# Collective Intelligence and the Mapping of Accessible Ways in the City: a Systematic Literature Review

*Full paper*

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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 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 that actively contribute, providing information to feed maps, and they restricted themselves to exploring three techniques: gaming, monetary reward and ranking; (ii) social networks are rarely used as a source of data for building and updating maps; and (iii) the literature does not discuss any initiative that aims to support the needs of physically and visually impaired citizens at the same time.

### Keywords

Physically impaired, visually impaired, disabled, accessible maps, routing, collective intelligence, web 2.0.

## Introduction

A significant number of people have some sort of physical impairment and are discriminated by our society, when not prevented from thoroughly exercise their citizenship. That happens, for example, when suitable paths and ways are not provided for them to move around to perform their daily activities (Broadus, 2012; Leitão, 2012). Footpaths and other access ways that are not thought for accessibility 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.

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 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 visually impaired 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 (2015).

New Information and Communication Technologies (ICTs) can contribute to the way people collaborate and work together, helping to reduce social and cultural barriers and maximizing the possible 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 a collaborative effort of a group of people jointly submitted to different challenges. It seems, thus, essential that people that have some sort of physical or visual impairment be included in the planning and execution of projects that are aimed at improving their own quality of life. After all, no one is better suited than themselves to understand the mobility challenges they face in their daily 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. Those systems could also absorb information that is generated while they are used, accepting input from users on the go. One way of doing that would be by including web 2.0[1] principles in their 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 that could be compared, helping future users to prioritize those that were more accessible. The generated information could also help city administrators and planners to take informed decisions about public work that could increase accessibility. But, is this kind of approach being used by researchers in the field and implemented in the IT artifacts they generate or study?

In order to answer this question and provide a better understanding of how the mobility issue of 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 the urban mobility of visually or physically impaired citizens address the issue? And (2) When collective intelligence is used, which techniques and motivational approaches are developed to engage users in the development and maintenance of the system and its database?

Our main contribution with this work was to identify the state of the art about systems to support impaired citizens' urban mobility and to organize the functionalities and approaches adopted by researchers who previously addressed 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.

## Social Inclusion and ICTs

For Castells (2000), the development of a nation is associated with the way information and communication technologies are used by society. Thus, the proposition of an informatization social policy should have as its objective, according to this author's perspective, to make the population more knowledgeable, by means of the use of emerging technologies.

One of the great challenges of research in computing is, therefore, to provide universal participative access to knowledge and communication, by means of the new visual and audio information resources (Carvalho et al., 2006). For Egler (2001), the new intelligence technologies represent a powerful instrument for producing new cognitive merchandize, that change the way production and consumption take place. "The new technologies represent a historical opportunity to overcome the unbalance in access to intelligent forms of life" (Egler, 2001, p. 1). Although there still are cultural, educational, technological, social and economic barriers that prevent many citizens from access to the new technologies associated to mobile devices and ubiquitous computing[2] (Netto, 2008), efforts towards overcoming such barriers will contribute to ensure that excluded citizens start actively participating in the generation of knowledge (Carvalho et al., 2006) and intelligent action towards the progress of the collective (Egler, 1998; Sfez, 1997).

According to Mononen et al. (2016), disability is not a barrier to studies in the ICT field. It is quite the opposite: disability is a motivator, especially if there is inclusive support from the society, the family or other persons with disabilities (PWD).

## Collective Intelligence

Malone et al. (2008) define collective intelligence (CI) as something that happens in a group of individuals acting collectively in a way that seems intelligent. It represents some sort of shared intelligence resulting form

[1] Web 2.0 is a term that is 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) which took place after the web started being perceived as an interaction and participation environment, by users and developers, which currently involve many languages and motivations (Lewis, 2006).

[2] Term used to describe the omnipresence of information technology in people's daily lives.

the collaboration of many individuals expressing their diversity. CI has been around for a long time (Lévy, 2003). Surowiecki (2005) reminds us that early in the 20th century, anthropologists, sociologists and other scientists were already trying to understand the reasons that lead groups of individuals to obtain better results working together than if they were apart. However, the capability of collecting, organizing and using such intelligence have increased enormously with the Internet, specially after web 2.0 was introduced (Tomaél et al., 2011).

The main forms of interaction and generation of collective intelligence involve people and other people, people and computers and computers and other computers (Tipton, 2007). *Wikipedia*, *Google*, *Waze* and *Linux*, to name a few, are all examples of CI in action (Kleiner, 2014).

Malone et al. (2009) defined a framework to identify how CI occurs and how it is stimulated based on four questions: "*Who* is performing the task?", "*What* is being accomplished"? "*How* is it being done?" and "*Why* are they doing this?", as shown in Figure 1.

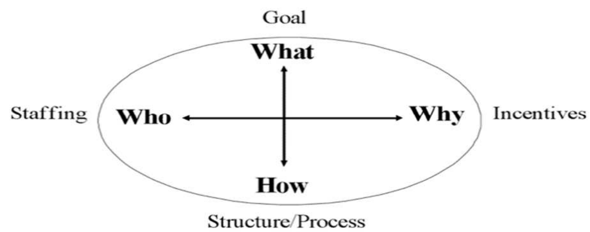


**Figure 1. Elements of CI building blocks (Malone et al. 2009)**

## Collaborative and Accessible Maps

Collaborative mapping is an initiative of building and using maps in a collective way (Haklay and Weber, 2008). By means of this approach, 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 it, including and using annotations or mapping a phenomenon or local happening, in a way that all collaborations contribute one to another (Gillavry, 2003).

Collaborative maps also contribute to easy the problem of 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. Initiatives such as *Wikimapia*, a portal where users mark places, adding relevant information, is just an example (Mummidi e Krumm, 2008).

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 to make content accessible to a wider range of users with disabilities, including visually impaired, hearing deficiency, cognitive, movement or speech limitations (W3C, 2008). It is extremely important to make sure the web is accessible, especially with respect to legal / governmental services and when it can bring benefits and facilities to the citizens (Wentz et al., 2013). Attention should be given to the accessibility and usability of proprietary and web-based applications designed for the omnipresent touch-based mobile interfaces (Wentz et al., 2015). 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).

When the issue is route planning services, there are several APIs and services available in the market, such as: *Google Maps, OpenStreetMaps*, *YahooMaps* and *BingMaps*. For accessible routes, there are also a few initiatives, among which: *OpenRouteService*, *OpenTripPlanner* and *EasyWheel*. However, according to Medina et al. (2015), most those web based maps has accessibility problems, 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 size and type of letter, 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).

## 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 by researchers. That search was carried out inlate in 2016 and early 2017 and followed the SLR protocol proposed by Kitchenham (2004).

The search involved the expression "*accessible maps*", which could be included 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 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 to 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 before 2006.

| 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** |

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

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 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 2 shows the filtering process that was used to select papers to be included in the *corpus* of the SLR.

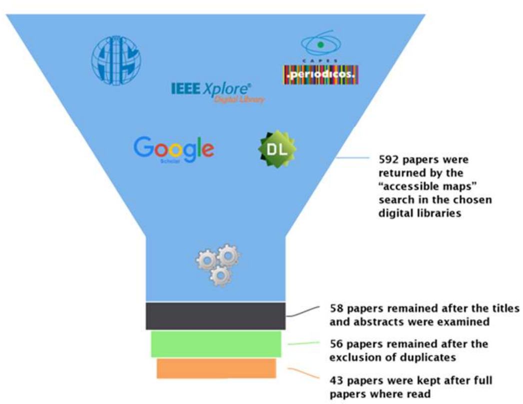


**Figure 2. Criteria for inclusion of papers in the *corpus* of the systematic literature review**

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

## Results

The 43 papers that met all the criteria to be included in the systematic literature review are presented in the Appendix[3]. According to Figure 3, there seems to have been an increase in interest for the issue of accessible maps over time.

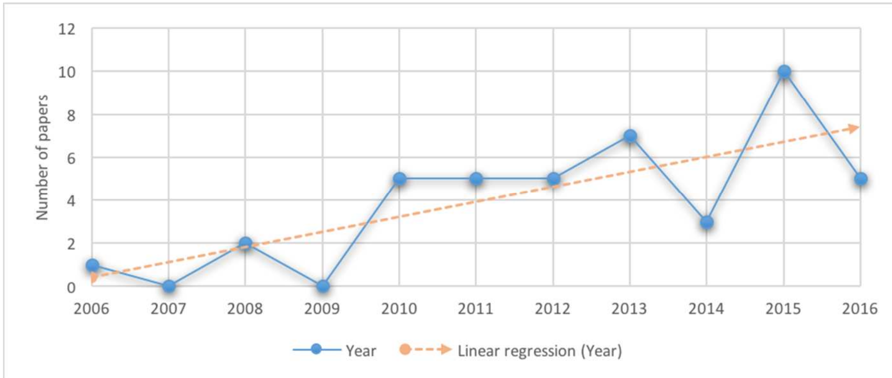


**Figure 3. Time distribution of papers about accessible maps in the literature**

A few central concerns were identified in the reviewed papers, such as the intent to generate accessible routes or maps, which 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 a stroller (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.

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*[4] or "experience-centric approach" as the tool to explore 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 is also considered in generating 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., 2016, 2014; Prandi et al., 2015a, 2015b), three deals with maps for visually impaired people (Palazzi et al., 2011; Guy e Truong, 2012; Calle-Jimenez e Luján-Mora, 2015), one is focused on urban planning (Shigeno et al., 2013) and one paper is specifically focused on the use of a particular social network as a database 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 feed data bases, with the intent of improving the quality of the information that is provided to users. They do not just consider static data that previously exist about a route or map. None of those papers considers special needs of blind 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 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 concerned with urban planning that are fed into the systems (Bolten et al., 2015; Kozievitch et al., 2016; Mirri et al., 2016, 2014).

However, the use of participatory design[5], including the potential users of the system in the solutions' design is explicitly considered by the authors of three papers, which are concerned with the visually impaired (Guy e Truong, 2012; Brock, 2013; Ducasse et al., 2015).

[3] Complete references available in https://drive.google.com/file/d/0B3yM126EnOojMTZiNXRiWFBfRVU/view?usp=sharing

[4] 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.).

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

In was not possible to find out, from the information contained in the analyzed papers, if a product was generated for the end user (equipment or software), based on the studies that were carried out. From what we could depict, *mPass* (Mirri et al., 2016, 2014; Prandi et al., 2015a, 2015b) seems to be the only system with chances of turning into a product 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[6], 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.

# Discussion

Based on the SLR that was carried out for this study, we could notice that there are several researchers interested in improving mobility, in the city by means of the use of ICTs, for people who have some sort of disability. 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 automatic capturing of data, using sensors in mobile phones, while the user is taking a specific route, in order to improve it. 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 rout or to make the route better for the next one who uses it. Some useful data that can be collected refer to ground elevation. 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 not good (Belson, 2016).

Some of the papers that deal with maps for physically impaired people already benefit from the collective intelligence of their users. 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., 2016, 2014; Prandi et al., 2015a, 2015b; Rashid et al., 2010; Shigeno et al., 2013; Völkel and Weber, 2008). None of such works, however, use public data extracted from social networks with a large user base, like Twitter, for example, 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 from 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[7]) format, while Karami 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.

A small percentage of the works tries to foster collective intelligence, offering some sort of reward for the contribution of its 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*[8] (Guy and Truong, 2012). Other more recent work (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. In those works, there was no evidence 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 address a technique to motivate new users, but report the problems of obtaining the motivation for generating collective intelligence, attracting new users, and the quality of the information generated by them.

There were a few improvement suggestions concerning the volitional participation of users in generating information for the discussed platforms that were provided by the authors of the analyzed papers, 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 access to in this review. Among those, we could highlight: using tags and posts in social media, such as Twitter, as an

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

[7] https://en.wikipedia.org/wiki/Scalable_Vector_Graphics

[8] https://www.mturk.com/mturk/welcome

alternative source for geographic data collection; including security, for example, data on thefts and mugging in the route/region; including routes for the blindly 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 (2009). However, "love", the third motivator, 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 that was conceived to help do good, chances are people will also contribute for what Malone (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 form the lack of standardization for 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 organization 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, as a source of complementary information for the system, regardless of the target audience being physically or visually impaired users. User can report how his / her experience was when s/he used a way, and also can include his/her 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 collective intelligence of users, in order 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, we can highlight some software solutions that are trying to change this. Poppinga et al. (2011) developed a map solution that releases an audio message with the location, when the user touches the screen of his/her 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 user from one street intersection to another by means of audio commands. Calle-Jimenez and Luján-Mora (2016) developed a geographical maps' prototype 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 assessed by visually impaired people.

In summary, by means of our SLR we were able to find out that several approaches have been attempted to use CI to improve accessible maps and urban mobility by impaired people, among which *crowdsourcing* 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 was not the concern of most authors, a few techniques, such as ranking and gamification, and even monetary rewards were attempted. Participatory design techniques were used to achieve involvement of users in the design of the proposed, with the intent to obtaining acceptance of the solution by the community.

## Conclusion

This paper presented a systematic literature review about mobility in the city for citizens that have some sort of physical or visual deficiency and the ways ICT is attempting 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 were 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 could realize that the collaboration of users is already explored to a good extent in systems that aim at physically impaired people. There is very little concern with visually impaired citizens, in that sense. Even in systems that already explore collective intelligence, it was not difficult 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 (Malone et al., 2010). 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, in order 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 the two groups of users with special needs, with respect to urban mobility, 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 an opportunity for future works to try to meet the needs of both groups with one only solution. 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. It should be remarked that, according to Malone et al. (2008) diversity improves the results of the use of collective intelligence. We also think that audio-tactile maps and the exploration of information about the existence of guides installed on side-walks for blind people could be merged with routing systems, originally intended at wheel chair users in future developments.

After performing this review work, we intend to code some of the functionalities and features that were discussed in the papers we analyzed, trying to push further some of the ideas authors presented in their work and developing a system that benefits from information provided by its direct users, as they use the system, to improve the way s/he and others move around the city, through each time more accessible routes.

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## Appendix – List of papers included in SLR *corpus*

| Year | Title | Author |
|---|---|---|
| 2006 | U-Access: a web-based system for routing pedestrians of differing abilities | Sobek & Miller |
| 2008 | People Helping Computers Helping People | Holone & Misund |
| 2008 | RouteCheckr: Personalized Multicriteria Routing for Mobility Impaired Pedestrians | Völkel & 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 & 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 Env. | 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 |
| 2011 | Accessible Maps for the Visually Impaired | Zeng & Weber |
| 2012 | CrossingGuard: exploring information content in navigation aids for visually impaired pedestrians | Guy & 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 & 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 & 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: vizualization 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 & 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 & 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 & Weber |