Implementation and Innovation in the Area of Independent Mobility Through Digital Technologies

Introduction to the Special Thematic Session

David Banes[1(✉)], Riccardo Magni[2], and Florian Brinkmann[3]

[1] Access and Inclusion Services, Milton Keynes, UK
david@davebanesaccess.org
[2] Centro Orientamento Ausili Tecnologici Associazione Onlus, Umbria, Italy
[3] Institute of Transportation Systems, German Aerospace Center (DLR), Cologne, Germany

Abstract. Digital technologies are having a profound impact upon all phases of mobility for persons with a disability. In this paper, the different stages of travel are reflected upon their potential pain points for travelers with a diverse range of needs. Furthermore, solutions in which emerging digital technologies are offering solutions to historic barriers are derived. The paper thereby reflects upon the five contributions to the special thematic session "Implementation and Innovation in the area of independent mobility through digital technologies" of the 17th ICCHP.

Keywords: Travel · Transport · Assistive technology · Inclusion · Technology · Innovation · Emerging technology · Technology trends · Independence

1 Introduction

Independent mobility is often cited as a requirement of people with a disability in seeking to increase opportunities for full access to education, employment, and daily living [17]. The European Accessibility Act[1] takes the obligations deriving from the UN convention on persons with disabilities and aims to ensure equal opportunities for all to enjoy seamless, accessible, and independent travel [4]. The goal of European Project TRIPS (TRansport Innovation for disabled People needs Satisfaction) is to design, describe and demonstrate practical steps to empower people with disabilities to play a central role in the design of inclusive digital mobility solutions.

We are witnessing fast progress in the development of mobility solutions, Ride Pooling, E-Scooter Rental (Sharing), Moped Taxi/Scooter Taxi, Car Sharing, Bike Sharing (including electric bikes). Yet not all of them are designed and operated in a way that they are accessible to everyone and only few research projects address the

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2015%3A0615%3AFIN.

K. Miesenberger et al. (Eds.): ICCHP 2020, LNCS 12377, pp. 277–285, 2020.
https://doi.org/10.1007/978-3-030-58805-2_33

challenge of accessibility in the context of new mobility systems [14]. Recent innovations in both assistive and accessible technologies, such as natural interfaces, wearable technologies and artificial intelligence suggest new ways in which navigation, orientation and wayfinding can be made accessible for people with a variety of needs including those with cognitive, sensory, physical impairments and the elderly.

For many people with disabilities, the barriers identified when travelling are often related to a lack of information to inform planning [11]. Digital assistive technologies impact across the entire journey through provision and ease of access to infrastructure, environment, points of interest, and the form of transportation itself. In seeking to understand the pain points within a journey, the model developed for accessible public transport in Australia provides a relevant framework [3]. These include:

- Pre-journey planning: decisions about using transportation that are made based on available information.
- Journey start and end: usually outside the transport system. For example, travelling from home to the stop, station or terminal along a footpath,
- Transport stop/station: locations that transport services operate to and from.
- Transport service: the conveyance that enables the journey, the 'on board experience', as well as the scheduling/routing of services
- Interchange: places where service or mode transfers take place.
- Return journey planning: reversing the journey for return or onward journey.
- Disruption to business-as-usual: this includes planned and unplanned disruption to transport services or along the journey start and end sections.
- Supporting infrastructure: this supports the journey and includes mid and end of trip infrastructure such as toilets, drinking fountains, wayfinding and seating

At each stage, we can explore where emerging technologies impact and promote ease of access. The five papers of the special thematic session address the different phases of the journey and propose solutions for making transport more accessible.

1.1 Pre-journey Planning

People with a disability may need to expend considerable time and effort at this stage to feel confident that they can efficiently and safely complete their journey. This contrasts with other customers who can often make more spontaneous public transport travel decisions.

The paper "AccessKB: Linked Open Data for Accessible Travel" addresses the topic of pre-journey planning by using open data for creating an accessible travelling decision support.

During this phase, users are seeking information to confirm the accessibility of all parts of the journey. Their decision making during this phase is influenced by experience and the experience of friends and family. Building confidence around the accessibility of the entire trip is key to enabling and encouraging more people to use a form of transport for their travel needs.

Emerging technologies can help to address some of the potential barriers at this early stage. For instance, natural interfaces offer more diverse and accessible ways for people with disabilities to interact with information [2]. Speech interfaces such as

Amazon's Alexa allow natural language to be used for enquiries, which are then spoken out supporting people with a visual or another form of impairment. An example might be "Alexa what time is the next bus to the airport" The system is location-aware and can understand the likelihood that you are searching for a route to the nearest airport. Such systems may then prompt with further information such as "do you want to know about later buses?".

AI can help us in planning journeys [5] by suggesting and recommending the best options for a journey. For instance, if we needed to get to the airport, we might enquire, what the best way to the airport, we might get asked whether we mean the fastest, most direct or cheapest journey and then recommend a solution based on refining the query. Over time the system can learn from our choices how we personally define "best" and retains that when responding to similar future enquiries.

The internet of things, when integrated with AI or machine learning, allows us to plan our journey based on the real-time experience of others with similar needs. For instance, the technology could form a planning support system which would inform the user that "people using a wheelchair near you, travelling to the airport by taxi take on average 22 min to reach the destination or 36 min by bus". Such systems could automatically then prompt users with questions such as "would you like us to book a taxi for you?"

Digital payment methods such as https://upipayments.co.in/digital-payment/ also allow travelers to pay or authorize payment at this stage, reducing the need to pay at kiosks or counters at stations, or to find cash or debit cards when boarding or departing a taxi or shared ride. Services such as Uber offer the ability to have payment pre-authorized and made automatically when the journey is complete.

VR as described by Neuburger Beck, and Egger, [10] can help to have a realistic simulation of the crucial phases of journey planning, to assist in choosing best options or preparing a user for the journey itself, anticipating views and operations (access, drive and use means of transportation).

The paper "How can I succeed in planning a trip with my disability? Identifying Gaps in the Travel Chain" reflects upon existing applications for trip planning and seamless navigation and identify gaps. The authors derive requirements for an automated generation of accessible indoor maps.

1.2 Journey Start and End, Including Entry and Exit from Transport Systems

To enter the transport system, people need to move from their current location to a transport point of access or to leave the system to enter a destination. People with a disability face challenges because of a lack of information about the environment they are entering. This is also a challenging part of the journey for providers and operators as they may have little or no control over conditions around the entrance and exit points and links to destinations.

The paper "Co-production of knowledge for designing inclusive digital mobility solutions – the methodological approach and process of the TRIPS project" addresses different phases of the journey by collecting requirements of users concerning different

transport systems. The authors aim to identify barriers of using public transport means by using qualitative methods.

Digital technologies can enhance this phase of the journey in a variety of ways. The Internet of Things allows for real-time tracking of transport, [9] which can be communicated to a person with a disability to aid them in leaving their location to reach the access point for the carrier. These can include both outdoor navigations, based upon GPS systems and indoor systems utilizing beacons. Ideally, these systems are integrated and seamless. Wearable technology and machine learning offer the opportunity to record the maximum time taken by the user to reach that point [6] and warn the person well in advance that they need to be leaving to reach the access point on time. For people with a disability, this reduces the risk of missing crucial transportation which may incur costs and add to frustration.

Augmented Reality such as that used by Google Maps[2] can indicate specific access points for both the passenger and the provider of the service. Meeting points can be displayed in AR, and can be used to show locations of bus stops or platforms which are permanent access points. Both points of access and routes to temporary access points, including ride-sharing collection points for services such as UBER[3] or the direct route to temporary transport such as eScooters or other shared vehicles.

Such AR systems can also take account of the need for easy routing to an access point, avoiding both fixed and temporary barriers to the desired location and reducing the risks of missing a transport connection.

Wearable and location-based technologies can support ticketless access and keyless unlocking of rental vehicles when the user is in proximity [12]. The automation of such services can be of value to those with cognitive impairment who may find codes complex to repeat into a keypad, and the provider can be assured that the vehicle will be automatically locked such as when the user is more than 10 m from the vehicle.

1.3 Transport Access Point

This stage is concerned with the person's experience at the access point, from their arrival until they board the vehicle or conveyance. Transport access points may be as simple as a sign or stop marker or as complex as a multi-modal interchange where different services converge.

In the study undertaken by DIRD [3] People with disability highlighted issues at this point in the journey, including:

- lack of shade and shelter
- sufficient space for mobility devices
- visual and audio 'clutter' associated with advertising or general street/road signage
- issues around identifying and hailing their service

[2] https://support.google.com/maps/answer/144361?co=GENIE.Platform%3DiOS&hl=en#:~:text=Share%20a%20map%20or%20location&text=Or%2C%20find%20a%20place%20on,the%20place's%20name%20or%20address.&text=Share.,the%20link%20to%20the%20map.

[3] https://help.uber.com/riders/article/what-are-suggested-pickup-locations?nodeId=9edf05bf-ac3a-4cf8-b08e-76e9ca767f7f.

- late changes to departure points
- difficulty in boarding a vehicle.

In larger transport settings such as bus, air or rail terminals, movement between drop-off points and access points for the next stage can be challenging.

Location-based services will allow the virtual access point to be shared with the provider and the precise details to be agreed such as that offered by UBER and other ride sharing services This allows a point of access to be confirmed, that has the facilities required by the passenger for their comfort and convenience. Choosing a virtual access point can also be eased with the addition of further data around the location indicating potential places with shade and shelter or other facilities for personal care.

The both papers "Analysis of Indoor Maps Accounting the Needs of People with Impairments" and "Considering Time-critical Barriers in Indoor Routing for People with Disabilities" address the challenge of indoor navigation.

5G offers opportunities for information on services to be delivered in a range of formats (image maps, videos.) in real-time. The speed of 5G connections allows multiple data sources to be integrated, including the location of the vehicle, the likely journey time and any immediate changes that are needed.

Next IOTs directly connected to 5G support services will allow for many passengers, the ability to automate the booking and payment system using wearable or portable technologies, reducing the risk of errors in payment, or reservation. The move towards cashless and contactless facilities makes payment both safer and more accessible for disabled passengers.[4] [15].

1.4 Transport Service

This phase involves the user's interaction with the vehicle and potentially any driver or other user of the vehicle. People may need assistance to board and exit in the form of ramp deployment or other aid; onboard communication should help build the confidence of the passenger that such services are prepared for arrival. Requirements of the in-vehicle stage may be different depending on the mode of travel and the length of the journey. Current Guidance in countries such as the UK[5] places the onus upon the person with a disability to ensure that the station or destination is both accessible and informed of arrival times.

During this stage of the journey, 5G and location-based services allow users to receive and share real-time ongoing travel data. The ability to share real-time travel locations can be especially valuable to some of the most vulnerable in society who can be monitored for safe arrival and greeted, and any additional support required provided. The ability to share locations and arrival in technologies offered by a range of transport

[4] "Transit and Contactless Open Payments: An Emerging Approach for Fare Collection" - A Smart Card Alliance Transportation Council White Paper.

[5] https://orr.gov.uk/__data/assets/pdf_file/0018/41517/accessible-travel-policy-guidance-for-train-and-station-operators.pdf.

providers including ride sharing and bus companies, alongside those integrated into mobile handsets can facilitate this.

For those with communication impairments, AI supports access to real-time communication with the transport provider, including real-time transcriptions of speech, word prediction and text to speech for communication [13]. It could be a help for all passengers, also those with a cultural disadvantage, considering language barriers in international contexts. Text can be augmented by symbols to aid understanding for those with literacy impairments or other forms of communication need.

Increased personalization of services can be established based upon the actual records of transport use and travel preferences [16]. Hence if a passenger has always required a wheelchair accessible vehicle than that is automatically ordered. If the passenger has needed help boarding a vehicle, such as a chair stored, this is instantly communicated to the provider when the booking is made. Equally, the accessibility of onboard services, including washrooms or restaurants, could benefit from the application of modular automation/robotics helping passengers to reach and use services. Such services are especially valuable to people with a disability in planning longer journeys.

1.5 Interchange

People with disabilities may need to transfer to another transport system, mode or route at a point during their journey. To do this, they exit the service, navigate their way through an interchange to the next service, and then board. Changing services or modes occurs at an interchange. Transfers need to be efficient and easy to use to maintain confidence and reduce stress.

People with a disability are less likely to embark on public transport journeys that involve interchanges as it adds complexity and uncertainty to their trip [3].

To address this, a range of new technologies can contribute. AR and location-based services offer the opportunity for real-time navigation through an interchange, [8] with live updated directions based on the movements of others. As with other such services, the ability to track the progress of users, including those with specific needs helps the passenger to be confident that they have the time and the optimal route for to reach the next stage of their journey.

AI applied to the analysis of other user movement take informed in real-time the passenger with a disability whether the planned transfer time is realistic or if they should make alternate plans. Such systems can alert the provider of a service that a passenger with additional needs is en-route and to request a delay or other accommodation to facilitate their transfer. The paper Evaluation of Feasibility and Requirements of Audio Navigation System for Older Adults offers a solution to the issues of indoor navigation for people with a disability that are often encountered during this phase of a journey.

1.6 Return/Next Journey Planning

Once people have reached a destination, they may need to return to their origin, or will need to undertake an onward journey to a second destination. Users should be able to

quickly find the start of their return journey by re-tracing their travel path to locate an access point and board services.

People with disability may arrange any further or return journey as part of their pre-journey planning. Travel plans may be fixed on returning on a specific service at a particular time. If their circumstances change, or if changes are made by service operators, it can be challenging to re-plan their return journey.

Research [7] would suggest that AI and location-based services have potential to support the recording of a journey and helping to plan a return or onward journey. One of the challenges experienced by those with disabilities at this stage is the uncertainty of departure times from the new location. The technologies can be used to maintain a live update on options for the next phase of the journey as the day progresses and this can be communicated on an ongoing basis with the use of high-speed 5G connectivity.

Similarly, AI and location-based services can offer real-time updates to plans taking account of data from other passengers planning to use similar routes and forms of transport. Sensors held with mobile and portable devices, and wearable technologies can track ease of movement and update planning options for the next stage of journeys.

For those with cognitive impairments, the capacity to have a journey replayed in reverse with VR and AR will add clear contextual information in unfamiliar contexts. Equally where an onward or return journey requires the person with a disability to make the journey using a different route or form of transport, then it is helpful for them to review a simulation of the journey before starting the next steps.

1.7 Disruption

Any journey may be subject to disruptions. These might include cancellations, closure of a service, weather-related interruptions, vehicle breakdown, vehicle and transport replacements, or evacuation of a vehicle or station due to an emergency.

Disruptions can be planned or unplanned. A planned outage is generally well managed with advance notice, and alternate arrangements can be put in place to minimise the effects of disruption on planning journey. Many of the lessons learned from emergency evacuation planning such as those suggested by Alexander et al. [1] can inform other responses to disruption, the mainstreaming of such information into everyday use may help prepare people with a disability to cope when a crisis does arise. Unplanned disruptions are more challenging, as information about the nature of the interruption, and alternate arrangements can be difficult to source and communicate.

DIRD [3] note that when disruption occurs, people should be made aware of the situation, how they should respond, and whether there are alternative arrangements in place for them to complete their journey. People with a disability say that disruptions are highly stressful, and the possibility of disruption is a significant barrier to their participation in public transport journeys. Emerging technologies can help anticipate potential problems and fund mitigations rapidly.

AI can interpret live data to predict and anticipate disruptions based on real-time data. Such real time data is employed in applications such as Waze[6] which tracks and

[6] https://www.waze.com/forum/viewtopic.php?f=6&t=205657.

analyses travel times from other app users to assist in planning and route changes. Unlike other users, those with disabilities need to understand options that are both available and accessible. The sharing of information on real-time disruption and arrival times can help ensure that destinations are aware of arrival times and can support those who are vulnerable.

Information gleaned from possible services linked through IoT can suggest the locations of alternate travel options through a mobile or portable device including the availability of rentable and usable vehicles in nearby neighborhoods.

1.8 Supporting Infrastructure for the Journey

People interact with a supporting infrastructure throughout their journey. This may include physical infrastructure such as bathroom facilities, drinking fountains, signage, seating, shelter, lighting, maps, and timetables. It also consists of the service provider infrastructure such as customer service, other operator staff and those involved in their journey. Both are critical to the experience of people with a disability while travelling. Interactions with service staff, drivers and other support people often define the success of a journey. In such settings, location-based services offer real-time information about surrounding and nearby facilities that are accessible and usable to a person with a specific need. Such data can also be used as part of planning a journey access point, destination, or interchange where users are aware that they may need such facilities.

Such information can be presented through AR on services such as Google Maps to offer instant redirection information to appropriate facilities on demand.

Access to information should allow users to personalize the data according to their needs: 5G technologies offer the capacity to draw together all the information needed on to a mobile phone or other device.

2 Conclusion

People with disabilities face potential pain points at every stage of the mobility process. Addressing these had traditionally been both frustrating and time consuming and may have acted as a deterrent to travel for many. The speed and ease of use of digital technologies address not only the specific pain points but also the underlying stress created by reducing the complexity planning and making a journey. As the ease of planning improves, there is likely to be added pressure on transport providers to accommodate increase numbers of people with disabilities seeking to travel and hence increase demand for accessible transport solutions.

Acknowledgement. The information outlined in this paper is based upon that undertaken for the TRIPS project which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875588 and reflects only the author's view and the European Commission is not responsible for any use that may be made of the information it contain.

References

1. Alexander, D., Gaillard, J.C., Wisner, B.: Disability and Disaster. The Routledge Handbook of Hazards and Disaster Risk Reduction, pp. 413–423. Routledge, London/New York (2012)
2. Balasuriya, S.S., Sitbon, L., Bayor, A.A., Hoogstrate, M., Brereton, M.: Use of voice activated interfaces by people with intellectual disability. In: Proceedings of the 30th Australian Conference on Computer-Human Interaction, pp. 102–112 (December 2018)
3. DIRD: The whole journey: a guide for thinking beyond compliance to create accessible public transport journeys Government of Australia (2017)
4. European Commission: European accessibility act (2020). https://ec.europa.eu/social/main.jsp?catId=1202&langId=en
5. Ghanim, M.S., Shaaban, K., Miqdad, M.: An Artificial Intelligence Approach to Estimate Travel Time along Public Transportation Bus Lines (2020)
6. Harms, T., Olaru, D., Pattison, C.: Active travel: using wearable technology to analyse daily travel behaviour. In: 41st Australasian Transport Research Forum (ATRF) 2019, ACT, Canberra (October 2019)
7. Huang, H., Gartner, G., Krisp, J.M., Raubal, M., Van de Weghe, N.: Location based services: ongoing evolution and research agenda. J. Locat. Based Serv. **12**(2), 63–93 (2018)
8. Kasprzak, S., Komninos, A., Barrie, P.: Feature-based indoor navigation using augmented reality. In: 2013 9th International Conference on Intelligent Environments, pp. 100–107. IEEE (July 2013)
9. Kumbhar, M., Survase, M., Mastud, P., Salunke, A., Sirdeshpande, S.: Real time web based bus tracking system. Int. Res. J. Eng. Technol. (IRJET) **3**(02), 632–635 (2016)
10. Neuburger, L., Beck, J., Egger, R.: The 'Phygital'tourist experience: the use of augmented and virtual reality in destination marketing. In: Tourism Planning and Destination Marketing, vol. 183 (2018)
11. Park, J., Chowdhury, S.: Investigating the barriers in a typical journey by public transport users with disabilities. J. Transp. Health **10**, 361–368 (2018)
12. Reger, L.: 1.4 the road ahead for securely-connected cars. In: 2016 IEEE International Solid-State Circuits Conference (ISSCC), pp. 29–33. IEEE (2016)
13. Shaheen, S., Bell, C., Cohen, A., Yelchuru, B.: Travel Behavior: Shared Mobility and Transportation Equity, prepared for Office of Policy & Governmental Affairs, Federal Highway Administration, Report No. PL-18-007 (2017). https://www.fhwa.dot.gov/policy/otps/shared_use_mobility_equity_final.pdf
14. Smart Card Alliance: Transit and contactless open payments: an emerging approach for fare collection. White paper, Smart Card Alliance, Princeton (2011)
15. Wansley, A.T., Chen, R., Liu, S.Y.: U.S. Patent Application No. 13/956,182 (2014)
16. Warren, N., Ayton, D., Manderson, L.: Mobility issues for people with disabilities. In: Michalos, A.C. (ed.) Encyclopedia of Quality of Life and Well-Being Research. Springer, Dordrecht (2014). https://doi.org/10.1007/978-94-007-0753-5_1826
17. Wise, P.H.: Emerging technologies and their impact on disability. Future Child. **22**(1), 169–191 (2012). https://doi.org/10.1353/foc.2012.0002