GatePal – Universal Design for Airport Navigation to Allow Departing Travellers to Stay Informed

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Abstract. Airports are challenging for travellers with disabilities and senior travellers with functional limitations due to the complexity of terminal environments and the variety of activities (e.g. navigation, check-in, security check) required for one to successfully depart or arrive. Without sufficient information associated with the context of airport environments, travellers with disabilities and functional limitations are not able to plan their activities or efficiently navigate through terminals and surrounding areas. For departing travellers, time is the most important contextual information due to constraints and potential barriers. Without providing the necessary information about the time it takes to complete each activity, especially when navigating, travellers with disabilities and functional limitations are not able to plan or anticipate any upcoming situations. This paper introduces a universal mobile application called GatePal that was designed based on the results of a preliminary user study and utilizes universal design principles to assist travellers with diverse abilities with navigation at airports.

Keywords: Decision making · Universal design · Indoor navigation · Information access

1 Introduction

In the United States, approximately 18.7 % of the population has at least one type of disability [1] and 61 % of the 44.7 million older adults have at least one basic activity limitation [2]. These disabilities and functional limitations can have a profound negative impact on people's ability to travel and, as a result, they usually experience more physical and psychological travel difficulties [3]. Airports, as complex public transportation structures, are full of challenges for travellers to successfully plan and carry out activities such as navigation, check-in, or baggage claim when departing and arriving [4]. In order to enable people with disabilities and functional limitations to travel by public transportation equitably, airports are required to comply with the Americans with Disabilities Act (ADA) to make the environment accessible by providing a variety of amenities such as accessible restrooms and elevators. However, these regulations primarily address the needs of people with mobility impairments, and

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only reduce a small number of the environmental challenges faced by these individuals as well as those with other types of disabilities.

Challenges posed by navigation and planning of routes to various destinations still exist and are not addressed by the ADA [16]. The planning of routes and location of activities are traditionally informed by informational signage and airport/airline support staff. When information is missing, ambiguous (e.g., is confusing to someone who is unfamiliar with terminology) or cannot be perceived (e.g., is not seen by someone with a vision loss or distracted by a child), the airport becomes inaccessible to these travellers. For example, without providing information about the location of elevators in a visible and clear way, travellers with mobility impairments will not be able to access other levels, which is often required to get from the ground transportation to the departure gates or from the gates to baggage claim.

At airports, situational/contextual information such as the flight schedules and the navigation information always go hand-in-hand. The separation of navigation and situational information makes it difficult for travellers to anticipate any impact of navigation choices on the over-all situation. The importance of providing information regarding navigation and activity planning to satisfy travellers' needs has been brought up in previous research studies [17–19]. Among these studies, travellers all expressed strong needs for information in regard to time such as up-to-date flight schedules, flight delays [18, 19] and quick check-in/baggage arrival [17]. Typically, important directional information comes from airport staff who not only tell travellers the required activities to get on a plane, but also the location of important services and destinations (e.g. gate direction, bathrooms, check-in counters). Airport staff were observed as playing a key role in balancing queues at airports in order to minimize waiting time for individual travellers [19]. In this case, airport staff have pre-planned routes for travellers and provided them with the critical information to support successfully navigating that route. Planning is important because it allows travellers to anticipate potential barriers, and make decisions about making their way through the airport. Planning is especially important for travellers with disabilities as they often require more time and special accommodations compared to travellers without disabilities. As a result, they are less able to compensate for unexpected route changes or delays, such as gate changes or long waiting times in security. It thus becomes more important for them to be aware of the situation and make alternative decisions on their activities [20]. Providing sufficient information to support the planning of activities and routes for travellers with disabilities enables them to be prepared for navigating in unfamiliar environments and situational changes that can impact route planning to activity destinations. Unfortunately, there are few studies that have examined the informational needs of people with disabilities or have attempted to provide the information from an activity planning perspective. More effort is required to identify their needs and provide them with the information to enable them to use the airport equitably.

In addition to the separation of navigation and situational information, ineffective communication of information also creates barriers for travellers with disabilities. For example, travellers with sensory disabilities have difficulty perceiving information provided by signage and FIDs. Although those travellers can ask airport staff for help with the information, the limited number of airport staff precludes this from being an effective and efficient way of communicating information. As a result, information that

is tailored towards their disabilities is needed when navigating and participating in different activities.

In order to facilitate travellers' navigation and participation in activities at airports, a system is needed that not only provides information about navigation, but also provides contextual information such as the time required for each activity to facilitate the proper planning and execution of airport activities. To achieve that, a universal design approach has been used to investigate the information needs of travellers with diverse abilities regarding the environment and the activity planning at airports. A navigation application has been designed based on the results of the investigation and universal design principles to support travellers' activities. In this paper, the universally designed navigation system is presented and the process of designing this system is detailed. We discuss our method of data collection and the ways in which this information guided our design decisions. Lastly, we discuss the future development and testing of this application.

2 Current Pedestrian Navigation Solutions

Current pedestrian navigation systems have used various approaches including different technologies and applications to solve wayfinding problems for people with and without disabilities. For people with visual impairments or those who are blind, pedestrian navigation systems have been developed with a specific focus on audio input and output as an accessible means of communicating information [10–12]. With audio output as the primary approach to communicating navigation information, many systems are less effective and efficient for people without visual impairments. In contrast, pedestrian navigation systems designed for people without disabilities have focused more on presenting navigation information graphically, which makes them unusable for people with visual impairments [12, 13, 15]. Whereas the emergence of off-the-shelf smartphones with built-in navigation capability and accessible I/O features has made designing such a system technically feasible, studies are needed to better understand the information needs of airport travellers with disabilities in order to design such a system to be useful and usable by all travellers.

3 Method

A user study was conducted to investigate the needs of older adult travellers and travellers with disabilities for three types of information: (1) time-related situational information (flight schedules and delays, time for going through security, etc.); (2) distance to destinations (length of a route from point A to point B); and (3) points of interest (POIs), such as restrooms, shops, restaurants. This data collection was a part of a large wayfinding study funded by the National Research Council to develop wayfinding guidelines for people with disabilities and older adults in airports. The study took place at the Austin-Bergstrom International Airport where participants were debriefed on their

Table 1. Demographic Information. Gender: M- Male; F- Female. User Group: HI- Hearing impairments; VI- Visual impairments; MI- Mobility impairments; O- Older adults without disability.

Participant	1	2	3	4	5	6	7	8	9	10	11	12
Gender	M	F	M	F	F	M	F	F	F	F	F	F
Age	50	70	74	56	57	32	39	62	69	70	48	54
User Group	HI	MI	O	HI	MI	VI	MI	VI	O	O	VI	MI

departing experience. By doing it in situ, it allowed participants to have more direct and up-to-date recall of using the airport.

3.1 Participants

A total of 12 participants with functional limitations were enrolled, including 3 people with visual impairments, 4 people with mobility impairments, 2 people with hearing impairments and 3 older adults (Table 1). It is worth noting that participant 11 has both visual and hearing impairments and she was counted as visually impaired since she has an implant to facilitate her hearing and did not require an interpreter for communication.

3.2 Data Collection

The participants were first asked to rank the order of importance of the three types of information (time, distance, and POI). This was followed by an interview to identify specific reasons for their ranking and preferences of obtaining and using the information provided. It was expected that some participants would consider time and distance to be the same concept since the distance from point A to point B could reflect the time spending on walking if the walking speed was known. To avoid possible misunderstanding, researchers explicitly explained at the beginning of the study that the time-related information refers to flight schedules and delays, and waiting time at the security. The result was analysed and used to develop the universal design criteria for designing an airport navigation system.

4 Results

4.1 Results from the User Study

Over all, participants considered *time* and *distance* as being the most important information to obtain. Point of interest, on the other hand, was ranked as less important than time and distance. There were 7 out of 12 participants who ranked *time* as the most important information, and there were 5 out of 12 participants ranked *distance* as the most important information. Most of the participants ranked POI as the least important information compare to *time* and *distance*. Detailed distribution of type of information, and rankings of importance level can be found in Fig. 1.

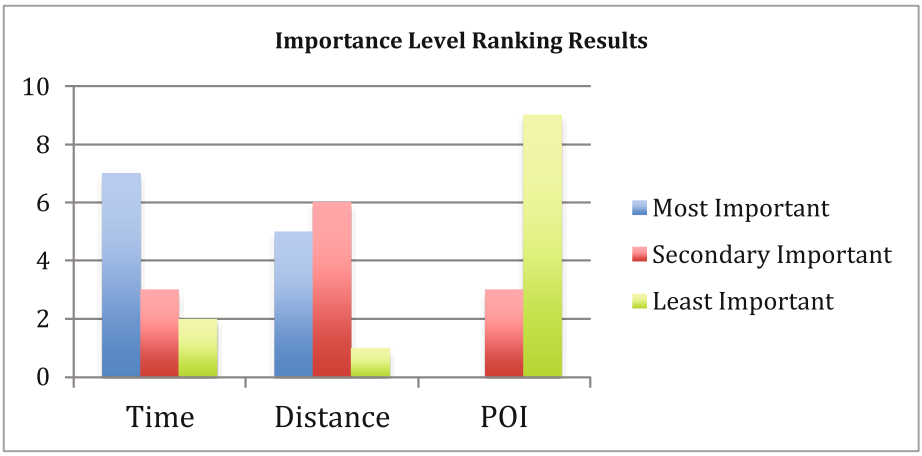

Fig. 1. Results of importance level rankings for the three types of information

In the interview session, not all participants were able to provide specific reasons for their rankings for each type of information. Among those who provided specific reasons, the importance level rankings of time and distance were interrelated in some cases. These cases were marked with "(I)". Detailed reasons provided by participants for their rankings can be found in Table 2.

Table 2. Detailed reasons for the rankings

Reasons for ranking time as the (most) important information to know	Reasons for ranking distance as the (most) information to know
P2 did not care about the distance because she was using a power chair (I)	P3 said he always go to airport early so time does not matter that much. So he picked distance (I)
P4 thought the flight information at the counter might not update	
P5 mentioned that the security "eats up" the time and it is really crucial when it's pre-boarding	
P9 mentioned that for most of the time she did not go to the airport early so she wanted to keep track of time. She mentioned the WAZE app she used in which it will say there's 10 min away for xxx	

During the interview, several themes regarding the preferences, the planning strategy and other concerns popped up and they were considered relevant to the access and use of information, thus were worth reporting.

Preferences for when to obtain the information: Three (3) participants mentioned that they wanted to know the information about the airport ahead of time (P7, P8, P12). The information they wanted to obtain ahead of time included, but was not limited to information about the locations of accessible restrooms and wheelchair service and the time it took to complete certain activities. P7 explicitly mentioned that if someone were using a wheelchair, it would take different amount of time for one to get to the gate. This kind of information should be provided a day before the actual air trip.

Use of strategy to plan activities: Strategy wise, 5 participants mentioned that they would go to the gate first and then explore the airport (P3, P7, P9, P10, P12). If they had extra time when they arrived at the gate, they would go for snacks or restrooms.

Inaccessible information: There were 3 participants mentioned that they wanted to know the information about the flight status change (P1, P4, P6). All of them have sensory disabilities that P1 and P4 are with hearing loss and P6 is with vision loss. Their sensory disabilities have prevented them from accessing the schedule change information that was presented through the audio announcements or the displays at the gate.

Location information for accessible amenities: There were 4 participants expressed the concern of not knowing the location of accessible bathrooms. (P2, P5, P7, P12) All of them have mobility impairments that they are wheelchair users.

4.2 Discussion of the User Study Results

Considering the relatively small size and one concourse linear layout of the Austin airport, the locations of many points of interest were fairly straightforward and uncomplicated. As a result, participants generally took relatively less effort to obtain the POI information because POIs were relatively obvious. This might be the reason for the skewed result that the straightforwardness of the POI information presented at Austin airport might prevent participants from realizing the importance of obtaining POI information. In addition, the size of the airport might affect the ranking of importance level for distance. Within this airport, the distance information can easily be anticipated based on the perceived size.

5 Design of the System

5.1 Task Analysis

In order to provide time-related information, a task analysis was performed to investigate the time consumption of required activities for departing at airports. Three types of time-related information were identified: (1) walking time (time required for walking from point A to point B); (2) waiting time (time required for waiting in lines); and (3) working time (time required for agents or travellers to work on activities). In Fig. 1, the 3 types of time are illustrated for travellers who either check in online and go straight to security (type 1), travellers who check in at an agent (type 2), and travellers who need to check in at kiosks and check their bags (type 3) (Fig. 2).

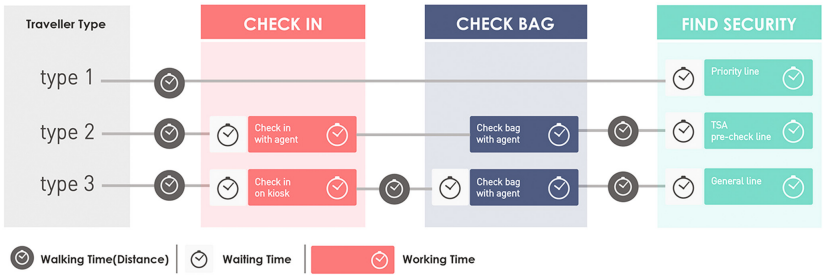

Fig. 2. Task analysis in terms of time consumption

5.2 Overview of GatePal

Following the task analysis the design team worked to ideate a system that would support airport navigation with an emphasis on making users aware of the time required to get from point to point. GatePal is an iBeacon-based indoor navigation system that provides step-by-step navigation information and real-time contextual and situational information to allow travellers to make route decisions based on time and distance. GatePal was universally designed to address the needs of all travellers. It includes specific accessibility information for travellers with disabilities as well as multimodal ways of providing input and feedback to convey information. A detailed description of each design feature is presented in the following section.

5.3 Design Features

Design Feature 1. Different route options for accommodating different needs. GatePal provides different route options based on several route characteristics and present all the route options in a consistent way of time. It allows travellers to successfully make route choices that are accommodating their needs and stay informed of the context.

Design Feature 2. Flexibility in navigation information presentation. GatePal provides different options for information communication. Travellers are able to choose the navigation information to be presented through text and map in different levels of details.

Design Feature 3. Different navigation modes for different strategies. GatePal provides "get to gate" mode and "explore" mode to support travellers' use of different strategies when navigating. Travellers are able to choose between following step-by-step information to their gate and exploring the airport environment on their own. They can switch between these two modes at anytime they want (Fig. 3).

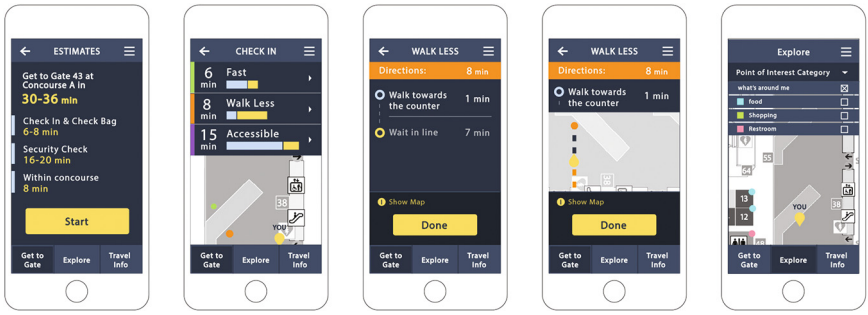

Fig. 3. Selected GatePal screenshots

6 Discussion and Future Work

There is great value in a navigation application that utilizes a universal design approach for concept generation and development. By considering all end users up front, mobile application systems such as GatePal have the ability to benefit a wide range of users in various contexts, all while providing a seemingly equitable experience.

This paper describes the rational for and the design of a universal navigation system that supports older adult travellers and travellers with diverse abilities to become aware of the context and situation in order to navigate through airports. Currently, the design phase of GatePal is complete and it is under development for implementing some of the design features to technically prove the concept. The next step is to implement the key design features and get it tested with users to further investigate its utility and usability. The results of user studies will be used for designing the next iteration of GatePal.

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