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EDITORIAL

Inclusivity and diversity of navigation services

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Our car seats, watch straps, seatbelts, and gym equipment are all adjustable because of the 'jaggedness principle', which basically says that nobody is average. If you gather many people or things and collect data about different aspects and features of them, you will find that none of the very people or items can match perfectly with the 'average'. That is why we have watch adjustment holes and adjustable car seats. But this also means, there will be no average individual with size of the average measurements. But if there is no average person to use the technologies, then how can we design devices and technologies that can be used by everybody? What would happen if, for example, we designed navigation devices, path-finding services and assistive technologies for an 'average user' and then expected everybody to use them? Would it be as dangerous as a car without an adjustable seatbelt, or is it just a minor difference that can be ignored by our forgiving end-user? This editorial looks at the importance of human factors, inclusivity and diversity-by-design in navigation services and will look at some examples where jaggedness principle has introduced challenges and problems to our navigation services.

1. On average, there is no average person!

In the 1950s, that glorious time when the new jet engines were making aircraft travel much faster, the US Air Force realised that its pilots seemed to be experiencing some troubles with controlling their aircraft. Of course, the pilots were the first to be blamed, but very soon the US Air Force realised that neither training nor greater experience could stop non-combat accidents and crashes. It became apparent that it was the cockpit that was the issue. The cockpits had been designed based on the size of an average pilot back in 1926, and apparently the US pilots had grown since then! The US Air Force decided to update the measurements and redesign the cockpits for a new 'average pilot'. Engineers invited 4063 pilots and measured 10 physical dimensions that needed to be adjusted in the new design. They measured torso length, arm length, crotch height, etc. The data from all the pilots who had been measured were averaged to define a new 'average pilot' who was supposed to fit into the newly designed cockpit. Well, the underlying assumption for this new design was that the majority, or at least many, of the pilots were within the average range on the majority of dimensions. But none of the 4063 pilots should be managed to fit within the average range of all 10 dimensions! Only 14 among all 4063 the pilots were within the average size for only three dimensions. And so, to avoid designing a cockpit that was good for nobody, the Air Force response was to ask the engineers to design adjustable cockpits.

There are many other examples that show the 'jaggedness principle' stands. There is no 'average' student, there is no 'average' pair of hands, there is no average user. This makes one wonder – if there is no 'average' user – how we can ensure our devices and services can be useful at all. And what are the implications of designing a technology, such as navigation devices and mobile apps, for an 'average' user or a certain group of users while expecting everybody to use it?

2. Challenges of one-size-fits-all navigation

A navigation service can have four main components: maps, path-finding or routing engine, positioning technology, and finally communicating the navigational instructions. Each of these components is designed and provided initially for a certain group of users. Each of these four components has some levels of adaptation and personalisation features to maximise the use to serve the majority of (the 'average'?) users as best as possible. Let us go through each of them and see how inclusivity could have changed them and affected the wider group of users.

2.1. Maps

Studies show that people in wealthier countries, countries with longer coastlines, and those with higher equality measures, are generally better at reading maps (Coutrot et al., 2018). Even on an individual scale, the same person at different ages can read maps better or worse. Our map-reading and navigation skills can be improved by exploring new environments and even by education. So, it seems unlikely that one single map can serve all of us equally well.

Are our maps produced for a certain group of users? Well, they used to be mostly two-dimensional, north up, and non-egocentric pieces of paper, produced by surveyors, pilots and explorers. Perhaps that is why we have a very poor coverage of maps for indoor areas, even for publicly open buildings such as shopping centres and airports where maps may not disclose any private or secure features. And it is no surprise that outdoor maps do not have the features of interest to some minority users, such as the surface condition, which is crucial for bicycles and wheelchair users.

Even when we look at some mapping projects that are technically open to anyone to contribute and map and add any features or attributes of their interest, including the successful 'crowdsourcing' projects such as OpenStreetMap (OSM), we see a significant level of bias both in terms of participants and the data they contribute (Bittner, 2017). Some studies have shown that due to lack of inclusivity in the mappers of a technically 'crowd'-sourced platform, some of the features shown on maps may be of interest to the contributors, while features of interest to other users are missing. Features that are more often of interest to women (e.g., 'childcare') may not exist on maps, while sexual entertainment venues seemed to have much more detail and classifications (Gardner et al., 2020). A study showed that when women map, they are more likely than men to represent women's specific needs and priorities. It also found that women tended to add to maps services often overlooked by men, such as hospitals, childcare services, toilets, domestic violence shelters and women's health clinics.

Stereotypically men are thought to be better than women at reading maps. But could this be because maps and navigation apps have been designed and developed by men and so they considered men's preferences better? There are some studies that show that women can find their destinations faster than men, with fewer mistakes (getting lost or turning onto a wrong road) in three-dimensional environments, while remembering a greater number of landmarks and with a much higher level of detail. So yes, men may read maps better than women, but only in the two-dimensional world (Mohan and Basiri, 2019).

2.2. Path finding

We should acknowledge that most path-finding and general navigation services have been initially designed and developed for in-vehicle use. Non-drivers, including pedestrians and wheelchair users, still use routing services designed for motor vehicles (as they are or with some minor changes), but this can cause problems. Unlike drivers, pedestrian or wheelchair users, are not limited to the road network and can move in any direction, go through buildings, or cross open areas such as parks and grasslands. This greater freedom of movement is not supported by most widely used path-finding and routing algorithms (Basiri, 2020) which still calculate the path between an origin and destination using graph-based path-finding algorithms. Pick two points within a park and see how Google Maps navigates you! It projects the origin and destination onto the existing network of paths, e.g., roads, and then navigates you through that. It completely ignores the fact that pedestrians can cross the grasslands and they are not limited to the network of roads.

For certain user groups, such as women and children, the safest path might be the best path, while almost none of widely used routing services provide this; the best is the shortest because we all are considered as cars! For some other users such as wheelchair users, the width of passage, surface condition, slope and weather are very important features to optimise. These are not factored in the currently existing path-finding algorithms simply because they are designed for cars which care more about fuel and traffic than surface condition.

Wheelchair users have more ‘freedom’ but a lower speed of movement than road traffic – they are more akin to pedestrians in some ways. The ability to move across open spaces makes them less constrained than road traffic but more vulnerable than cars and pedestrians to environmental conditions. In addition, any changes in the pre-planned path can impose a significant amount of energy and time to be spent. Ferrari et al. (2014) showed that half of the trips in London become 50% longer for people with mobility impairments as they need to take longer trips or change the planned routes to avoid obstacles and inaccessible areas.

2.3. *Positioning and tracking*

Humans, unlike aircraft and ships, spend most of their time indoors and so may not have access to freely available Global Navigation Satellite Systems (GNSS) may not be a luxury they can have. Even when we are outside, we are more likely to be between buildings, e.g., in urban canyons, where the GNSS satellites in view might be limited. Just recently three-dimensional mapping aided positioning has been considered, despite GNSS having been in operation for several decades. This is partly because of the complexity of the issue, but also because urban navigation systems simply ignored it for some decades.

In addition, different users may prefer to have different levels of privacy or reliability, according to their context. Some studies have found that location obfuscation (which is the degradation of locations in order to preserve users’ privacy) could be a good solution, however, different services and different locations (e.g., closer to home or at work) require different levels of accuracy, reliability, continuity and even associated cost. We need to study users’ privacy, battery and power, reliability, and cost-related concerns better.

2.4. *Communicating navigational instructions*

The last component is about communication of navigational instructions. Our navigation apps can hugely improve through multi-modal communications, e.g., haptic, sounds, videos and images (of landmarks along the way). Some users may not feel safe or happy if they have to be attached to their phone to ensure they do not miss the next turning point. Some users may feel more confident that they haven’t got lost when they see a building of which a photograph or video was provided as a part of their navigational instructions. Also, the sense of touch is one of the first senses we have and one of the last ones we lose, so vibration would be a good way for providing navigational instructions to those who cannot hear or see as well as others.

3. Conclusion

As you can see, diversifying users and considering human factors and the uniqueness of individuals can actually play an important role in the usability of navigation services. Thankfully, this is now an important research topic in our area. In this issue of the *Journal of Navigation*, Arslan et al. (2020) look at the usability of electronic chart display and information systems (ECDIS), which is one of the major components of ships’ bridge navigation systems. They studied eye movement data, collected from experienced port pilots operating on three different models of ECDIS, and found a significant difference between the participant port pilots and expert users. Wang et al. (2020) examined the effect of colour combinations on performance of visual search tasks and found that colour combination significantly affected response time of the participants while not having a significant effect on their performance. They recommended colour combinations with negative polarity (e.g., yellow on black and white on black) for presenting search interfaces. These findings are of importance in human–computer interface designs for information display under vibration conditions. Ghosh et al. (2020) looked at student performance and assessment factors, and Iftikhar et al. (2020) studied cultural elements in the design and visual preference of signage information. They explored the variance in design and visual preferences of wayfinding signage at a university and its influencing elements and conducted a survey among 170 university students and visitors. The results demonstrated that the student participants preferred inline colours of signage, along with mono or less colour coding and detailed information, while the visitors preferred attractive colours with multi-colour coding and less detailed wayfinding information with pictograms. Individual differences concerning age, literacy level and gender were also computed, however, the differences recorded were trivial. This study suggests the need for detailed cross-cultural investigation concerning elements of signage design and visual preference to identify the drivers for culturally consistent university signage.

As we move towards more data-centric design of technologies, we should be even more careful about the representation of under-represented groups of users, putting inclusivity and diversity at the heart of our data collection and engineering. This will allow future data-driven decisions technologies to consider, integrate, monitor and customise according to the needs and demands of the end users, including the under-represented users. This will ultimately promote equal opportunity and access for all potential users. It is great to see that the Royal Institute of Navigation's vision includes the two terms of inclusivity and diversity as the main way to live in a more navigable world.

References

Arslan, O., Atik, O. and Kahraman, S. (2020). Eye tracking in usability of electronic chart display and information system. *Journal of Navigation*, 1–11. doi:10.1017/S0373463320000624

Basiri, A. (2020). Open area path finding to improve wheelchair navigation. arXiv preprint arXiv:2011.03850.#.

Bittner, C. (2017). Diversity in volunteered geographic information: comparing OpenStreetMap and Wikimapia in Jerusalem. *GeoJournal*, **82**, 887–906.

Coutrot, A., Patai, E., Silva, R., Manley, E., Weiner, J., Dalton, R., Hoelscher, C., Hornberger, M. and Spiers, H. (2018). *Cities Have a Negative Impact Navigation Ability: Evidence from Mass Online Assessment via Sea Hero Quest*. Neuroscience 2018. Society for Neuroscience, November 2018, San Diego, CA.

Ferrari, L., Berlingerio, M., Calabrese, F. and Reades, J. (2014). Improving the accessibility of urban transportation networks for people with disabilities. *Transportation Research Part C: Emerging Technologies*, **45**, 27–40.

Gardner, Z., Mooney, P., De Sabbata, S. and Dowthwaite, L. (2020). Quantifying gendered participation in OpenStreetMap: responding to theories of female (under) representation in crowdsourced mapping. *GeoJournal*, **85**(6), 1603–1620.

Ghosh, S., Brooks, B., Ranmuthugala, D. and Bowles, M. (2020). Investigating the correlation between students' perception of authenticity in assessment and their academic achievement in the associated assessment tasks. *Journal of Navigation*, 1–18. doi:10.1017/S037346332000051X

Iftikhar, H., Asghar, S. and Luximon, Y. (2020). A cross-cultural investigation of design and visual preference of signage information from Hong Kong and Pakistan. *Journal of Navigation*, 1–19. doi:10.1017/S0373463320000521

Mohan, M. and Basiri, A. (2019). *Usability Analysis of 3D Maps for Pedestrian Navigation among Different Demographic Profiles*. Proceedings of the 15th International Conference on Location-Based Services, Vienna, Austria, 11–13 November 2019. Research Group Cartography, 259–263.

Wang, H., Tao, D., Liu, S., Zhou, T. and Qu, X. (2020). Application of colour combinations on visual search tasks under vibration environments. *Journal of Navigation*, 1–17. doi:10.1017/S0373463320000533

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