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Research on barrier-free wayfinding and navigation

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Abstract: *Up to today, we are living in an environment surrounded by buildings, including shopping malls, museums, university campuses, and also other types of public and private construction. The purpose of this paper is to focus on current studies on accessible wayfinding; also, this paper includes research aimed at people's mental stages during the wayfinding process. There are 38 papers that have been selected and reviewed in this paper. At the end of this paper, the direction and future investigation of accessible wayfinding will be discussed.*

Keywords: *Wayfinding, Inclusive Design, Universal Design, Literature Review, WAZE, Dark Souls*

1. Introduction

Researchers have studied more accessible route navigation for the elderly, especially motor-impaired people (MIP), visually impaired people (VIP), hearing-impaired people (HIP), and older people who may have more than one type of disability. Thus, a considerable amount of literature has been published on developing time-saving methods for providing directions for accessible wayfinding systems by several researchers [10-18]. The importance of acknowledging the study of efficient route navigation is valuable and undoubted. Up to now, at least one study indicates that pleasure is a high-level need in the hierarchy of walking needs [30]. From the research into 37 papers, 14 of them focused on different types of disabilities, including motor disability, visual disability, and being elderly; 7 papers focused on indoor wayfinding systems; 2 papers discussed the possibility of combining augmented reality with navigation; 1 mentioned the possibility of letting volunteers become involved in the navigation system; 3 articles demonstrated the importance of inclusive design; and 2 of the papers examined the importance of psychological response as a crucial element of the wayfinding system. The topic covered in this paper will start from accessible design, then to wayfinding, and the discussion on the future study will at last.

2. Related Work

2.1. Overview of Research Papers

The motivation for this research started from personal experience: an injury to my foot resulted in me spending two months walking while wearing a walking boot. Until then, I had never noticed the "barriers" surrounding us. Disability is a critical issue and might be addressed to solve the problem of making the reachable environment to be more accessible. Architectural barriers exist, and they will exist for long. Such as labyrinth-like shopping malls designed for customers to spend considerable time on each floor to increase sales [1]. These semipermanent architectural difficulties are physical obstacles to people with disabilities (PWD) and might not be aware by people without disabilities. Achieving a qualitative change to the PWDs' experience with restructuring these buildings requires time and cannot solve the urgent need. Although studies are researching accessible wayfinding, to date, only a few papers focused on the mental stage and mental requirements of wayfinding [2, 30, 34]. Research also indicates that different types of disabilities require different support for wayfinding [1]. For the analysis of the selected research papers, please refer to Table.1, every article will be analyzed, and the focus point of each paper will be listed[19-27].

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Table 1: List of research papers by focus topic.

Author	Year of publication	Focus topic
Prandi et al.	2021a	Accessible wayfinding
Wang et al.	2022	Universal access
Moss et al.	2006	Elder
Fermandes et al.	2019	VIP wayfinding
Sandoval-Bringas et al.	2022	MIP wayfinding
Pomberger et al.	2006	AR wayfinding
Shepherd & Bleasdale-Shepherd	2011	Virtualgeographic
Hoe et al.	2019	Elder
Tang et al.	2021	VIP
Fernandes et al.	2012	VIP
Valipoor & Antonio	2022	VIP
Zeng et al.	2017	VIP
Serrão et al.	2015	VIP
Engelbrektsson et al.	2004	VIP
Edwards et al.	2001	MIP
NItakolia et al.	2022	VIP
Park et al.	2022	Elder
Barlott et al.	2016	Information society
Prandi et al.	2021b	Indoor wayfinding
Wheeler et al.	2020	Wayfiinding
Gharebaghi et al.	2021	MIP
Fogli et al.	2020	Universal design
Delnevo et al.	2018	Accessible indoor wayfinding
Delnevo et al.	2020	Accessible indoor wayfinding
Kunhoth et al.	2019	VIP
Pugh et al.	2021	Safe & efficient navigation
Constantinescu et al.	2019	VIP
Baldwin	2003	VIP
Passini	1996	Wayfinding and architect
Karimi	2016	MIP
Alfonzo	2016	Walking needs
Persson et al.	2015	Universal access
Farr et al.	2012	Wayfinding
Spiers & A.Maguire	2008	VR wayfinding
Mackett	2021	Mental health and wayfinding
Nuenen	2016	Post-panopticon
Spawforth & Millard	2017	Player interaction
Laor and Galily	2022	User behavior

2.2 Universal Design in Wayfinding

Although it is necessary for assessing the implications of mental activities in wayfinding in this literature review, the importance of inclusivity in the wayfinding system should be considered as the priority. Investigators compared and drew distinctions between inclusive design, universal design, accessible design, and design for all [31]. All four of these terms have slightly different approaches. Until today, the concept of design for all is much more applied and related to other concepts [31], refer to Table 1. The current indoor and outdoor wayfinding systems ordinarily only focused on one type of people, such as MIP, VIP, HIP, or people without disabilities. Although providing services to mainstream users would bring benefit to the service provider, it is still beneficial to expand the diversity of users [31]. Connecting users as many as possible is the key to the road to universal design for wayfinding design. To assess this aim, one study examined an inclusive design approach in the communities of universities in indoor wayfinding [1-4]. Through this study, researchers developed an application for students and visitors in the university for navigation, and the results included students with disabilities; this application is especially useful in unknown places. Even though this investigation evaluated the system with only 18 users, its methods are inspirational for further research projects. Understanding users' demands through the same scenario but testing with different types of users is

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indispensable for the project which aims to design solutions for all[28-36].

2.3 Wayfinding

Researchers are looking for an efficient and accessible wayfinding system that can be used both indoors and outdoors [5-9], but the time comes where psychological feelings should be considered as well. The hierarchy of walking needs a mention of pleasure as a higher-level need [30], and this theory provides inspiration for further studies which can be referred to in Section 4. The user experience when they are lost in an indoor but complicated environment or facing unexpected obstacles could result in a change in the mental stage [33]. The unknowns and out of expectations are issues to both indoor and the outdoor wayfinding system. Although it is far from the usual innate character of wayfinding, which is that wayfinding is the process of finding your way to a destination in a familiar or unfamiliar setting using any cues given by the environment [32]. Spiers and Maguire (2008) suggested that anxious and angry thoughts dominated the emotional state in wayfinding from their investigation; and in their study, by getting to the destination, the subjects' emotional states will transform to being happy. From the investigation, Mackett (2021) indicates that one of the reasons that wayfinding causes anxiety is time pressure. Then to reconsider this point, it is not difficult to get the answer: if the time pressure no longer exists, does the obstacle still creates anxiety? One word to conclude this opposite opinion will be exploration. Exploration takes time and conflicts with the time pressure in traditional wayfinding. It seems impossible to balance these two in wayfinding, however, users' mental stage changes to negative emotions happen when there are unexpected scenes, such as rocks blocking the road [34]. Architecture barriers can be identified and install a beacon at these barriers for application to determine [22], but the temporary obstacles appear without expectation and would result anxiety or anger. Refer to the study researched by Mackett (2021); there are 59% of people felt anxious when they felt disorientated, 65% felt anxious when getting lost, "having to make decisions about where to go" making 62% of people feel anxious, and "remembering where they are going to" result in 65% of people getting anxiety. As ordinary wayfinding addresses the efficiencies in route planning [25], a research gap is shown that by lowering expectations on the efficiency of wayfinding to study if the mental stages of users become more stable than using regular wayfinding applications and at the same time, as "design for all" is one of the requirements needs to be considered for the accessible wayfinding system. Ideally, the overall wayfinding experience might be transformed into a more expectational journey than traditional wayfinding.

3. Discussion

Wayfinding as a commonly used technology has been become important to people's quality of life [1]. Accessible wayfinding should learn from the traditional wayfinding application, for example, GPS-based navigation for cars. The interaction between users plays a massive part in the navigation application called Waze. A recent study by Laor and Galily (2022) d emonstrated users' behavior in a GPS-based navigation application for smartphones called Waze. They suggested that if users were encouraged to report accidents, traffic jams, road work, and hazards, then other users would be able to judge whether the report is helpful. Figure 1 shows the interface of Waze. They also indicated that Waze has become popular not only because its user friendliness made it simple to employ, but also because the interface is similar to a gaming interface that highlights consumers' engagement.

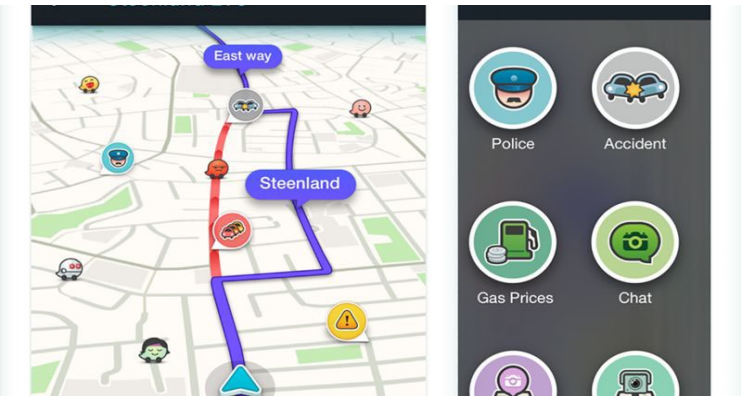

Figure 1: Screenshot of Waze application, screenshot credit to CNN.

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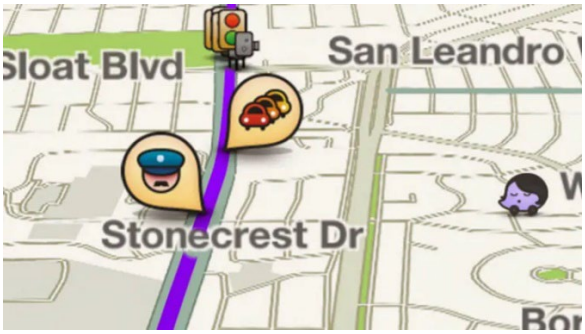

Figure 2: Traffic track on Waze application, screenshot credit to CNBC.

The gaming-like experience in Waze is user-based, and the entire process is kept anonymous, which is identical to a series of games called Dark Souls produced by From Software. Nuenen (2016) reported experience with Dark Souls' elaborate multiplayer mechanics in which players will mainly have a single-player experience throughout the entire game, but they can occasionally see half-visible traces left by others, as shown in Figure 2. Moreover, players can communicate with other players indirectly by leaving anonymous tips and clues for other online players. Figure 3 shows the messages left by the other players in the Dark Souls 3, and from Figure 4, half-visible players and messages left by anonymous players can be referred. Spawforth and Millard (2017) suggested that the indirect multiplayer experiences in Dark Souls add detail and richness to the world, which creates deeper narrative storytelling. Considering Waze and Dark Souls together, both programs use the anonymous indirect communication system between users, and this system establishes a community where users help each other with dynamic clues, hints, and their own left-behind traces. The reason behind the success of this two software in different fields brings space for the theory and concept for future study to discover as its basement. As technology develops fast today, the design for accessible wayfinding should be more inclusive. To bring a gaming-like element into the design might also show respect for a person's dignity, letting each user participate in the system. To combine this gaming-like element with the aim of an accessible wayfinding system, that is "designed for all", there should be multiple manifestations of the wayfinding information, thus people with different types of disabilities could have the same experience to help their exploration[37-39].

Figure 3: Screenshot of Dark Souls, 3, red marks are messages left by anonymous players.

Figure 4: Screenshots of Dark Souls messages left by anonymous players and half-visible player.

4. Conclusion

Unlike the ordinary wayfinding navigation systems, the accessible wayfinding system aims to have different types of users, get the chance to explore indoor and outdoor locations they are unfamiliar or familiar with through the supports provided by the system. Like traditional wayfinding systems, the

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anxiety and anger created by unexpected events should be considered during the development. The possible solution to this problem is to remove the time pressure, and this can be achieved by redefining and providing a different perspective of the wayfinding system by changing the ultimate goal of navigation to a trip of exploration from getting to the destination to exploring place. Although it conflicts with the purpose of wayfinding which is to get to the destination efficiently, it is still valuable to investigate the possibility of the balance between efficiency and entertainment.

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