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Accessible maps and the current role of collective intelligence

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Abstract This paper has the objective of assessing how ICTs are being used to provide accessibility in urban mobility, with special interest to collective intelligence based approaches. A systematic literature review (SLR) was performed, using several different criteria to filter down the 500 + academic papers that were originally obtained from a search for "accessible maps" to the 43 papers that finally remained in the *corpus* of the SLR. Among the findings, it was noticed that (i) few studies explored the motivations of users to actively contribute to improving accessible maps, by providing information to feed such maps; (ii) studies restricted themselves to exploring three techniques: gaming, monetary reward and ranking; (iii) social networks are rarely used as a source of data for building and updating maps; and (iv) there is no discussion of any initiative that aims to support both, the needs of physically and visually impaired citizens, at the same time.

Keywords Accessible maps · Physically impaired · Visually impaired · Routing · Collective intelligence · Crowdsourcing

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Introduction

A significant number of people have some sort of physical or visually impairment and are discriminated by our society, when not prevented from thoroughly exercising their citizenship as a result of that. That happens, for example, when suitable sidewalks are not provided for them to move around to perform their daily activities (Broadus 2012; Leitão 2012). Footpaths and other access ways that do not take accessibility issues in consideration make it difficult for wheel chair users and blind or visually impaired people even to go from a block corner to the next in the city.

The social inclusion of these citizens is harmed as highlighted by Maciel (2000, p. 51): "the ways our societies have been structured, since ancient times, has always excluded those who have any sort of disability, marginalizing them and depriving them from freedom". The acknowledgement of this has led to some efforts in planning routes in cities for accessibility (Menkens et al. 2011; Paladugu et al. 2010; Sobek and Miller 2006; Sumida et al. 2012). However, most such initiatives, especially those aimed at visually impaired citizens, do not take into account the collaboration of those who would benefit the most from them, i.e. the disabled people themselves, in order to update and improve maps and routes. In the few cases in which that happens, involvement is little, and a great opportunity is missed to include such people more thoroughly in our society (Zeng and Weber 2011;

Chandler and Worsfold 2013). Another important fact to consider is that even Google Maps and Bing Maps, the dominant mobile map systems currently available on the web, are not fully compliant with the WCAG 2.0 (Web Content Accessibility Guidelines) standard, as remarked by Medina et al. (2015).

New Information and Communication Technologies (ICTs) can contribute to improve the way people collaborate and work together, helping to reduce social and cultural barriers, while maximizing the results from mutual collaboration (Malone and Bernstein 2015). According to Nagar (2013), collective intelligence systems are becoming an important way of getting ideas and developing plans, projects and forecasts, based on the collaborative effort of a group of people, jointly submitted to different challenges. It is essential, though, that people who are physically or visually impairment are included in the planning and execution of projects aimed at improving their own quality of life. After all, no one is better suited than them to understand the mobility challenges they face in their routine.

We believe that involving the most interested stakeholders, those physically or visually impaired, into the conception and design of systems aimed at improving their mobility in the city is crucial and that collective intelligence approaches may provide a very effective way of achieving that. One way of doing that would be by including web 2.0[1] principles in accessible maps' design, allowing for the collective intelligence of users to be harnessed from the interactions they have with such systems. Each user's choices of paths could contribute to create alternative ways to move around that could be compared, helping future users to prioritize those that were more accessible. But, is this kind of approach being used by researchers in the field and implemented in the IT artifacts they generate or study to improve accessibility in the city?

In order to answer this question and provide a better understanding of how the mobility issue of visually or physically impaired citizens has been addressed by academia, this paper presents a systematic literature review on ICTs for improved accessibility and mobility, which intends to identify perspectives, assumptions and approaches concerning it. The research questions we attempt to answer by means of this systematic literature review (SLR) are: (1) how do the initiatives or systems that already exist to improve urban mobility of visually or physically impaired citizens address the issue? And (2) when collective intelligence is used, which techniques and motivational approaches are carried out to engage users in the development and maintenance of the system and its database?

The main contribution of this work was to identify the state of the art about systems to support impaired citizens' urban mobility and to organize approaches adopted by researchers who have dealt with it, identifying gaps which could be filled by future work, improving accessible maps and the way they contribute to the mobility of visually or physically impaired citizens in the city.

The remaining sections are organized as follows. First, accessible maps are discussed. Then the research methodology is presented in detail. Subsequently, the results of the Systematic Literature Review (SLR) that was used to answer the research questions are presented and discussed. The final section concludes this study and outlines directions for future research.

Accessible and collaborative maps

WC3 defines a set of guidelines for accessible web-based or mobile applications development (Web Content Accessibility Guidelines—WCAG 2.0). Compliance to those recommendations is expected, in order to make content accessible to a wider range of users with disabilities, including visually impaired, and people with hearing deficiency, cognitive, movement or speech limitations (W3C 2008). It is important to make sure that the web is accessible, especially with respect to legal/governmental services and to make sure all citizens benefit from it. Systems and platforms should be easily recognized and integrated to existing accessibility tools such as *JAWS*, *Window Eyes*, *VoiceOver* or *NVDA* (Wentz et al. 2013, 2015).

There are several APIs and services available in the market that are intended to help people planning how to move in the city, such as: *Google Maps, OpenStreetMaps*, *YahooMaps* and *BingMaps*. Some of them are concerned with the provision of accessible routes,

[1] Web 2.0 is a term used to refer to a second generation of communities and services on the web, based on the idea of "web as platform" (O'Reilly 2005), after the web started being perceived as an interaction and participation environment by users and developers (Lewis 2006).

among which: *OpenRouteService*, *OpenTripPlanner* and *EasyWheel*. However, according to Medina et al. (2015), most web based maps have accessibility issues, i.e., software that was intended to be the solution to the accessibility problem is not fully accessible in all its features (colors, contrast, font and size, according to the accessibility standards defined by *W3C*. There are very few navigation systems that are targeted at pedestrians that have any sort of impairment and who need precise and suitable geographical data to allow successful mobility (Chandler and Worsfold 2013).

Collaborative mapping is an initiative of building and using maps in a collective way (Haklay and Weber 2008). By means of this, it is possible for a group of people to create models of the real world that are shared with other people who can also contribute to them, including and using annotations or mapping a phenomenon or local happening, in a way that all collaborations contribute to one another (Gillavry 2003).

Collaborative maps contribute to improve mobility in large urban areas (Drodzynski et al. 2007). Often, information is collected by many participants, stored in a central database and distributed using various digital formats over the web (Haklay 2010). For Goodchild (2007), the use of VGI (Volunteered Geographic Information) is a special phenomenon in the web, with content generated by the users themselves, due to the popularization of web 2.0.

This idea of involving the users themselves to build and populate maps is very appealing, because the new ICTs provide a suitable platform for collective intelligence to flourish.

Methodology

A search was made in the following digital libraries: *AIS Electronic Library*, *IEEE Xplore Digital Library*, *ACM Digital Library, Periódicos Capes* and *Google Scholar* to provide the *corpus* for the systematic literature review (SLR) with respect to how the urban mobility issue for physically or visually impaired people is being dealt with by researchers. That search was carried out late in 2016 and early in 2017, following the SLR protocol, proposed by Kitchenham (2004).

Search involved the expression "accessible maps", which could be present in any part of the searched papers. Using just this single expression for the search, it was possible to gain access to papers that use the most different techniques and approaches to address the issue, generating more material to start the screening in the SLR. Only for Periódicos Capes' database an additional restriction was established for the preliminary search, which was, selected papers should be "peer reviewed papers". Overall, 592 papers were returned as a result of this first enquiry, as shown in Table 1. The oldest paper was from 2006, which was not surprising as that had already been remarked by Karimi (2013), who had not found any papers dealing with roting services for wheel chair users or visually impaired people, written prior to 2006.

The titles and abstracts of the papers that were returned by the preliminary search were read as a first criterion to filter papers. The title or the abstract were expected to refer to accessible maps and include a concern for visually or physically impaired citizens' mobility in the city. By means of this filtering procedure, 534 papers were excluded.

Among the remaining 58 papers, it was noticed that there were two duplicates, i.e. papers that appeared in more than one of the digital libraries. So, 56 papers remained for a careful, in depth, reading of their whole content. After such thorough reading of the papers, 43 were selected to be included in *the corpus* of the study, as they definitively discussed accessibility and mobility issues concerning maps and routes for physically or visually impaired people. Figure 1 shows the filtering process that was used to select papers to be included in the *corpus* of the SLR.

Assessment of the quality of papers was not part of the scope of the study, which means that all papers that addressed the topic of interest were included in the study, if they just survived all filtering criteria that were set for the SLR.

To organize the data extraction process, the form presented in Table 2 was used.

Results and discussion

The 43 papers that met all the criteria to be included in the systematic literature review are presented in the "Appendix". According to Fig. 2, there seems to have been an increase in interest for the issue of accessible maps over time.

Table 1 Papers that were returned after the preliminary search for "accessible maps"

Database	Number of papers including "accessible maps"
IEEE Xplore	12
ACM Digital Library	22
Google Scholar	355
AIS Electronic Library	155
Periódicos Capes	48
Total	592

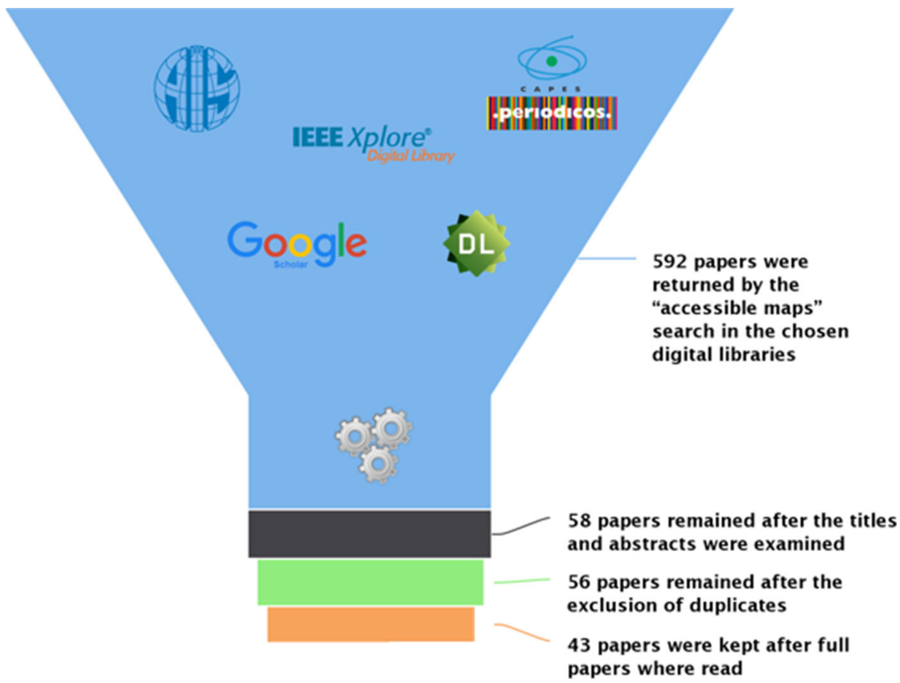

Fig. 1 Criteria for inclusion of papers in the corpus of the systematic literature review

Table 2 Data extraction form

Title	
Summary of the study	
Scope	[ ] Accessible maps for physical impaired [ ] Accessible maps for visually impaired [ ] Other purpose
Method used	
Factors derived	
Category of factors	
RQ1—Is CI used to improve the collaboration process and make maps update? What techniques are used?	
RQ2—When collective intelligence is used, which techniques and motivational approaches are carried out to engage users in the development and maintenance of the system and its database	

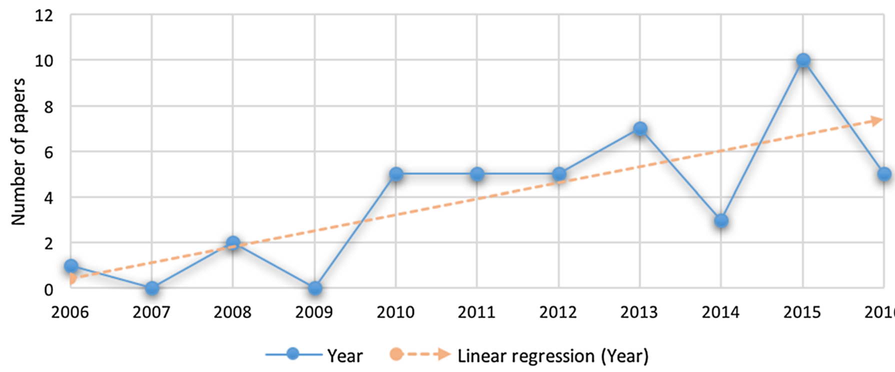

Fig. 2 Time distribution of papers about accessible maps in the literature

A few central concerns were identified in the reviewed papers, such as the intent to generate accessible routes or maps that could be used by people with some sort of mobility limitation, among whom wheel chair users, people that need the support of a walking stick, adults carrying kids in strollers (18 papers in total) or people with visual deficiency (22 papers). There was still a paper that discussed the privacy of users, one that was primarily concerned with the planning of urban mobility and accessibility and another one which was related to both disabilities (physical and visual), however with a focus on the use of a specific social network as a tool to improve map updating.

Answering the first research question, in twelve of the 43 papers that were reviewed, collective intelligence was explicitly mentioned by the authors, who many times referred to the use of *crowdsourcing*[2] or "experience-centric approach" as ways of exploring the users' availability and interest in contributing with the development of the application and generation of content. In those papers, the information that was generated and collected with the support of users, in addition to being shown in the maps as points of interest, was also used for suggesting better routes. Seven of those nine papers deal with maps for physically impaired people (Cardonha et al. 2013; Holone and Misund 2008; Menkens et al. 2011; Mirri et al. 2014, 2016; Prandi et al. 2015a, b), three deal with maps for visually impaired people (Palazzi et al. 2011; Guy and Truong 2012; Calle-Jimenez and Luján-Mora 2015), one is focused on urban planning (Shigeno et al. 2013) and one discusses the use of a particular social network as the source of information to update maps (Karimi et al. 2014).

In eleven other papers, despite not mentioning collective intelligence directly, the authors use some information gathering technique that collects data directly from users or sensors that they carry in order to improve the quality of the information that is provided to users. They do not just consider previously existing static data about a route or map. None of those papers considers special needs of visually impaired people. They were all conceived having physically impaired users as their target audience. Some of them discuss ways in which users can annotate maps (Kulakov et al. 2015; Rashid et al. 2010; Völkel and Weber 2008), the use of data collectors based on the sensors installed in wheel chairs or sensors in mobile phones (Bardaro et al. 2015; Iwasawa et al. 2015; Palazzi et al. 2010; Sumida et al. 2012), or open data from public offices that are fed into the systems (Bolten et al. 2015; Kozievitch et al. 2016; Mirri et al. 2014, 2016).

However, the use of participatory design,[3] including the potential users of the systems, is explicitly considered by the authors of only three papers, which are concerned with the visually impaired (Guy and Truong 2012; Brock 2013; Ducasse et al. 2015).

Our second research question concerned identifying which techniques and motivational approaches are used to engage users in the development and maintenance of the system and its database when CI is used. A small percentage of the works tries to foster

[2] A production model that uses the collective intelligence and collective knowledge of the crowd to solve problems, create content, solutions or develop new technologies (Wikipedia, n.d.).

[3] A design approach that tries to actively engage and involve all those 'concerned', being them employees, partners, consumers, citizens, among others, in the process design to help the designed product to meet the required needs and to be useful.

collective intelligence offering some sort of reward for the contribution of users, such as ranking (Menkens et al. 2011), gamification (Cardonha et al. 2013; Prandi et al. 2015b) or monetary reward, paying a small amount of money to users through *Amazon Mechanical Turk*[4] (Guy and Truong 2012). Other more recent works (Bolten et al. 2015; Kozievitch et al. 2016; Mirri et al. 2014) use open data from official agencies to feed their algorithms for calculating routes. However, no evidence if presented of users' participation, as an additional source of information for updating maps or routes. They only used open data for that purpose. Karimi et al. (2014) do not discuss any specific approach to motivate new users, but report the importance of motivating them to participate in the collective intelligence effort, providing good quality information.

It was not possible to find out, from the information contained in the analyzed papers, if a product was generated for the end user, based on the studies that were carried out. From what we could depict, *mPass* (Mirri et al. 2014, 2016; Prandi et al. 2015a, b) seems to be the only system with chances of turning into a product that the end user could directly benefit from, including some collective intelligence principles in its features. *IBM® Citizen Sensing/Accessible Route* (Cardonha et al. 2013; Shigeno et al. 2013), according to IBM's blog—Simpler IT,[5] in partnership with AACD (the Association for the Support to Impaired Children), was made available in *Apple Store* in 2013. However, the program was no longer available for download when we performed our search.

Based on the SLR that was carried out for this study, we could notice that there is a lot of interest in improving mobility in the city, for people who have some sort of disability, by means of the use of ICTs. However, there has been very little practical result, so far, that can make a difference in people's lives.

One interesting issue that is discussed in a few of the papers (Bardaro et al. 2015; Iwasawa et al. 2015; Palazzi et al. 2010; Sumida et al. 2012) is the automatic capturing of data, using sensors in mobile phones, while the user is taking a specific route. In the presented solutions, the data that is captured by sensors is constantly sent to a server that uses it to improve the user's current route or to make the route better for the next one who uses it. Some useful data that can be collected refer to slope inclination of the ground. Changes in elevation are associated with a physical effort that needs to be performed by a wheel chair user, for example, to take a specific route. However, we still must consider that the bandwidth required to transfer such information in real time may be a constrain. This could, in fact, be a huge problem in places where the quality of Internet connections is still not very good (Belson 2016).

Some of the papers that deal with maps for physically impaired people already benefit from the collective intelligence of their users. Sometimes, by means of the apps, themselves, users can comment and annotate maps (Cardonha et al. 2013; Holone and Misund 2008; Kulakov et al. 2015; Menkens et al. 2011; Mirri et al. 2014, 2016; Prandi et al. 2015a, b; Rashid et al. 2010; Shigeno et al. 2013; Völkel and Weber 2008). None of such works, however, uses public data extracted from social networks with a large user base, as proposed by Russell (2014), to gain access to valuable data. Including this type of data source may allow for many more users to contribute, populating data into the system, in addition to those who are directly interested and affected by it. Some papers focusing on visually impaired users also address the use of collective intelligence for updating their maps, at least to some extent. Guy and Truong (2012) developed a web application where users rate and/or drill down information about points of interest and locations with Google Street View photos. Calle-Jimenez and Luján-Mora (2015) use crowdsourcing to annotate maps in a scalable vector graphics (SVG[6]) format, while Karimi et al. (2014) suggest the use of a social navigation network (SoNavNet) as a tool to make maps more up-to-date, based on an "experience-centric" approach, complementing other existing data sources.

There were a few improvement suggestions concerning the volitional participation of users in generating information for the discussed platforms, such as increasing the audience of the system by including additional features, such as data on the traffic (Mirri et al. 2016). We could also add a few other suggestions on our own, inspired by the academic sources we had

4 https://www.mturk.com/mturk/welcome.

5 http://www.timaissimples.com.br/2013/10/aplicativo-rota-acessivel-ja-esta/.

6 https://en.wikipedia.org/wiki/Scalable_Vector_Graphics.

access to while carrying out this review. Among those, we could highlight: using tags and posts in social media, such as Twitter, as an alternative source for geographic data collection; including security information, for example, on thefts and mugging in the route/region; including routes for the visually impaired considering the existence of special signaling on the ground; (v) exploring new motivation and compensation mechanisms, in addition to ranking and gamification. These motivations are based on "glory" and "money", two of the motivators of people support, according to Malone et al. (2009). However, "love", the third motivator mentioned by that author, could also represent an important reason for people to contribute. If the developers can show the social relevance of the system, the importance of trust and the value of the locals' knowledge of the place they live to improve the quality of the information others could get from a system conceived to help people do the good (what they consider to be the right thing), chances are that people will also contribute for what Malone et al. (2009) would qualify as "love".

We noticed that all papers that discussed the use of open data (Bolten et al. 2015; Kozievitch et al. 2016; Mirri et al. 2014) had a very narrow geographic scope, limiting their range to specific suburbs or cities. This may result from the lack of standardization of open data, which could make it difficult to consolidate data from different geographies (Ferreira da Silva et al. 2014). Auer et al. (2007) had already remarked that standardizing the display of open data would help data collection and the organization of data from distinct sources, increasing the geographic scope of a system, without the need to develop specifically for each different source.

Karimi et al. (2014) use experiences reported by users through a specially designed social network (*SoNavNet*) as a tool for map updating, to obtain complementary information for the system, regardless of the target audience being physically or visually impaired users. The user can report how her/his experience was when s/he used a route, and also can include her/his limitation level, so that other users with the same disability can take advantage of the report. This contributes to the quality of the available information, with respect to the routes and maps, benefiting from the information of those who take those routes and use those maps, to improve the overall knowledge of the system (Passos et al. 1999).

The majority of the authors that study the mobility of visually impaired people are still more concerned with the design of equipment and maps, and with how to make points of interest and routes understood by the users, than with allowing on line and real time interaction during navigation. The use of the collective intelligence of users to generate more (and more precise) information to be included in the maps has also not been the priority of these researchers, up to now. However, some reported software is changing this. Poppinga et al. (2011) developed a map solution that releases an audio message with the location, when the user touches the screen of her/his smartphone. In spite of the interesting achieved result, the author acknowledges some problems, such as the impossibility of knowing if one path is close to or has an intersection with another one. Palazzi et al. (2011) developed a serious game to capture data from traffic lights at street intersections. Guy and Truong (2012) worked on a map application that guides users from one street intersection to another by means of audio commands. Calle-Jimenez and Luján-Mora (2016) developed a tool to deal with geographic maps using the WGAG 2.0 and SVG standards, performing compatibility tests in three web browsers (*Google Chrome*, *Firefox* and *Microsoft Edge*). However, their prototype has not yet been tested by visually impaired people.

In summary, by means of our SLR we found that several researchers have attempted to use CI to improve accessible maps and, therefore, the urban mobility of impaired people, among which CI techniques deserved special attention. They were used to allow tagging by users or to convert users into human sensors. A social network was specifically designed for this purpose, where users share their experiences while walking. Although the motivation to take part in CI efforts has not been the concern of most authors, a few techniques, such as ranking and gamification, and even monetary rewards have been tried. Also, participatory design techniques were used to achieve involvement of users in the design of the proposed system, with the intent to obtain acceptance of the solution by the community.

Conclusion

This paper presented a systematic literature review about mobility in the city for citizens that have a physical or visual deficiency and the ways ICT is being used in attempt to make their lives easier in that respect. We were specially interested in the use of collective intelligence as a strategy to improve the quality and quantity of data available to the systems for the creation of accessible maps and routes, as we believe that the direct participation of those who could benefit from such systems in defining features and populating data could be an interesting way to go. Besides, all humans are becoming each time more traceable with respect to where we are and where we are heading to, based on the sensors (mobile phones) we carry around all times. So, it would be expected that data from humans, as sensors, could also be used in improving maps and routes.

We found out that the collaboration of users is already explored to a good extent in systems that aim to support physically impaired citizens. There is very little concern about the visually impaired, in that sense, so far. Even in systems that already explore collective intelligence, it is easy to depict improvement opportunities, such as the inclusion of more comprehensive new sources of data, such as social networks and open data from official offices.

The literature says little about the motivation of users to contribute to systems and platforms. Do they do that for glory, love or money? One interesting future study could involve accessing the kinds of incentives that can be provided and the effectiveness of using each one of the possibilities to achieve the best results, in terms of offering a reliable and efficient service to users.

In none of the papers that were reviewed, functionalities were implemented considering both groups of users with special needs, i.e., those with physical or visual impairment, although Karimi et al. (2014) propose the use of a social network to make maps updatable based on the users' own experience. In that sense, we identified that an opportunity for future work is to try to meet the needs of both groups with the development of one only app. One way of achieving that would be by using voice commands to perform annotations. This would increase the number of users and, thus, also increase the possibility of success of any collective intelligence initiative. Diversity improves the results of the use of collective intelligence (Malone et al. 2008). Therefore, it makes a lot of sense to try and involve the physically or visually impaired citizens, as well as anyone else interested in contributing with the collective effort to make mobility in the city easier for all parts.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Appendix

See Table 3.

Table 3 List of papers included in the corpus of the SLR

Year	Title	Author
2006	U-Access: a web-based system for routing pedestrians of differing abilities	Sobek and Miller
2008	People Helping Computers Helping People	Holone and Misund
2008	RouteCheckr: Personalized Multicriteria Routing for Mobility Impaired Pedestrians	Völkel and Weber
2010	Usage of multimodal maps for blind people: why and how	Brock et al.
2010	Negotiating privacy boundaries in social applications for accessibility mapping	Holone and Herstad
2010	On presenting audio-tactile maps to visually impaired users for getting directions	Paladugu et al.
2010	Path 2.0: A participatory system for the generation of accessible routes	Palazzi et al.
2010	Users Helping Users: User Generated Content to Assist Wheelchair Users in an Urban Environment	Rashid et al.
2011	Making Visual Maps Accessible to the Blind	Buzzi et al.
2011	EasyWheel—A Mobile Social Navigation and Support System for Wheelchair Users	Menkens et al.
2011	Combining Web Squared and serious games for crossroad accessibility	Palazzi et al.
2011	TouchOver map: Audio-Tactile Exploration of Interactive Maps	Poppinga et al.

Table 3 continued

Year	Title	Author
2011	Accessible Maps for the Visually Impaired	Zeng and Weber
2012	CrossingGuard: exploring information content in navigation aids for visually impaired pedestrians	Guy and Truong
2012	AccessibleMap—Web-Based City Maps for Blind and Visually Impaired	Klaus et al.
2012	Interactively Displaying Maps on a Tactile Graphics Display	Schmitz and Ertl
2012	Dev of a Route Finding System for Manual Wheelchair Users Based on Actual Measurement Data	Sumida et al.
2012	Audio-haptic you-are-here maps on a mobile touch-enabled pin-matrix display	Zeng et al.
2013	The MGIS: a minimal geographic information system accessible to users who are blind	Brittell et al.
2013	Touch the map! Designing interactive maps for visually impaired people	Brock
2013	A crowdsourcing platform for the construction of accessibility maps	Cardonha et al.
2013	Understanding the requirements of geographical data for blind and partially sighted people to make journeys more independently	Chandler and Worsfold
2013	Citizen sensing for collaborative construction of accessibility maps	Shigeno et al.
2013	From perceptual supplementation to the accessibility of digital spaces	Tixier et al.
2013	"Pray before you step out"	Williams et al.
2014	Pre-journey Visualization of Travel Routes for the Blind on Refreshable Interactive Tactile Displays	Ivanchev et al.
2014	Wayfinding and Navigation for People with Disabilities Using Social Navigation Networks	Karimi et al.
2014	A context-aware system for personalized and accessible pedestrian paths	Mirri et al.
2015	Accessible Urban Routes Reconstruction by Fusing Mobile Sensors Data	Bardaro et al.
2015	Urban Sidewalks: visualization and routing for individuals with limited mobility	Bolten et al.
2015	Interactivity Improves Usability of Geographic Maps for Visually Impaired People	Brock et al.
2015	Using Crowdsourcing to Improve Accessibility of Geographic Maps on Mobile Devices	Calle-Jimenez and Luján-Mora
2015	From Open Geographical Data to Tangible Maps	Ducasse et al.
2015	Road Sensing: Personal Sensing and Machine Learning for Dev of Large Scale Accessibility Map	Iwasawa et al.
2015	The route planning services approach for people with disability	Kulakov et al.
2015	An estimation of wheelchair user's muscle fatigue by accelerometers on smart devices	Nagamine et al.
2015b	From gamification to pervasive game in mapping urban accessibility	Prandi et al.
2015a	Trustworthiness in crowd-sensed and sourced georeferenced data	Prandi et al.
2015	Interactive Audio-haptic Map Explorer on a Tactile Display	Zeng et al.
2016	Accessible map visualization prototype	Calle-Jimenez and Luján-Mora
2016	An Alternative and Smarter Route Planner for Wheelchair Users—Exploring Open Data	Kozievitch et al.
2016	Personalizing Pedestrian Accessible way-finding with mPASS	Mirri et al.
2016	Exploration of Location-Aware You-Are-Here Maps on a Pin-Matrix Display	Zeng and Weber

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