Improving Accessibility through Wayfinding Applications

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

"Inaccessibility usually comes from a point of ignorance" (Gilbert, 2019). Accessibility, in its simplest form, is the practice of making activities, goods, and services easily available to all people, especially to those with disabilities. Many times, what we consider to be routine and simple day-to-day tasks are not always as easy as we believe them to be for individuals with disabilities. For such individuals, these tasks may be particularly demanding and require a considerable amount of effort and adaptation. According to the World Health Organization (WHO), 1.3 billion people experience significant disabilities worldwide, meaning current societal infrastructure is not accessible for every 1 in 6 people (World Health Organization, 2023). Therefore, prioritizing accessibility in the design process of all activities, goods, and services with accessibility in mind is essential to ensure that there are no significant barriers to any group of people, and that everyone has equal access to the same opportunities (Gilbert, 2019).

This Science, Technology and Society (STS) paper aims to identify how existing wayfinding applications show clear, accessible routes for navigation, as well as how they can be improved to enhance accessibility. Navigation is exceptionally difficult for people with certain visual or mobility disabilities. Many places in suburbs and cities do have many elevators, ramps, etc. both inside and outside buildings to help people get around. However, they sometimes lack physical signage or such to point them in the right direction (Parker, 2012). Wayfinding is incredibly important in order to allow people to get to know their surroundings, as well as to build a good sense of comfort and familiarity with their environment for all pedestrians, regardless of the level of disability (Gupta, 2020; Patterson, 2012). There already exist some wayfinding applications that provide accessibility guidance on regular pathways and public transit routes. However, accessibility applications, tools, and data are not always available to the public and easy-to-use (Wheeler, 2020). In this paper, I provide a more detailed analysis of existing wayfinding applications to show exactly what difficulties users may face and what features of the applications can assist them and provide the best possible experience.

Methods

In this section, I provide an explanation and analysis of various currently existing wayfinding and navigation apps and technologies. Along with each application's unique features and functionality, I discuss the impact of the features as well (i.e. software/compatibility, method of data collection, etc.). This helps to identify which features seem to be the most effective, and how wayfinding applications can be improved overall.

Disability Studies "[enhances] the understanding of disability by [analyzing] social, cultural, historical, legal, and political perspectives, including the connection between disability and other identities; disability is a fact of the human experience, not the exception" (University of Washington, 2024). Researching these applications can first and foremost make the world a more accessible, easy-to-navigate palace for individuals with disabilities. In the process, we can also help able-bodied people to understand the experiences of disabled people and stress the importance of empowering the disabled community to identify existing issues and challenges to assess potential solutions. Just as other marginalized groups throughout history, individuals with disabilities have often been overlooked, resulting in a lack of attention to the historical, cultural, and legal aspects of disability. Society has been shaped through this neglect, ignorance, and prejudice, hindering individuals with disabilities in everyday activities; the impact of this discrimination is still evident in areas such as education, employment, and most of all, transportation and access to public spaces (Rice, 2024).

I used two other important frameworks, which are technological determinism and social construction: the ideology that society grows and progresses because of technology and the ideology that society is what determines the growth and progression of technology, respectively (Buzzle.com, 2015). In other words, some people believe that technology shapes the way society works, while others say that society shapes what technology is developed (Bijker, Hughes, Pinch & Douglas, 2012). There are many historians that support both sides of this argument. Some historians try to understand how technology is connected to society, economics, culture, and how it fits into our already existing system. Thinking about the cycle in this way implies that studying technology is not just about looking at the individual intentions of the technological invention itself, but rather understanding the entire system and relationships between us and existing technology. Other historians and scholars, however, consider this approach of a "systematic view" to be incorrect. They say that each technology should be considered independently, as introducing a new technology and adopting it sometimes can change society entirely (i.e. introduction of interstate highways), rather than seamlessly fitting into existing society (Buzzle.com, 2015).

Although technological determinism and social construction are ideologically opposing, they in fact co-exist in a sort of mutual, positive feedback loop; in other words, new technologies change society, and society gives 'feedback' on the technology, which is constantly being adapted based on what is more appropriate for the current state of society. We can see this idea clearly demonstrated in accessible wayfinding. Society has become very technologically advanced in terms of transportations– we have cars, trains, buses, planes, etc. that are used for people to get from one place to the other, and people adapted to using these from old-school methods of travel. However, many people have begun to advocate for more accessibility when it comes to these modes of transportation, causing existing technology to change. Now, we have more ramps, accessibility signs, accessible seats on buses and trains, accessible bathrooms, etc., which continue to be improved every day (Gilbert, 2019).

Curb cuts are small ramps that are built into sidewalks at pedestrian crossings. These curb cuts make it easier for individuals who use wheelchairs, push strollers, delivery cards, and others who struggle with regular curbs. Originally, cub cuts were promoted and advocated for by advocates for disabilities in the United States during the 1970s (Blackwell, 2023). However, they are now a standard part of our regular urban infrastructure. They are excellent examples of universal design, which aims to make spaces that are accessible to all people, regardless of their limitations in mobility. Curb cuts show how advocating for one group can lead to widespread societal change, benefitting a broader audience, such as skateboarders, people with luggage, baby strollers, etc.

As this topic deals with building tools for a specific group, the research methods I used consist of finding, reading, and synthesizing previous literature on this topic. I analyzed previous literature as my main research method, as much of the project is an analysis on existing wayfinding applications– this method of research involves identifying existing applications, finding their building process and features, reading other write-ups, and so on. I focus on the impact on accessibility for individuals with mobility disabilities and how tools can be improved further for them. The following section goes into more detail about different four particular applications: 1) Project Sidewalk, an application started by the University of Maryland Science Department used in major cities; 2) CityGuide, a mobile app used in some European cities; 3)

NavCog, an application out of the School of Computer Science at Carnegie Mellon University; and 4) a Guide Beacon System, a complex system installed by some museums to provide a more immersive experience for visitors. Although I focus on improving wayfinding applications specifically for individuals with mobility disabilities, many of the four applications discussed are not specifically for mobility disability individuals; they can be targeted towards individuals with visual impairments, cognitive disabilities, and so on. Regardless, these four applications have unique features that can be implemented and/or incorporated into an app in order to improve accessible navigation.

Results

This section is divided into four subsections. Each section discusses applications aimed to improve accessibility or consumer experience, the particular features of the application, and finally, the impact of the application and the user feedback. The goal of some of these applications is to create a more engaging and immersive experience for all users rather than focusing on the experiences of individuals with disabilities; however, I discuss these applications as many of the features can be utilized and adapted to create an improved navigation experience for mobility disability users.

Application 1: Project Sidewalk

Project Sidewalk is a web-based tool developed by the Department of Science at the University of Maryland (sidewalk-sea.cs.washington.edu, 2012) . This application functions similarly to the popular navigation app "Waze" in that it relies on user input to update its information. In addition to this, it offers a unique interface that lets users virtually "walk through" city streets with Google Street View, allowing them to identify map challenges with pedestrian-related accessibility problems. Since its creation in 2012, the ultimate objective of this application has been to produce a comprehensive map of global accessibility.

Project Sidewalk uses a combination of computer vision and crowdsourcing on an online mapping system to regularly update the map. It encourages users to report physical accessibility issues, providing a quick, at-a-glance overview of all physical accessibility issues at any location selected by the user at the street level (Project Sidewalk, 2024).

Project Sidewalk's volunteer-based participation model is one of its unique selling points. Users can sign up to contribute to the data set by identifying and marking locations on Google Maps with different accessibility labels, like curb ramps, missing ramps, obstacles on paths (sidewalk obstructions that are difficult for persons in wheelchairs to pass), surface problems (ex. degradation of pathways over time due to weathering), or other obstacles. Participants can also assign a severity rating to each obstruction on a range of 1 to 5. The application uses colors many times throughout the application to easily distinguish between very accessible and not accessible obstacles, shown in green and red, respectively.

An additional feature Project Sidewalk is in the process of introducing is "accessibility aware routing". Just as Google Maps/Apple Maps has a pedestrian route option to a destination, the goal is to introduce a feature that provides an accessibility route for users with multiple suggested routes. The routes will include pictures of potential path obstructions and problems to allow users to evaluate whether or not they would be able to navigate that path depending on their level of mobility and comfort (Saha, 2019).

Since its launch in mapping accessibility difficulties in Washington, D.C., Project Sidewalk has already made a significant impact on the community. The most notable feature of this application is undoubtedly the data collection strategy. This strategy allows for fast and effective data collection and also gathers different viewpoints on accessibility, saving money in comparison to more conventional approaches. The engagement of the public in data collection not only provides valuable information but also fosters a sense of community. Users have reported that the application is “easy to learn and fun to use”, and that Project Sidewalk has enhanced independence for individuals with mobility challenges. However, feedback says that the accessibility ratings of the obstructions should be more accurate; many users found that people report an issue as accessible, but upon arrival, it turns out to be inaccessible. A data validation study conducted by the team found that only 63% of all accessibility issues were reported accurately.

Application 2: CityGuide

CityGuide, an application originally developed for European cities, serves as a navigational tool tailored to find accessible routes within major urban areas (cityguide.no, 2024). As public transport is one of the primary methods of travel in many cities in Europe, CityGuide places a particular emphasis on accessible public transportation routes.

CityGuide relies on OpenStreetMap (OSM) data, a collaborative project that creates and distributes free geographic information globally, for updates on path changes. The application offers maps with real-time traffic information, providing users with up-to-date details on traffic accidents, road conditions, traffic jams, speed cameras, and police presence. One of its notable features is the offline navigation system, allowing users to download map data for selected areas to their devices to use in places of unstable or weak internet connection. However, it faces challenges, such as a requirement for a license to run the app as there is limited compatibility with newer phone versions and software updates. Users have also expressed a need for expansion in terms of language support because the app only functions in a limited number of languages..

Users noted that the GPS navigation feature of CityGuide was extremely useful and did provide some accessible routing, and was easy to use as it had a similar interface to popular navigation apps such as Google Maps. Despite its claims of prioritizing accessibility, some users felt that the application leans more towards providing traffic-related data on major roads rather than emphasizing accessibility features and pathways (cityguide.no, 2024). The offline navigation, although appreciated, introduced new issues such as infrequent updates and inaccurate information. Nevertheless, the GPS navigation functionality remains an important feature that users seeking accessible routes within major cities can use easily.

Application 3: NavCog

NavCog is an new and innovative iPhone application created by the School of Computer Science at Carnegie Mellon University (CMU) that is specifically designed to meet the needs of the visually impaired when navigating indoor environments (https://www.cs.cmu.edu/~NavCog/, 2024). Unlike conventional navigation applications, NavCog concentrates on offering precise direction in indoor spaces. This free app, available exclusively on the AppStore for iPhone users, uses Bluetooth Low Energy (BLE) beacons in conjunction with smartphone sensors for precise localization. BLE beacons are small wireless devices that work with bluetooth. These are devices that broadcast radio signals that can be transmitted to devices that have bluetooth, which receive the signals and display information preprogrammed into the beacons. These beacons can be placed in any indoor or outdoor space and programmed to distribute any form of information the installer desires (Wang, 2024).

NavCog includes a number of features to improve the indoor navigation experience for people with visual impairments. The application allows users to select their destination through voice search, providing an inclusive and user-friendly interface (Asakawa, 2015). The most notable feature of NavCog is its audio feedback system, which allows its users to follow voice/audio instructions without needing visual cues.

NavCog's indoor navigation system is its primary feature. Through the use of BLE beacons and smartphone sensors, the app is able to provide a precise location in indoor spaces. Nevertheless, there are drawbacks to this technology. BLE beacons require a team or few personnel buying, installing, deploying, managing, and maintaining beacons. These beacons must be pre installed in indoor spaces, and the buildings themselves must be set up in a way they may easily accommodate this technology. The beacons must also be trained with sample data by adding accessibility information and data about points of interest to the BLE beacons (Lin, 2015).

Users have claimed that the NavCog application is difficult to use and not as simple to understand as they would have wished. BLE beacons make up a large portion of the costs for this approach to increasing accessibility, but it is easily scalable once established. Additionally, users noted that they would have liked for the application to be available on both iOS and Android rather than just iOS ("NAVCOG at annual PCB conference", 2017).

NavCog's most impressive feature is its effective use of the Bluetooth Low Energy (BLE) beacons in conjunction with the application to provide audio instruction. This aspect of the technology contributes to making indoor spaces more accessible for individuals with visual impairments, promoting independence and confidence in their navigation. While the tool may be slightly more costly than others, NavCog was proven to be a useful and impact tool in increasing accessibility for visually impaired individuals in an indoor environment ("NAVCOG at annual PCB conference", 2017). Overall, NavCog has a meaningful impact on individuals with visual impairments by providing greater independence and autonomy; the application makes indoor spaces much more accessible.

Application 4: Guide Beacon System

The Guide Beacon System is an innovative way designed to enhance accessibility navigation and improve overall museum display experience; this system is similar to *Application 3: NavCog* in the technology that it requires, but they are used in a different way. This system makes use of Bluetooth Low Energy (BLE) beacons to offer a dynamic and interactive experience to all visitors, with an emphasis on improving accessibility for those who are visually impaired; for the visually impaired, this system is meant to add onto the traditional braille signage and audio guides (BeaconZone Ltd., 2023). As the main aim of this system is navigation functionality and to guide visitors through the museum, the BLE beacons are strategically placed every 10 - 20 feet throughout the museum layout with step-by-step audio cues.

The Bluetooth Low Energy (BLE) beacons used in this system collect data such as how long users interact with a certain beacon on average. Based on this information, museums can change the placement of beacons to be in optimal positions throughout exhibits and change each beacon to give information specific to the location they are placed in. Museums can also have the user's smartphone display detailed information specific to location through these beacons as well. This access additional information, enriching their understanding of exhibits and creating a more engaging experience.

Beyond navigation, the beacons contribute to real-time communication, keeping users informed about schedules, events, and offers. This adaptability extends to using the system for important environmental change updates, ensuring visitors are well-informed and engaged throughout their museum journey.

The Guide Beacon System successfully improved accessibility for visitors with disabilities, fostering a more inclusive and welcoming museum environment (Liu, 2020). The positive reception reflects the system's effectiveness in enhancing overall wayfinding and providing a personalized, informative, and enjoyable museum experience for everyone. Out of all the features of the Guide Beacon System, the most well-received feature is the precise navigation with step-by-step, real-time audio cues and location based information, data collection capabilities, and seamless integration with both Apple and Android smartphones. These features together create an completely engaging and immersive experience, catering to the diverse needs of all museum visitors.

Discussion

According to user feedback, it seems that beacons placed throughout the indoor environment provided the most costly yet most effective and enjoyable experience for users, seen in both NavCog and the Guide Beacon System (Liu, 2020). Although the NavCog and Guide Beacon System was used for all museum visitors in general, the beacons in the system can be strategically placed throughout the indoor environment and programmed to give step-by-step, real-time audio cues to direct individuals with mobility disabilities in the direction of ramps, accessible bathrooms, or warn them of any construction, floor texture changes, or other physical barriers preventing easy navigation. Additionally, the application being available on both iOS and Android in several different languages seemed to be particularly important to the users in order to have a more widespread audience.

The best feature of Project Sidewalk is the strategy used to collect the data, which was proven to be a very fast, effective, and cost efficient method of data collection. As mentioned, it gathers different viewpoints on accessibility. Not only does it save money, but it also is a great way to get the community involved and foster a sense of community, making more people aware about how important it is for individuals with mobility challenges to feel.

The Guide Beacon System is an excellent example of the curb cut effect. As discussed before, the curb cut effect is "when you design for disabilities, you make things better for everyone in the process" (Sheridan, 2021). Just as curb cuts helped more than just the target audience, the Guide Beacon System began as a project for wheelchair users and mobility disabled individuals can be extended to become multimodal and address issues for other visually impaired individuals, people with hearing impairments, etc., eventually becoming a system that can enhance the overall quality and experience of a museum visit entirely.

The feedback from users on different applications is an excellent example of all the STS frameworks coming into play. All of the applications discussed above were built with people looking at disability in the context of current culture, society, and politics in an attempt to "bring the [disabled community] closer to the established norm", trying to understand the experience of disabled people in the regular day-to-day world better (Rice, 2024). These technologies were built and released, and then target audiences changed and adapted their ways of navigating to these technologies, which is technological determinism. As seen above, the process of evaluating all of these applications and giving feedback as users leads to social constructionism–after all, new and innovative tools only succeed if they fully satisfy the needs of its target audience.

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