needs to ensure the applied relevance of the research. Then, travelers with mobility disability requirements were examined to match the linked data-related technology environment for the research and identify the research artifacts through environmental field-testing. To achieve rigor in this project, we drew on existing theories and knowledge-based methods and then added newly generated knowledge to that base. The central design cycle focused on the construction and evaluation of artifacts and processes through qualitative and quantitative evaluation methods. Accordingly, we conducted several focus group interviews to assess the usefulness and functionality of the system. These were conducted iteratively in parallel with software development to ensure that their suggestions were incorporated in the design.

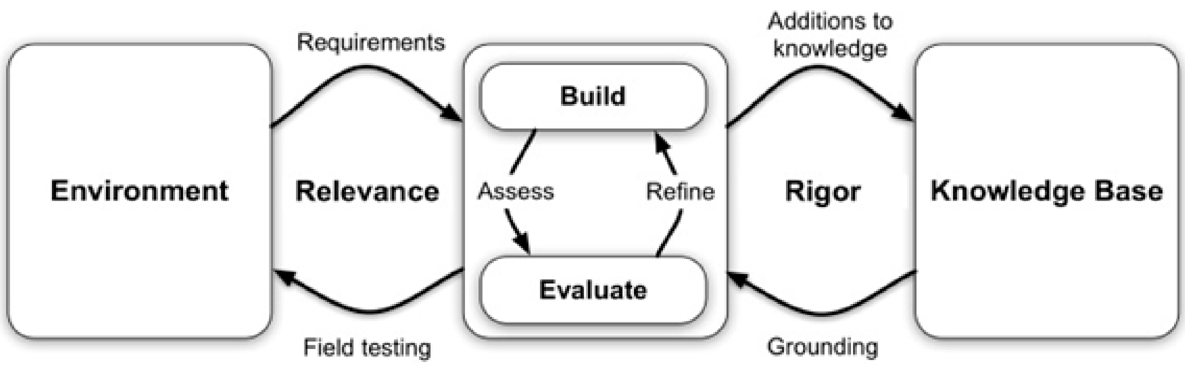

Fig. 2. Information Systems Research Framework (Based on Hevner et al., 2004).

Business Needs and Key Findings from Online Survey

We used a quantitative method in the form of an online survey to determine the users' real needs with respect to accessibility. We recruited 74 participants, 52 women and 22 men with different backgrounds (e.g., professor, social educator, journalist, secretary, psychologist, etc.). They ranged in age from 17 to 77 years, with a mean of 40.5. Sixty percent of the participants were accompanying persons for people with mobility in their professional or private lives, and the remainder were people with mobility disabilities. Most participants (75%) indicated that they used a wheelchair for their normal travel.

In this step, we examined primarily two objectives: the scope of information about mobility disabilities (types of mobility, frequency of trips, means used, facilitators or obstacles identified), and evaluation of mobile application ideas. The results showed that disabled access in the Canton of Valais is unsatisfactory for people with mobility disabilities. The average rating of satisfaction concerning existing information about mobility disabilities was 4.64/10, as shown in Figure 3, where zero signified no satisfaction at all, and 10 signified total satisfaction.

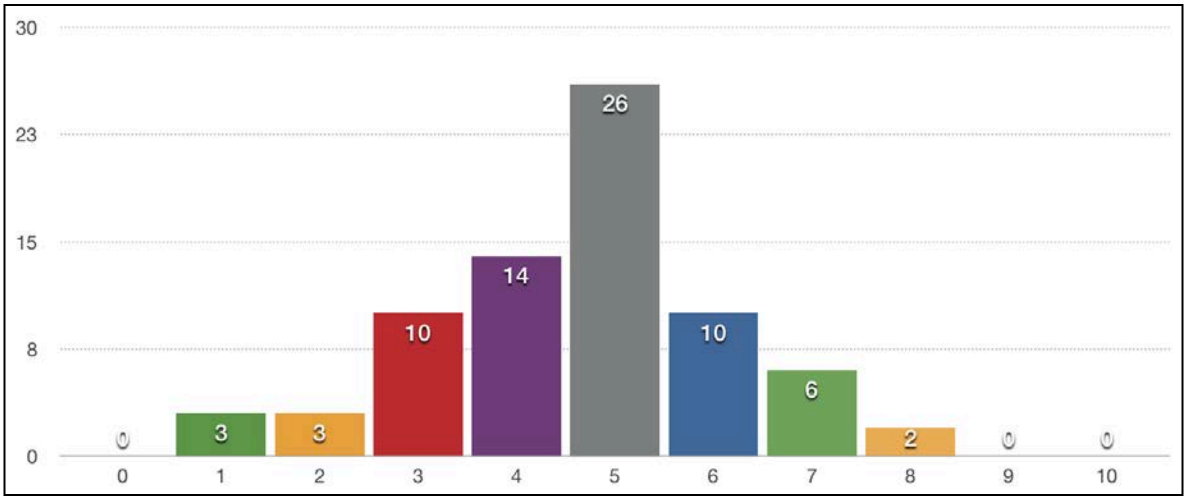

Fig. 3. Satisfaction with Existing Information on Mobility Disabilities (Canton of Valais, Switzerland).

The idea of the application was welcomed widely, with a rating of 9.08/10 (shown in Figure 4). The participants stated that it would very useful for people with mobility disabilities, and for those who worked with disabled people as well. They indicated that they intended to use the application and make contributions to help others as well.

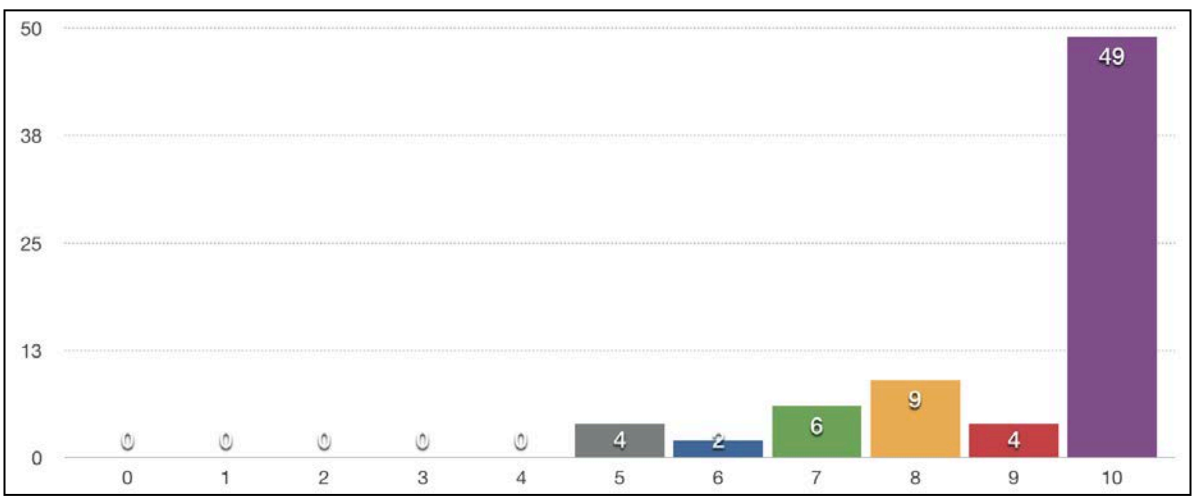

Fig. 4. Satisfaction with WEMAP Application Ideas.

Moreover, our participants rated and defined six accessibility criteria: 1) slope of over 10 degrees; 2) parking for people with disabilities; 3) disabled toilets; 4) entrances without steps; 5) obstacles on the path, and 6) sidewalks. Table 1 shows these criteria and their definitions.

Table 1. Accessibility Criteria and Definitions.

Criteria Name	**Definition**
Slope > 10 degrees	Slope of more than 10 degrees of angle
Parking for people with disabilities	Identified as accessible and reserved for people with disabilities
Disabled toilets	Adapted toilets for people with disabilities, including room size requirements, large space, toilet support
Entrances without steps	Entrances to buildings have no steps
Obstacles on the path	Some form of substrate is an obstacle to accessibility (e.g. too soft, gravel, grass)
Sidewalk < 1.5 meters	The dimension of the level landing should be at least 1.5m x 1.5m to allow wheelchair users to stop and rest without blocking the flow of pedestrians

Related Works

Several studies have been conducted on the subject of wheelchair accessibility. Most traditional solutions have focused on data collection and visualization using the approach of crowdsourcing in a set of specific places (i.e. AxsMap; Wheelmap; AmiWheelChair; Wegoto; Access and Earth), that help people with mobility disabilities find places suited to their needs. These often allow users to add data in the defined POIs, and provide a rating system on accessibility information. However, most of the data collected from these applications are closed, and are not structured as linked data. Table 2 compares various existing solutions and their functionalities. We argue that it would be difficult to share and re-use these data for other purposes or platforms. In addition, the information these solutions provide about accessibility in Switzerland is rather limited. Finally, and most importantly, none of them provides automatic door-to-door route generation functions so that people with mobility disabilities can enjoy greater freedom in their decisions. In this paper, we created the WEMAP mobile application to fill these research gaps.

Table 2. Comparison of Existing Mobile Applications.

Functionalities	Axs Map	Wheel Map	Ami-WheelChair	Wegoto	Access Earth
Add information	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Add the steps	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Rate a location	**Yes**	**Yes**	No	No	**Yes**
Rate the entryway	**Yes**	**Yes**	No	No	**Yes**
Rate parking facility	**Yes**	**Yes**	No	No	**Yes**
Take a photo	No	**Yes**	**Yes**	No	No
Add review	**Yes**	**Yes**	Yes	No	No
Incentive mechanism	**Yes**	No	No	No	No
Login and profile	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Multi-language	No	**Yes**	No	No	No
Mobile app (Android)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Mobile app (HTML5)	**Yes**	**Yes**	No	No	No
Wheelchair sensors/monitor	No	No	**Yes**	No	No
Different types of street	No	No	No	**Yes**	**Yes**
Calculate the short route	No	No	No	**Yes**	No
Structured data (schema.org)	No	No	No	No	No
Open data	No	No	No	No	No
Open source	No	**Yes**	No	No	No
Linked data from other resources	No	No	No	No	No
Plan the journey from door to door	No	No	No	No	No

Mobile Application Design and Development

Once we understood the users' real needs, we began to design and develop the mobile application. We built an easy solution that allowed visualization of linked data to help people with disabilities make their travel plans. This solution was constructed based on three different approaches, i.e., integrated-source, business-source, and crowd-source. Using linked data technologies, the integrated-sources function defines and integrates the data from different sources about accessible tourism with different formats. Moreover, we integrated information provided by local businesses and other facilities, such as stations, museums, shops, hotels, and restaurants. Actually, many facilities provide relevant information on their websites, but such information is usually scattered, and in certain circumstances, not easy to access. Exploiting and establishing the structure of linked data can help identify good evidence types for information integration. Thus, our objective was to integrate business-sourced information as a tool with which people with disabilities can determine what buildings are accessible, and to what extent. Nevertheless, self-assessment as a single source of data is somewhat biased, as the meaning of the statement "We are disability friendly" varies. To this end, we included a platform that allowed people to rate the accessibility of the facilities and, more importantly, to share that crowd-sourced information. In this way, the more evaluations users made, the more useful and reliable the information became. We believed that ratings provided by the "disabled community" would be more reliable, because people without disabilities cannot understand fully the challenges and problems that the disabled face. Hence, ratings and comments made by people who identify themselves as members of the "disabled community" should be given more weight, and listed at the top of the comments.

The following figures show the interfaces of the mobile application WEMAP. We developed this application, which included two main functions: data collection and visualizing route services, with the HTML5, PHP, and Javascript languages. The first function allowed users to add information from a list to a new or existing location, as shown on the left side of Figure 5. This list contained a set of POIs based on the user's position, or a specific address within a 300-meter radius. Once the user selected a POI, our system automatically crawled and linked the POI's information to other open ontologies, such as its address, phone number, official website, Wikipedia page from DBPedia, if available, location descriptions from GeoNames, and weather information. Then, users could select the criteria, as well as add photos and comments (shown in the middle of Figure 5). If the POI had been defined already by another user, users also could rate the existing information to control its quality (shown on the right side of Figure 5).

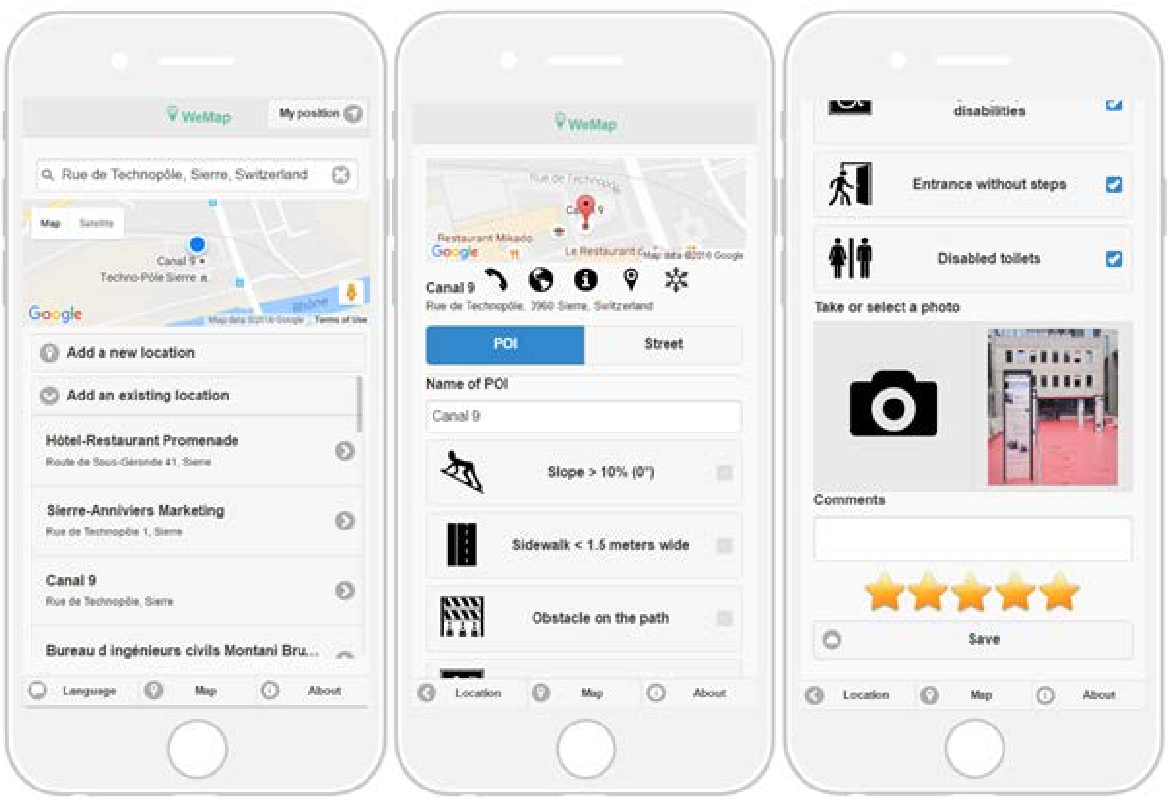

Fig. 5. WEMAP Data Collection Interfaces.

The Route Service function generates door-to-door routes automatically to avoid obstacles to wheelchair accessibility. This function allows users to select the travel mode from among wheelchair, pedestrian, bicycle, and car, as indicated on the left side of Figure 6. By entering the addresses of departure and destination, and selecting avoiding road types, users can generate their travel routes, as WEMAP calculates and finds a suitable route to satisfy the user's needs. For example, if there is an avoiding road between the departure and destination markers, our application suggests an alternative road to reach the destination, as shown in the middle of Figure 8. Moreover, detailed information is available and displayed on the map. Users can find these details by clicking on each marker—the details also can be modified (as shown on the right side of Figure 6). Finally, to motivate users to add information to this application, we award five credits for each new location added, and two credits for rating the existing location. The credits can be used for route services.

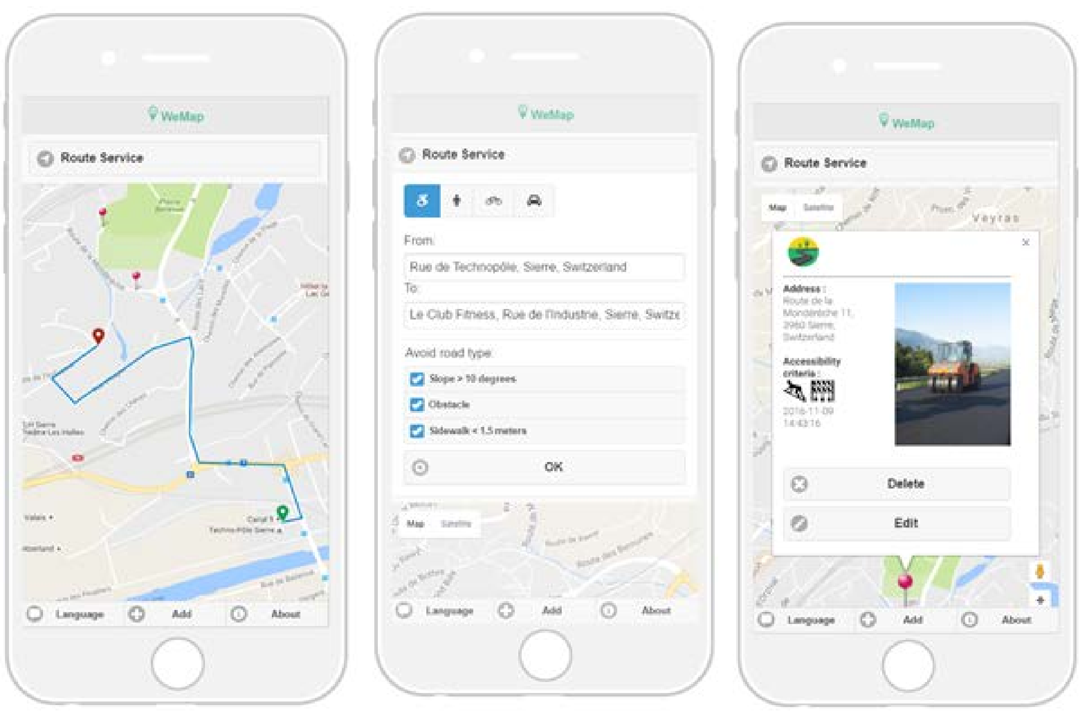

Fig. 6. WEMAP Route Services Interfaces.

Usefulness Evaluation

We tested and evaluated the mobile application with people from the Canton of Valais. To date, more than 800 POIs have been collected from the cities of Sion, Sierre, and Val d'Anniviers with the help of Swiss Post. We invited 12 participants who completed our online survey during an earlier stage to use the WEMAP mobile application. We also conducted three focus group interviews with four people per group. During the interviews, we asked about the users' experiences with respect to how easy it was to use the application and its utility in making their travel plans. At the end of the discussion, 11 out of 12 participants indicated that WEMAP could play a useful role in their lives and expressed their willingness to continue using it.

Conclusions

In this paper, we described a semantic linked data technology-based solution to help people with mobility disabilities plan their travels. To accomplish this, we collected and analyzed both unstructured and structured data from different databases, sources, and analyses available from social experts and organizations. Most importantly, we designed and presented the scientific methodology to build a user-friendly, crowdsourcing-based mobile application by integrating this heterogeneous information. Our solution allows people with mobility disabilities to search for and access useful, real-time information.

This research contributes significantly to both the tourism industry and the scientific community. For the tourism industry, it provides excellent opportunities to develop an accessible strategy that will increase competitiveness, as the market is predicted to grow because of the aging population. Therefore, regions that are experiencing low growth in tourism can benefit from investments in accessible tourism services and maintain and/or develop more activities. Moreover, the intensive analyses performed in this research provided a comprehensive view of disabled travelers' preferences for products and services, and also can help us understand the decisions made by potential tourists. From a scientific perspective, we filled an important gap in the literature on linked, data-based technologies for tourism services, as little is known to date about tourism-related services and products for people with disabilities. By analyzing the special needs of actual disabled persons, our study provided a better understanding of these factors. In addition, our results allowed us to enhance our knowledge of the ways in which disabled travelers perceive and evaluate tourism destinations.

Future research could include integrating photo recognition approaches to control the quality of the data users input automatically. In particular, we intend to double-validate the accuracy of information by both humans (rating system) and machines (photo recognition). Moreover, we intend to add some mini games to our mobile application as an incentive to motivate users to include more information that will help people with mobility disabilities.

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