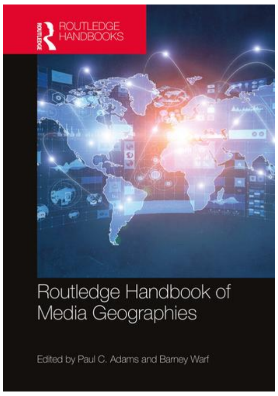

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6

DIGITAL MEDIA AND PERSONS WITH VISUAL IMPAIRMENT OR BLINDNESS

Susanne Zimmerman-Janschitz

The dynamic evolvement of information and communication technologies (ICT) offers both opportunities and challenges for persons with visual impairment or blindness (VIB). Digital information appears to be available 365 days a year, 24 hours a day; but this is only true for parts of (Western) society. Some people are still excluded. There are limitations concerning availability of the internet and technological resources in terms of cost, digital divide, social exclusion and/or accessibility. This is especially true for persons with VIB. What is intended to support unlimited access to information and therefore to enhance independency and self-determination often contains hurdles or barriers. From a geographical perspective the focus is on space-related information, because spatial data or maps are important to enhance personal mobility—in digital as well as physical environments.

It might be assumed that persons with VIB are generally disadvantaged or even excluded in terms of using spatial information. Thinking about mobility in this context, the widely imagined scene is of a person with a long white cane walking along a street. Yet, the reality is far more complex and so are the strategies to cope with limitations in access of spatial information. However, the individual and therefore unique needs of persons with VIB regarding information can seem contradictory. Some persons with remaining sight use buildings reflecting the light (e.g. with glass fronts) to orient themselves, others avoid high reflecting surfaces because of glare. Persons with color vision deficiency might have problems distinguishing colored symbols on a map, while for persons with vision loss, colors are helpful to differentiate symbols due to a reduced ability to identify details. These examples illustrate that persons with VIB are a very heterogeneous group (Huebner 2000, 55; Zimmermann-Janschitz et al. 2017, 68), requiring different approaches in scientific theory as well as in practice.

From a practical viewpoint, solutions can be constructed upon, for example, (1) the existing disability or limitation (e.g. based on the International Classification of Functioning, Disability and Health (WHO 2001)), (2) the sense used to complement or replace vision (auditory, kinesthetic, tactile, olfactory or combination) or (3) the technical approach for the assistive tools or technologies used (GPS, GIS, etc.). The theoretical perspective is based on two main research foci (Worth 2013, 575). Golledge (1993) as well as Kitchin and Jacobson (1997), amongst others, discuss the cognitive representation of spatial settings seen from the personal limitation, and hence follow the medical model of disability. Scholars around Butler

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(Butler & Bowlby 1997, 421) shift the attention towards the social experience in public space, following the social model of disability which identifies the society as the obstacle to accessibility. The advancement of the social model shifts with Worth (2013) and Macpherson (2010) towards a relational perspective, where people "engage and perform their embodiment and in so doing re/produce and transform both themselves and their surroundings" (Hall & Wilton 2017, 728).

This chapter will give an overview of the variety of scientific approaches to supporting accessibility of (spatial) information, starting off with a look at the legislation(s) enhancing accessibility in ICT. Two core aspects, the accessibility of information and the information about accessibility of the built environment to support orientation and wayfinding, will be discussed. Current research trends next to future research issues are intended to reflect the findings.

Legislation as framework

Visual impairment and blindness in numbers

The World Health Organization states that 2.2 billion people around the globe are visually impaired or blind (WHO 2019, 26), including also mild forms of visual impairment. For the year 2020 Bourne et al. (2017, e894) present an estimated number of 237 million people with moderate or severe visual impairments around the globe, of whom 38.5 million persons are blind. This number corresponds with a percentage of 3.06% of persons with visual impairment and 0.50% of persons with blindness worldwide. In the United States, Varma et al. (2016, 806) compute the number of persons with visual impairments (aged 40+) for the year 2020 at 3.67 million persons, and 1.12 million people with (legal) blindness. Remarkably, there is a lack of up-to-date and comparable statistical data due to differing models of surveying and projection as well as contrasting definitions of impairment. It is noteworthy, though, that there are no comparable figures available for the European Union (EU).

Legislative frameworks

The increasing number of individuals with VIB and the shift in the paradigm of disabilities has lead to numerous legislations, standards and recommendations at different institutional levels. At the international level a milestone for the implementation of equality of persons with disabilities (PWD) was achieved with the "Convention on Rights of Persons with Disabilities (CRPD)," adopted by the United Nations General Assembly on December 13, 2006 (United Nations (UN) 2006). Article 4 promotes ICT with the integration of Universal Design (para. f), and "mobility aids, devices and assistive technologies suitable for PWD, giving priority to technologies at an affordable cost (para. g)" (UN 2006, 6). Article 9 (UN 2006, 9) focuses on accessibility of ICT and the built environment. Despite being binding, the CRDP needs (supra-)national laws and standards for guideline realization.

The EU provides support to get the CRPD into practice at the supra-national level. While the "European Disability Strategy 2010–2020" focuses mainly on the reduction of barriers (European Commission 2010), the "European Accessibility Act" promotes employment and occupation. Extra emphasis is given to the accessibility of websites and mobile apps of public sector bodies (European Commission 2015). European Standards define specifications and technical details, e.g. the accessibility of ICT (EN 301 549), of websites and mobile applications (EN 301 549), of the built environment (EN 17210), or "Design for all" standards (EN

17161) (European Commission 2020). The subjects covered by national laws and their enforcement vary significantly between member states, although basic strategies are adopted in all EU countries (Waddington & Lawson 2009, 54).

Pioneering in 1990, the United States established the Americans with Disability Act (ADA). This protects the rights of PWD and ensures their access to employment, goods and services, places of accommodation and telecommunications. Title II specifies that "individuals who are blind, deaf-blind, or visually impaired may not be denied full and equal enjoyment of the goods, services, facilities, privileges, advantages, or accommodations provided by a state or local government or place of public accommodation" (American Foundation of the Blind 2020). Explicitly, ADA covers the elimination of communication barriers by providing auxiliary aids and services to persons with VIB and removal of structural communication barriers through the Americans with Disabilities Accessibility Guidelines (ADAAG) (Joffee 1999, 8–10). The ADAAG fosters the accessibility of facilities, public buildings and public rights-of-way like accessibility of street furnishings, curb ramps, crosswalks or pedestrian signals (United States Access Board 2020). Section 508 of the Rehabilitation Act of 1973 particularly addresses accessibility of ICT provided by Federal governments (GSA 2019). To give some examples, braille visualizing signs, large print signage, audio displays, new ICT devices, detectible warnings at curb ramps, etc. can be indicated. Similar to the EU, state laws complement and/or strengthen the ADA.

Why laws are not enough

Even if standards and laws are well established, there is a gap between the legislative framework and reality in daily life. For example, laws on the protection of historical buildings in European cities with their historical heritage overrule accessibility of newly constructed or refurbished buildings. Regardless of a detailed design of public space, curbs, sidewalk width, the amount of space to guarantee barrier-free movement, etc. often fails to provide an accessible urban setting. Access to the built environment is also limited due to the attitudes of people and the "barriers" in their minds. Moveable obstacles like parked bicycles or pavement signs in front of shops often block the way. Next to construction sites they define essential barriers for persons with VIB, but this cannot be governed by law (Zimmermann-Janschitz et al. 2017). Legislation can also be contradictory for different disabilities: while persons using wheelchairs need low or no curbs in terms of access, persons with VIB often use curbs to orient themselves, e.g. when using a long white cane.

Information in digital media as key to independence

Availability and accessibility of information are key elements to independence for persons with disability, as they support self-determined participation in daily life. For example, the menu in a restaurant or information at the destination board of a bus line are inaccessible to persons with VIB if not available digitally or in braille. Common orientation hints like streets signs, visual landmarks or maps are barely perceptible, underpinning the importance of access to information. Consequently, wayfinding challenges in particular can be considered as problems of information quality and access (May & Casey 2018, 84).

A matter of format and content

Accessibility of information in general is a two-sided matter in which each aspect is dependent on the other; it can be defined by the (1) *format of its presentation* as well as by the (2) *content* itself (European Agency for Special Needs and Inclusive Education 2020). While the format must address at least two senses, haptics and/or sound in the context of VIB, the content needs to allow easy orientation.

Alternative *formats* of presentation in ICT are well established and several scholars give overviews and critical reflections on techniques and tools to complement or replace the visual sense (see e.g. Jansson 2008; Power & Jürgenssen 2010; Fuglerud 2011; Bhowmick & Hazarika 2017). Although digital forms of (inter-)action from e-business to social networks increasingly shape daily life, "traditional" and analogue formats of information stay crucial (Janschitz 2012, 73). Braille is an analogue way of displaying text, e.g. on automated teller machines, medicine boxes or in elevators. In regards to geography, tactile and talking maps (Miele et al. 2006; Stampach & Mulickova 2016), 3D models and tactile graphics (Völkel et al. 2008) have to be mentioned. However, braille displays are serving as a bridge to assistive technologies and digital forms of information access. Moreover, ICT finds counterparts to large print for persons with low vision with screen magnifiers.

The other sense used by persons with VIB is sound. Although olfactory hints may be useful especially in terms of orientation, they can hardly be digitized and are therefore omitted in this chapter. Parallel to haptics, a shift towards digital tools can be indicated. Traditional methods like audiobooks, auxiliary audio channels (second audio program) on TV or voice instructions in the elevator, etc. are extended by software solutions like screen readers (e.g. JAWS, VoiceOver, NVDA, etc.), the sonification of maps (Kaklanis et al. 2013) and hardware approaches with assistive devices like electronic white canes or mobile phones (see discussion below in the section "Types of assistive devices").

Aside from addressing alternative senses, the *structure of the content* is of equal importance. Screen reader software converts the content of a screen into synthesized speech. Since the navigation is based on using the keyboard instead of the mouse, navigation elements need to be defined in documents (e.g. headers, font, etc.). Feedback of websites is achieved by earcons, e.g. sound illustrating the opening of a document (Power & Jürgenssen 2010, 98). Next to the navigation, the structured content and the reduction of redundancy adds to the accessibility of content. Silva et al. (2017, 155) along with Giraud et al. (2018, 26) therefore developed key items and guidelines to increase accessibility.

More information—less accessibility

With technological development, media involves more visual-based information like pictures, videos and animations (Kern 2008, 144). Even maps gain new importance. Although ICT context, tools and techniques have improved, access to the digital information environment for persons with VIB has not advanced to the same degree. When it comes to a critical evaluation of progress, various gaps can be identified.

After investigating the content accessibility of 50 popular websites, Sullivan and Matson (2000, 144) state that despite availability and knowledge of guidelines, accessibility is hardly implemented: 82% of sites analyzed are inaccessible regarding at least one accessibility criteria. WebAIM analyzed one million webpages, 98% of them failed the Web Content Accessibility Guidelines 2.0. These guidelines define legislations and standards to guarantee accessibility of (public) webpages (WAI 2020). More than half of the pages show errors due to low contrast text (86%), missing alt text for images (66%) or empty links (60%) (WebAIM 2020).

Croll (2009) mentioned that graphical as well as video elements are inaccessible due to missing alternative formats. This is ever more true for social media. Hence, increasing the accessibility of photos and videos is gaining importance in recent research (Morris et al.

2016). Next to technical issues (keyboard accessible elements on the webpage, mosaic maps), Calle-Jimenez and Lujan-Mora (2016, 81) address the differentiation of colors and text in image format as the most important hindrances. Ducasse et al. (2018) offer an overview of hybrid solutions, combining sound and touch. Richardson et al. (2014, 664) reflect the importance of colors and contrasts when capturing websites.

Another accessibility dimension opens up with the touch interface of smartphones. Rodriguez-Sanchez et al. (2014, 7212) especially identify problems with wayfinding applications: "the information is not dynamic, the design is not universal, the interface is not adapted to different users and preferences, blind users need assistance to open the application, the typical screen reader is not applicable, they need to install a special screen reader or the auditory feedback is not enough." Damaceno et al. (2018, 429–432) categorize problems in seven dimensions (buttons, data input, gesture-based interaction, screen reader, screen size, user feedback and voice command), and additionally offer solution strategies based on an extensive literature review.

Finally, and next to the technical barriers, the digital divide refers to a barrier in accessing the digital information environment. Financial, technical and economic barriers (Kern 2008, 144–145), age and (dis-)abilities, but also aspects of literacy detain people from retrieving information (Goggin 2017, 76–77). For insights refer to Chapter 2 in this book.

Digital media and spatial accessibility: Dimensions of research

In terms of information and accessibility, the (geo)spatial component plays an important role (Anselin 1989; Goodchild 2001, 1). However, spatial cognition and spatial perception vary between persons. Guidice (2018, 269) identifies more limits for persons with VIB regarding their spatial competences than the disability itself. Spatial accessibility or access to the built environment and the accessibility of information on the built environment have to be core components to increase mobility and independency. Addressing the access of the built environment is predominantly associated with challenges in wayfinding, and comes along with issues of localization, orientation and navigation. Analogue and digital maps, (geographic) information systems, navigation systems and 3D models support these processes.

From the perspective of applications, individual mobility issues need further research regarding for example urban/public transport, health/emergency management and spatial planning. Access to transportation hubs (airport, train and bus terminals) (Guerreio et al. 2019), availability of means of transport and the development of assistive (electronic) devices supporting mobility (Strumillo 2010) are overlapping with challenges of public transportation (Ghalleger et al. 2011). The perspective in emergency, disaster and health management shifts from the individual with VIB to institutional (urban/regional) decision and planning support systems (Arai et al. 2013). Spatial information and information about the built environment serve for management decisions, for simulation purposes and for designing more inclusive settings by reducing barriers.

Moving forward from the areas of implementation towards structuring scopes and research topics, accessibility of the environment and mobility issues can be seen from diverse dimensions. Granting that these dimensions are linked and interconnected to each other (Figure 6.1), emphasis can be given to the:

- spatial context, looking at outdoor or indoor settings or a combination of both
- orientation elements implemented in the wayfinding process and obstacle detection
- senses used to complement or supplement vision
- methods and/or technologies applied
- types of assistive device customized

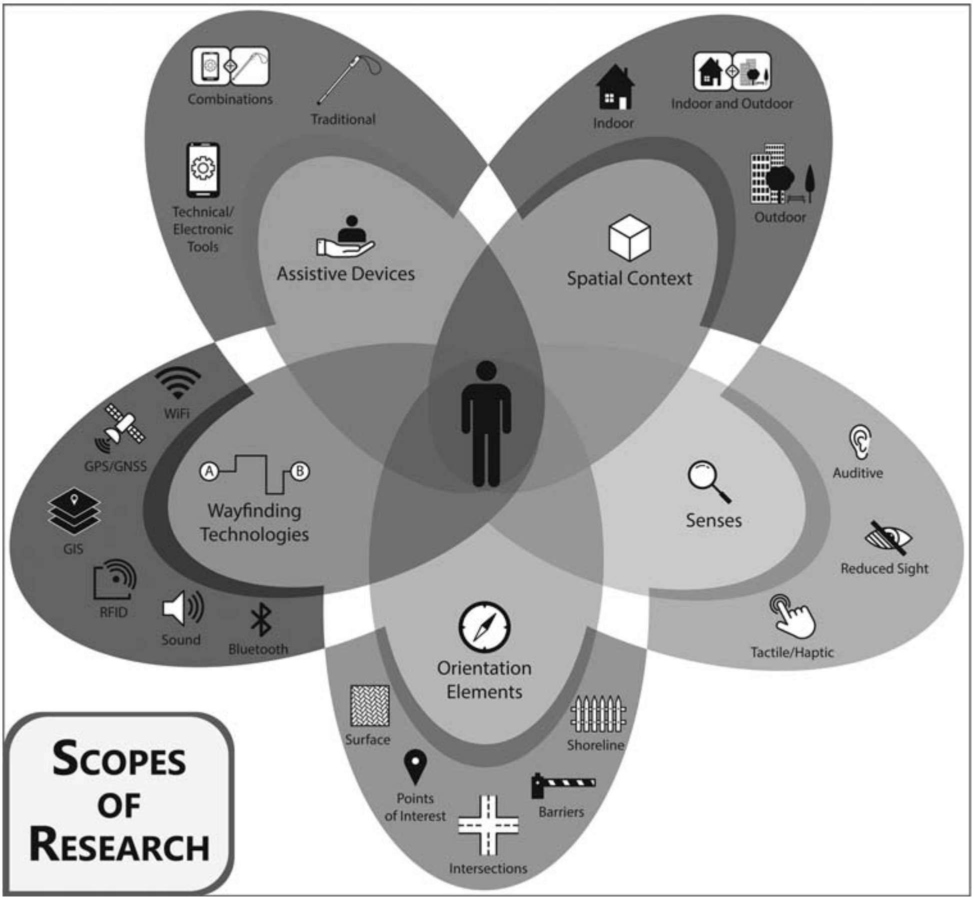


Figure 6.1 Essential research topics in the context of orientation and navigation for persons with VIB

Spatial context: Outdoor and indoor environments

Golledge (1993) was a forerunner in investigating orientation and navigation in urban settings with a focus on persons with visual impairments and their spatial cognition. His work is a milestone in, if not the beginning of research on, wayfinding of persons with VIB in geographical context. It was the outdoor environment where scholars started research. Outdoor orientation and navigation differ from indoor environments due to the utilization of orientation elements, technologies and/or assistive devices. Hints for outdoor orientation used by sighted persons combine directions, street names, landmarks or points of interest (POI) like unique buildings, while in indoor settings, hallways, floor levels, exits, stairs and rooms dominate descriptions for wayfinding. These references are integrated in standard navigation tools, but are not sufficient for persons with VIB, who need additional and more detailed descriptions for wayfinding. This includes alternative features like walls, fences, acoustic pedestrian signals, tactile pavement, etc.

The evolution of Global Positioning System (GPS), or more precisely global navigation satellite system (GNSS), navigation systems and web-maps (Google, etc.) intensified the discussion on wayfinding for persons with VIB (Real & Araujo 2019, 1). Outdoor wayfinding

(Kammoun et al. 2012; Emerson 2017) commonly integrates GPS; indoor solutions need alternative modes of positioning to compensate for the lack of GPS signal (Lakde & Prasad 2015, 167). New technologies such as radio-frequency identification (RFID-9), Bluetooth, etc. (see discussion below in the section "Types of assistive devices") led to a rise in interest for indoor applications after the millennium (Gallagher et al. 2011; Miao et al. 2011; Serrão et al. 2012; 2015; Murata et al. 2019). Additionally, some systems combine technologies for in- and outdoor wayfinding (e.g. Ran et al. 2004; Fernandes et al. 2014). The implementation of technologies for localization, orientation and navigation has led to the design of several prototypes and assistive devices (Ran et al. 2004; Wilson et al. 2007; Mayerhofer et al. 2008; Strumillo et al. 2018; Zimmermann-Janschitz 2019).

Prerequisites for wayfinding: Orientation elements and obstacle detection

As stated before, persons with VIB have demand for alternative, additional and supplementary information regarding their personal mobility (Dias et al. 2015, 147). Moreover, approaches to wayfinding are subjective due to the heterogeneity of the group. Landmarks, points of interest (POI)—like bus stops— and olfactory cues—e.g. trash bins—are indicated as important orientation elements (Strothotte et al. 1995; Afrooz et al. 2012, 1086; Serrao et al., 2014; Park et al. 2015, 24470). Shorelines like walls, curbs, fences, etc. are used as guiding features (Koester et al. 2017). Changes in surface and pavement (e.g. cobblestone, asphalt) support orientation. The infrastructure at intersections (tactile pavement, acoustic pedestrian signals, crosswalks) is of special interest, since intersections pose both amplified risk as well as navigational support to persons with VIB. Consequently, applications are looking at the automatic detection and implementation of intersections in the routing process (Coughlan & Shen 2013; Ahmetovic et al. 2017; Bentzen 2017).

Missing landmarks count as barriers, as do urban environmental conditions (e.g. construction sites, narrow sidewalks or squares) and moveable or fixed obstacles on sidewalks (unloading cars and parked bicycles, street furniture like benches, poles, boom barriers, etc.) (Zimmermann-Janschitz et al. 2017). Additionally, noisy surroundings interfere with the orientation of persons with VIB. Bergner et al. (2011) add an emotional component to navigation, measuring the stress of persons with VIB when approaching an obstacle.

Next to the subjective adequate number of orientation cues, orientation needs to be based on sidewalks instead of streets. Hence, the spatial accuracy of street-centerlines used in commercial navigation tools designed for motorized vehicles is insufficient (Neis & Zeilstra 2014, 70). Pedestrian networks allow the integration of impassable segments in networks (e.g. pedestrian zones, shortcuts, etc.) as well as the differentiation between left- and right-hand sides of the street, since persons with VIB orient themselves towards traffic. The automated generation of pedestrian networks as the basis for navigation is therefore important (Ballester et al. 2011; Karimi & Kasemsuppakorn 2013, 958). Factors contributing to the accessibility of sidewalks and influencing the route choices of persons with VIB are evaluated by Tajgardoon and Karimi (2015, 85).

Landmarks and POI serve as upgrades for step-by-step wayfinding directions, while reference to obstacles increases safety issues (Rice et al. 2013; Park et al. 2015). Both static and permanent barriers (e.g. post boxes, boom barriers) as well as movable obstacles (e.g. bikes) pose a risk to persons with VIB of getting injured when moving independently. Obstacle detection includes not only the recognition of obstacles, but the development of collision avoidance systems (Bhowmick & Hazarika 2017, 164).

Apparently, the amount of data involved in the wayfinding process, the availability of the information, georeferenced data on sidewalks, possibilities to gather information as well as the method of presentation are crucial components in the design of a tool to support wayfinding processes.

Senses used to complement or supplement vision

Similar to the individual needs regarding the content of step-by-step directions, the presentation of spatial information for orientation and navigation purposes has to be distinct from conventional, commercial navigation aids. At this point the focus is set to the spatial component with a crossover to technologies and assistive devices.

For persons who are visually impaired or blind, navigation tools and route planners need to transfer textual step-by-step directions into speech and maps need to be made accessible via touch and/or sound. Persons with remaining sight want an appropriate presentation of the map regarding extent, labeling, contrast and/or colors (Jenny & Kelso 2007, 64; Calle-Jimenez & Luján-Mora 2016, 81; Henning et al. 2017, 17). Tactile maps, used if remaining vision is not sufficient to fully discover maps, have a long tradition in cartography. Zeng and Weber (2011, 5) present a classification based on the mode of exploration of tactile maps (braille tactile map, virtual tactile map, virtual acoustic map, printable tactile map, augmented paper-based tactile map), indicating the complexity of approaches as well as the move towards a combination of touch and sound with the generation of web-maps.

The presentation of tactile maps and attempts at their automated production (Miele et al. 2006) as well as the potential of technological developments made in recent decades is not yet fully exploited (Lobben 2015). Rather, with the increasing number of online maps, the problem of inaccessibility rises. However, there are numerous approaches to overcome this problem and progress is being made in touch interfaces, integrating haptic or tactile information. Haptic information refers to an (inter)active capturing of information on objects and typically involves feedback to the object, while tactile information is perceived passively (Hersh & Johnson 2008, 137). A detailed description of accessible interactive maps is given in Ducasse et al. (2017). For wayfinding purposes, Wang, Zheng and Fan (2017, 721) offer different patterns of vibration feedback in terms of intensity and frequency of feedback to help staying on the route. Wang, Li and Li (2012, 98) for example designed a prototype to transfer online maps for navigation to scalable vector graphics (SVG) which can be printed as tactile maps. Other scholars use devices (e.g. belts, pointers) as spatial tactile displays to give vibration feedback regarding direction of movement (Marston et al. 2007, 205; Heuten et al. 2008, 175).

An important support for the communication of spatial information is the use of sound. This approach covers voice, audio and music in- and output tools with a strong focus on the output. Speech recognition is used sparingly (see Roentgen et al. 2008, 714–718). Interactive maps present in addition to touch features, acoustic feedback to users with VIB through audio and/or voice annotations (Siekierska 2003, 487). Navigating the map, sound represents orientation features, while annotations on objects present additional information with voice. Feedback via sound is also used to represent obstacles (Moreno et al. 2012, 80). A completely different approach to read maps is made via sound and music. Bearman and Fisher (2012, 159–160) turn information in maps into music by assigning for example changes in elevation to a sound scale. The sonification of statistical data in maps is clarified by Zhao et al. (2005, 2).

When it comes to navigation, text-to-speech can be seen as the most common form of presenting step-by-step directions to users, regardless of using screen reader software or recorded audio (Brock et al. 2015, 161). The combination of voice recognition, sound feedback as earcons and speech synthesis can be found in Parente and Bishop (2003) or O'Sullivan et al. (2015). Several scholars combine touch and sound elements to a multimodal experience in interactive, talking maps (Parente & Bishop 2003; Kaklanis et al. 2013) as well as in navigation tools and devices (Rodriguez-Sanchez et al. 2014; O'Sullivan et al. 2015; Wang et al. 2017). Some projects extend sound and touch to the virtual space using virtual or augmented reality. A three-dimensional virtual reality serves as a basis for mental maps and supports the acquisition of information on objects. This is consequently transferred to real space by the user and serves as a source for navigation (Lahav & Mioduser 2008; Katz et al. 2012).

Presenting the information: Methods and technologies applied

Alternative modes to make information available and accessible for persons with VIB require not only other types of information (as discussed above), but also additional technology to gather and display this information. The localization and tracking of a person with VIB along the route have to be very precise in terms of safety. For instance, if road works occur along a route, there should be the possibility to avoid the construction site. While GPS in general is sufficient in outdoor surroundings, differential GPS (DGPS) offers higher precision. Still, GPS signals can be shielded by trees or reflected in street canyons, followed by signal delay or coarse positioning (Ladke & Prasad 2015). The algorithm of Ivanov (2012, 1560–1562) simplifies GPS tracking by including only GPS points which indicate changes in the direction. Accessible GPS comprises solutions integrating haptic and/or sound interfaces to retrieve position and tracking information en route (May & Casey 2018).

In indoor environments, beacons, sensors and markers based on radio-frequency, infrared-, ultrasound signals, or using existing wireless networks (e.g. WiFi), are used to define positions. Yanez et al. (2016, 349) equip persons with several ultrasound sensors to detect obstacles in the surroundings, distributing the relevant information via WiFi. Regardless of whether Bluetooth is used (Castillo-Cara et al. 2016, 692) or RFID (Fernandes et al. 2014), beacons provide the spatial information in buildings and have to be placed on strategic locations. RFID determines the position utilizing tags on the floor, which are read with a corresponding device, e.g. an electronic white cane. Fernandes et al. (2014, 6–7) implement RFID in combination with a Geographic Information System (GIS) to store and analyze additional environmental information. Finally, cameras—either those attached to external equipment or smartphone cameras—are integrated to capture obstacles, landmarks or other environmental settings (Moreno et al. 2012; Serrao et al. 2015; Ahmetovich et al. 2017).

Shifting the focus from localization and tracking technologies towards analyzing spatial information for navigation purposes, GIS comes into play. Even though GIS is mainly used to store, manipulate and visualize spatial data in maps, its core part and intrinsic potential, analyzing spatial data, is not fully exploited. In the 1990s Jacobson and Kitchin (1997) gave a reflection of the potential of GIS for navigation and orientation of persons with VIB. Golledge et al. (1998, 728) utilize the full potential of GIS, using it to calculate routes and store for example landmarks and present them to the user while keep the user on track. Other scholars focus on the database to manage the amount of data characterizing the environment (Fernandes et al. 2012; Serrao et al. 2015). The analytical component is applied to analyze and examine networks, calculate routes or integrate parameters as the basis for decisions. Zeng and Weber (2012) developed a user interface based on braille and sound to overcome accessibility barriers. Bearman and Fisher (2012) turn information into sound. Zimmermann-

Janschitz (2019) implemented a web-GIS on a medium-sized city scale to support wayfinding and closest facility search (see case study "ways2see").

Case study: ways2see (text by Simon Landauer)

ways2see is a web-based wayfinding application assisting people with visual impairment or blindness when preparing and planning routes and shorter trips of everyday life in an urban outdoor environment. Focusing on the concept of availability and accessibility of information, the detail and selection of content are designed in accordance with the format of presentation.

Concerning wayfinding technology, ways2see uses GIS to manage and process necessary data for routing of pathways. The wayfinding itself is based on a specifically designed pedestrian routing network, incorporating type of way-use (sidewalk, footway, cycle way, etc.), auditory and tactile features of crossing, obstacles and barriers (boom barrier, pole etc.) as well as shorelines (house wall, fence, etc.) and surfaces (pavement, cobblestone, etc.). Results are consequently returned as turn-by-turn directions, where each segment holds details on the aforementioned information (see Figure 6.2). Aside from addresses, POI (medical facilities, supermarkets and drug stores, education infrastructure, entertainment, etc.) can be chosen as destinations according to their distance from the starting point. The tool further addresses the issue of user heterogeneity by introducing three user profiles and one open profile, determining the routing according to a pre-defined ruleset. Yet, the application does not feature on-site routing via GPS/GNSS due to the focus on pre-trip navigation as well as issues of GPS signal accuracy in the context of VIB. Consequently, the application is considered an assistive planning tool, supporting the use of traditional assistive devices along with new technology.

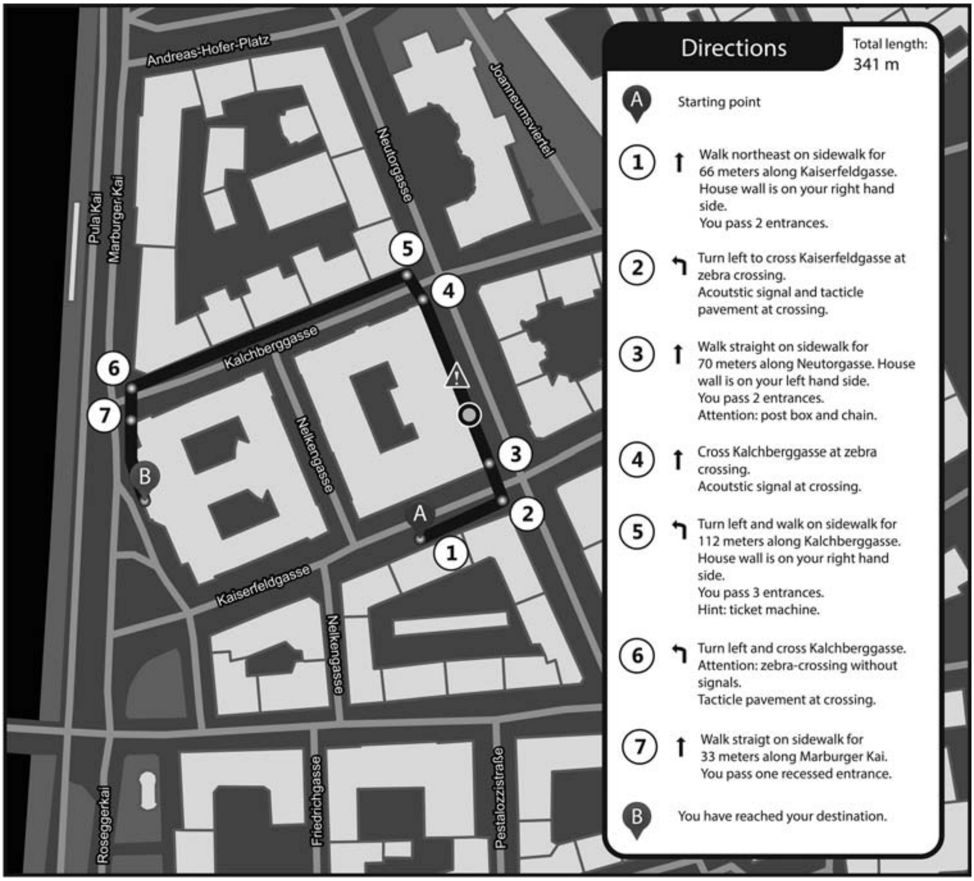
In terms of format, the accessibility of content is provided through the screen reader compatibility of the entire application and navigation through keyboard-only input. Use of high contrast coloring for visual aspects and maps allows for additional access of output for users with reduced vision. Furthermore, keeping maps features limited to essential elements enhances usability and performance. The same holds true for the cartographic as well as overall symbology used. Predominantly designed for desktop use, implementation on mobile devices is considered challenging.

For further information: https://barrierefrei.uni-graz.at/ways2see/

Types of assistive devices

Orientation, navigation and wayfinding research has produced a wide range of assistive devices over the last few decades. Several studies, evaluating the topic from diverse perspectives, document scientific progress and drawbacks. Roentgen et al. (2009; 2011) investigate the performance of obstacle detection and navigation tools. The focus of Hakobyan et al. (2013) is on mobile devices covering orientation and navigation next to smart homes and robotics. Lakde and Prasad (2015) investigate indoor and outdoor navigation systems. Tapu et al. (2018) and Real and Araujo (2019) give a holistic view on tools and devices supporting navigation from the application side, as Bhowmick and Hazarika (2017) approach assistive technology with the goal of identifying research networks and clusters.

Additionally, assistive devices not directly associated with orientation or navigation have to be mentioned, since they often are an integrative part of assistive tools to support mobility. Amongst these are screen reader software, refreshable braille displays, raised pin pads and sensitive tablets.



Directions

Total length: 341 m

A Starting point

1 ↑ Walk northeast on sidewalk for 66 meters along Kaiserfeldgasse. House wall is on your right hand side. You pass 2 entrances.

2 ↰ Turn left to cross Kaiserfeldgasse at zebra crossing. Acoutstic signal and tacticle pavement at crossing.

3 ↑ Walk straight on sidewalk for 70 meters along Neutorgasse. House wall is on your left hand side. You pass 2 entrances. Attention: post box and chain.

4 ↑ Cross Kalchberggasse at zebra crossing. Acoutstic signal at crossing.

5 ↰ Turn left and walk on sidewalk for 112 meters along Kalchberggasse. House wall is on your right hand side. You pass 3 entrances. Hint: ticket machine.

6 ↰ Turn left and cross Kalchberggasse. Attention: zebra-crossing without signals. Tacticle pavement at crossing.

7 ↑ Walk straigt on sidewalk for 33 meters along Marburger Kai. You pass one recessed entrance.

B You have reached your destination.

Figure 6.2 Detailed turn-by-turn directions in ways2see for people with VIB

“Traditional” types of assistive devices to support individual mobility of persons with VIB are the long white cane, the guide dog as well as sighted guides (orientation and mobility trainers, friends or family members). In terms of independency, the long white cane is indicated as most important (Ladke & Prasad 2015, 166). For this reason, electronic adaptions and extensions of the long white cane are significant. An overview of haptic and/or sound features for long white canes is given in Khan et al. (2018). Next to the electronic cane numerous new devices have been designed, combining sensors, cameras, canes and computers or phones in complex assistive devices. Cameras or GPS attached to a hat, computers in backpacks, sensors integrated in belts, bracelets or all over the body, even tablets used for communicating with the system can be found as described above (examples in: Roentgen et al. 2009, 2011; Tapu et al. 2018; Real & Araujo 2019). Nowadays, applications for smartphones have gained importance, offering multisensory equipment in one device (Rodriguez-Sanchez 2014; Murata et al. 2019).

“Nothing about us without us”: Challenges and future research

The chapter illustrates the variety of digital media as well as their prerequisites for persons with VIB. The development of assistive devices and tools supporting their daily life, particularly enhancing their personal mobility, is an emerging research topic. Numerous articles, approaches and applications go together with the progress made in ICT. During the last two decades, the increasing number of evaluation papers shows an accelerating trend.

It is remarkable, and has been stated many times, that the improvement for persons with VIB—generally and related in terms of mobility—has been limited (e.g. Chandler & Worsfold 2013, 920; Rodrigues-Sanchez et al. 2014, 7211). Bhowmick and Hazarika (2017, 164) express: “Although the advancement of technology is evident, only a limited number of assistive technology solutions have emerged to make a social or economic impact and improve quality of life.” Since digital media and ICT offer tremendous potential regarding what can be achieved for persons with VIB, it is not sufficient at this point to end with an overview of this topic and a snapshot of the development. There is need for a final critical reflection of ongoing research and a glimpse of future research strands.

Data as critical input

From a technical perspective, specific data is the most crucial part in the design of mobility support for persons with VIB. Therefore, many applications have a narrow spatial extent and are limited to university campuses, city blocks or single buildings or remain prototypes (Roentgen et al. 2009, 745; Murata et al. 2019, 14). These “lab conditions” use a limited data set. Many factors play a role regarding data: the data volume, for example data included in wayfinding (cues, barriers etc.) or network data as the basis for the navigation process. The elements and objects relevant for the navigation process of people with VIB are assessed by interviews or questionnaires (Chandler & Worsfold 2013), but the necessity for individuality (Cuturi et al. 2016) is barely achieved. Ballester et al. (2011) certify the need for pedestrian networks offering an automatization of network generation.

There are different attempts to overcome data limitations. Open source and open government data, volunteered geographic information and crowdsourced data are intended to reduce costs. Free data make applications available for wider spatial extent and raise the chance to integrate appropriate data for individual solutions (Kaklanis et al. 2013; Rice et al. 2013; Zeng et al. 2017). However, open data generate additional challenges like spatial accuracy, reliability or coverage. Emerging new technologies, e.g. big data, the internet of things (IoT) or laser scanning, promise to provide data previously not available.

Technological development

Fast-evolving information technology is an integral part of life, especially for the youth. ICT, including assistive devices for PWD, are not commonly accepted the same way. Söderström and Ytterhus (2010, 307) found that young individuals with visual impairment try to avoid the use of assistive devices, since they perceive them as stigmatizing and excluding. People who are blind rather embrace assistive devices as a chance to be integrated into (ICT) society. Eventually, ICT can be perceived as both opportunity and threat. Obvious obstacles are affordability, complexity and usability. Moreover, map literacy and technical literacy hinder persons with VIB from using assistive devices. Additionally, a certain amount of training is needed (Tapu et al. 2018). Cuturi et al. (2016, 241, 248) criticize the amount of information involved in complex assistive devices and tools. The development towards smartphone-based solutions is promising, since this device is easy to use, affordable and has the potential to be adapted to individual needs (screen reader etc.) with low effort.

Participation and empowerment to reduce "barriers in mind"

Finally, there is a need to look at the humans concerned: persons with visual impairment or blindness. There is no doubt that mobility is a human right and increasing individual mobility provides a step towards a self-determined and independent daily life. Technology and media are an important part of achieving this goal, but nevertheless they are only one part. Inclusive and integrative research design (Butler 1994, 368) and the empowerment of persons with VIB leads to wider acceptance and implementation of research results. Guidelines, laws and standards are available, but if not implemented, they are inoperable. The advancement of ICT has the potential to support society towards inclusion, raise awareness and generate sensibility in society for PWD. But there is still a long way ahead to reduce remaining "barriers in our minds."

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