A Mobile Guide System for Visually Disabled Passengers

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Abstract

This paper presents a new interactive guidance system for passengers. The system developed for the visually disabled consists of a cane, a portable information terminal, and RF-ID tag-installed tactile tiles. The tag reader in the tip of the cane reads a location datum in the tag and transmits it to the portable information terminal by radio waves. The information terminal generates appropriate guide and navigation messages by utilizing geographical information and personal data of the user. The user can acquire interactively messages by communicating with a system. We carried out a field test to evaluate the system at a station in Tokyo. In this test a number of visually disabled persons used the system in the actual conditions. The results of the test have shown the good availability of the system.

Keywords: Passenger services, Barrier-free, Guidance system, Visually disabled persons

1. Introduction

Recently, the realization of "barrier-free" environment for public transport is increasingly drawing concerns of the society. At a number of Japanese railway stations, elevators and escalators have been newly installed to help passengers in moving. However, it is indispensable to remove barriers in obtaining information necessary for utilizing railways. For visually disabled passengers, it is difficult to know accurately where they are now. Moreover, they cannot use visual information boards. In this paper, we introduce a new personalized guidance system for visually disabled passengers and report the results of evaluation tests carried out at our institute and an actual station in Tokyo.

2. System concept

The current information services aim at showing general information to all the passengers equally, so it is not possible to answer a particular question made by a particular passenger. Those passengers who want to have some particular information must find where the information is given by their own efforts except the case they can find station crews to ask for. Namely, a user must find the necessary information among a lot of information and make some decision to utilize the railway. Ordinal passengers perform this task almost unconsciously in the usual situation. However the information provided when some accident has happened is generally not sufficient, so they are dissatisfied with the current information services. In some cases, troubles have happened because of the lack of information. This situation is considered to be more serious for the aged people and the handicapped people. Thanks to the spread of the Internet and personal computers, we can acquire many kinds of information about the utilization of railways, such as fares, kinds of trains and routes etc. However it is not easy for ordinary passengers to select the proper information from vast amount of information and make good use of them. We think that it is indispensable to remove barriers of information to make railways friendlier to the passengers.
The information necessary for utilizing railways is as follows.

1. Geographical information: map of station, current location, direction to the destination, etc.
2. Travel information: selection of trains, how to change trains, the location of the platform where the train leaves, etc.
3. Ticket information: fares, kinds of tickets, how to buy tickets, how to use vending machines, etc.
4. Utility information: locations of several utilities in the station (toilets, shops, restaurants and others), how to utilize them, etc.
5. Dynamic information: train operation schedules, irregular conditions, etc.

We think it is necessary to realize a system, which can offer the information listed above to the passengers at any place and anytime in an intelligible manner. Fig.1 shows a concept of an ideal system, which always grasps the information about the railway and can offer the required information by the user.

Fig.1 Image of interactive guidance system

3. Mobile Guide system for the visually disabled

Based on the fundamental research, we have developed a guidance system for visually disabled persons who are in the most inconvenience situations in railway stations. Since it is difficult to acquire the visual information for visually disabled persons, the following issues must be solved.

1. The system must identify the current location of the user correctly and offer the necessary information to guide and navigate the user with the sufficient accuracy.
2. The system must communicate with the user by voice and not by visual information.
3. The system must offer adaptive guidance and navigation messages according to the actual move of the user as the user may walk to the wrong direction.
To resolve the above requirements, we have studied several technical issues and built up a trial interactive guidance system (Fig.2). This system consists of three main components, a cane, portable information terminal and RF-ID tag-installed tactile tiles (Fig.3). An RF-ID tag is a small electronic device having memories and a radio communication function. The data in the tag which are used as the location information of the user are read by the tag reader on the tip of the cane and transmitted to the portable terminal by radio. Information about the current location of the user is offered vocally by the portable terminal using the station map stored in it. When the user indicates a destination where he/she wants to go by voice to the terminal, it computes the best route to the destination from the current location and guides the user afterwards.
Fig. 3  System configuration

(1) Portable information terminal
The portable information terminal consists of main unit and collar unit (Fig.4). It is assumed that the user brings the main unit in a pocket and puts collar unit on the collar of his/her clothes. Thus the system is made as wearable, the user can use it in hand-free manners. The main unit has a CPU, batteries, main electronic board, etc. and the collar unit has microphone, speaker, demand switch, etc. The main unit has also a microphone for canceling the environmental noise of the station to improve the voice recognition performance. As the user carries the portable terminal in the daily life, it should be small, light and power-saving as much as possible. The size of the trial version of the terminal is 145 x 80 x 20 millimeters, the weight is about 240 grams. The terminal can work about 3 to 4 hours continuously with 2 batteries of type AA.
(2) Cane unit
The inside structure of the cane unit is shown in Fig.5. The cane reads the location data from the tags installed in tactile tiles with the antenna at the tip and transmitted them to the portable terminal by radio. If the cane reads the data indicating that the place is dangerous, it vibrates a internal vibrator and makes a caution to the user. The cane looks and feels like a normal cane for the visually disabled. It weights about 250 grams and is 105 to 125 centimeters long with a handle of 17 millimeters around. The cane works about 4 hours continuously with 2 batteries of type AA. The cane sends the data from the tip unit to the grip unit using FSK communication so that it can be folded up.
(3) Tactile tile unit
There are two types of tactile tiles, one is made of concrete and another is the sheet type made of vinyl chloride. The concrete type tactile tile is usually laid indoors and the sheet type is laid outdoors. In the case of using the concrete type tactile tile, tags molded by plastic are laid under tactile tiles. In the case of using the sheet type tactile tile, a special tactile tile is laid. The tactile tile looks like a normal sheet type tactile tile, but it has an about 10 millimeter-long battery-less tag and simple coil (Fig.6) in it. When the tag reader on the tip of the cane comes close to the tag, it supplies the tag with power via radio waves so that data can be exchanged. The horizontal transmission area is approximately the same as the area of a tactile tile and the vertical transmission distance is about 20 centimeters. As the transmission area is sufficiently large, the user can move the cane in somewhat rough manner. As the tag can work without battery, the maintenance of the tag is unnecessary after it was buried under the tactile tile. These tactile tiles with tags are installed at important points in the lines of tactile tiles throughout the station to provide guide information to the visually disabled.
The maps of stations are described by XML (eXtensible Markup Language), so it has extendibility and flexibility. Namely, when new functions or applications must be added, the map can be rewritten easily without discarding the current functions or applications. The map file can be downloaded from the center system by the telephone line of the user's house.

4. User functions

The functions of the system for users are shown in Table 1. All the functions are performed by the exchanges of voice commands. Whenever a user has needs to use the system, it can be set up and give an appropriate answer. How to use the system is shown below.

1. When a user uses the system without setting a destination, the system only gives the information about the current place.
2. When the user tells the terminal where he/she wants to go, the best route is computed and presented it to the user. For example, when he/she tells "I want to go to platform No.3", then the system will recognize the words and set the platform No.3 as the destination. And it gives messages such as "Please turn to the right and go ahead 30 meters."
3. If the user deviates from the route suggested by the system, the system gives a message such as "Please go back and turn to the left."
4. If the user does not know how to use the system in some situation, the user can say "Help", then the system tells all the commands which the user can use at the time.
5. If the user misses the last message, the user can say "Once more", then the system tells the last message again.
6. The user can adjust the volume and the voice pitch of messages.
7. When batteries run short, the system makes a warning to the user without the inquiry by the user.
8. If the user's sex (male or female) is registered as one of the personal information, if necessary, the system guides to toilets for males or females tacitly.
9. As the speech recognition function of the system can work independently to speakers, anyone can use the system. Furthermore, if the speaker's peculiarity is registered to adapt the speaker in advance, the performance of speech recognition can be improved.
Table 1 Functions for user

<table>
<thead>
<tr>
<th>Mode</th>
<th>Function</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guidance mode</td>
<td>Simple guidance</td>
<td>Indication of the current place.</td>
</tr>
<tr>
<td></td>
<td>Navigation</td>
<td>If a user inputs the destination, the system will navigate the user by calculating the optimal route to the destination.</td>
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<tr>
<td></td>
<td>Location inquiry</td>
<td>Indication of the current location by inquiry of the user.</td>
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<td></td>
<td>Whereabouts inquiry</td>
<td>Explanation of neighborhood by inquiry of the user.</td>
</tr>
<tr>
<td></td>
<td>Train route guidance</td>
<td>Presentation of the fare to the destination station, transfer information and the time required.</td>
</tr>
<tr>
<td></td>
<td>Additional explanation</td>
<td>Information such as how to use a ticket machine placed nearby etc.</td>
</tr>
<tr>
<td></td>
<td>Date or time inquiry</td>
<td>Presentation of the date or the current time.</td>
</tr>
<tr>
<td></td>
<td>Battery inquiry</td>
<td>Presentation of the residual quantity of battery.</td>
</tr>
<tr>
<td></td>
<td>Guidance level setup</td>
<td>Choice of guidance level (simple or detailed).</td>
</tr>
<tr>
<td>Setup mode</td>
<td>Personal information setup</td>
<td>Set of the personal information of the user, such as the disabled degree etc.</td>
</tr>
<tr>
<td></td>
<td>Speaker adaptation</td>
<td>Registration of the speaker's voice peculiarity, in order to improve the performance of speech recognition.</td>
</tr>
<tr>
<td></td>
<td>Station data download</td>
<td>Downloading of the map data of the stations used.</td>
</tr>
</tbody>
</table>

5. Infrastructure for field test

Fig. 7 Installation of RF-ID tag
We have conducted an investigation about the passenger flows in many stations, and chosen a big terminal station in Tokyo as a place for the field test. As shown in Fig.8, RF-ID tags were embedded in the mortar layer under concrete type tactile tiles in the station. Since this method is almost as same as the method used for installing tactile tiles without tags, it has the advantage that the same reliability can be kept. However, in case of a station with a long business time, it is difficult to secure the sufficient work time to install the tags, so there is a problem that the efficiency of work is not high. If tactile tiles will be installed newly, no extra construction work is necessary since tags are only embedded together with tactile tiles. Although we embedded the RF-ID tags under the tactile tiles, we have confirmed that the communication capability is sufficient for the practical use.

6. Results of field tests

Before executing the test in an actual station, we have conducted preliminary tests at a dedicated test place in our institute. The test place is made to emulate the environment of railway stations. There are several virtual equipment and utilities in the test place, such as a bus stop, ticket vending machines, ticket checking machines, a toilet, a kiosk, steps to a platform etc. The configuration of the test place can be changed to emulate various kinds of stations. In these tests, ten visually disabled persons used the trial system and walked along lines of tactile tiles according to guide messages given by the system. Though any person did not have knowledge about the map of the test place beforehand, all the people could get to the indicated destination.

The summarization of their estimation for the system is as follows;
(1) They can move alone in unfamiliar stations if they can use this system.
(2) As for their familiar stations, it is also useful because they can confirm the current place and direction when they lose their way. This function can mitigate their stress in railway stations.
(3) It is helpful to get information about dangerous places such as the end of a platform or the top of stairs, etc.

All of the participants of the tests answered "I want to use this system in actual stations very much."

Though the total estimation for the system was satisfiable, there were various technical issues that should be improved before executing the test in an actual station. So we have redesigned the hardware and software of the system for preparing the field test.

The participants of the field test for estimating the system are the same ten visually disabled people as of the test in our institute. We did not change or control the conditions of the environment in the station, such as train operation schedules, broadcasting voice messages and passenger flows. However in the case there was a dangerous situation such that another passenger may hit the disabled person, we went in to guard the disabled person. Before starting an examination, the participants were given the information about the improving points of the new system and used it in the concourse of the station for getting accustomed with the usage of the system. Then, we gave them three subjects,
(a) Walking from the a place outside of the station to another place which is positioned in front of a train door on a platform (there are steps in the route)
(b) Walking using the two kinds of guidance levels which differ in their details of guide messages and compare them
(c) Usage of the function by which the system gives the users where they are now. During the their test walks using the system, we took videos by two sets of video cameras and kept on writing the guide messages and the reactions of users on notebooks by walking with them.

A scene of the test is shown in Fig.9.
By examining the results of the field test, we have confirmed that the functions of the system work effectively in actual stations too. The considerations about the results of the test are as follows.

1) Move by voice guidance and navigation
   The subject (a) is to walk from the point before ticket vending machines to the point in front of a specific train door on a platform. This route is about 100m distance and there are ticket checking gates and descending steps on the way. We have confirmed that the user can arrive at the destination by only following the guide messages of the system. The mean time required to the destination is 3 minutes and 58 seconds. The mean speed is 0.57 m/sec when walking in the concourse. We asked the participants who have the mental map of the test area beforehand to walk the same route in the concourse without the system. The mean speed of the case is 0.60 m/sec. In the hearing session after the test, they said that the move by the guide of the system is satisfactory. However, examining the video recorded in the test, five of ten participants sometimes went past the turning point one or two steps. We expect that this phenomenon will disappear if they get more familiar with the usage of the system.

2) Installation of the tactile tiles
   There is an expansion joint --- the joint position of buildings --- in the concourse and it often confused the participants because they misunderstood that it was a line of tactile tiles. The complicated installation of blocks such as those near a toilet entrance perplexed their walks. In order to use this system more effectively, it is required to consider the optimum installation method of the tactile tile too.

3) Arrangement of RF-ID tags
   The RF-ID tags are embedded keeping the interval of less than 5 meters in the straight line of tactile tiles. On the turning points, in order to guide them in an early timing, tags are embedded in the neighbor’s blocks to the turning point. Consequently, it was sometimes observed that detecting the tag in the center of turning point is difficult for the user who stopped at the turning point. So it
is considered that tags should be embedded in the tactile tile positioned at the center of the turning point.

(4) Size and weight of portable system

Nine of ten participants desired that a portable terminal would be smaller and lighter. Five participants commented that the cane unit is heavy. As the current system is a trial product, it is designed with the margin in the size and the weight. So many of the participants were not satisfied with the current system as expected.

(5) Guidance level

The system has two guidance levels, the detailed level and the simple level. In the detailed level, the system tells the user the distance to the destination and it also tells the distance to the next right or left turning point. In the simple level, the system omits the distance information etc. We asked the participants to compare the two guidance levels considering the user-friendliness. Although the opinions which level they prefer differ by person, most comments can be summarized as "I want to select either of them accordingly if I am familiar with the station or not." Moreover, all of them estimated the function as "It is very good for users to be able to select the guidance level on their will like this system."

(6) Human interface

In order to evaluate the human interface of the system, we asked participants to operate the system by themselves. The operations they did are setting destinations, selection of a guidance level and setup of a voice pitch of messages offered by the system. As the consequence, we have confirmed that even the aged participants can use the system without special training. In the hearing session after the test, they answered that the operation using collar unit is satisfactory. As for the operation by voice, eight persons answered "It is easy", but two persons commented that the performance of voice recognition is poor. In addition, a few persons commented that it is necessary to be able to sense how it works more clearly when he/she operates the small volume dial attached to the portable terminal.

(7) Mental stress and resource for attention

In the test at the actual station, noise from environments, such as announcement, voice of other passengers and noise generated by trains, differs from that of the test field in the institute. In addition, visually disable persons get more stress caused by the interference of other passengers and the fear of the fall from a platform, etc. Since visually disabled persons cannot depend on visual information like ordinary passengers, they need to pay attention to the aural information and the contact information from their feet or canes to detect the difference in level or obstacles. We asked the participants about their mental stress and resource for attention. All of them answered that it is possible to pay attention to the surroundings and sense dangerous points. And they said that they could get information from this system easily even when the train was approaching.

(8) Others

The points that many participants estimated as good about the functions are as follows.
(a) Though there is a restriction that they must use it only on the tactile tiles, they can get the current location whenever they want.
(b) The system offers proper information to guide to the train door or stairs even on platforms. Moreover, if he/she miss the route, the system offers a message to correct the route.
(c) The system gives a chance that they use various equipment and utilities in large stations effectively as they can get the information about them.

A research, which investigated the difficult tasks when a visually disabled person uses a railway without a care worker, has reported the difficult tasks in a railway station are ``purchase of tickets'', ``move to a platform'' and ``move on a platform''. Orientation --- knowing the relative position between him/herself and surrounding things --- is indispensable to the task about moving. The reason why the task about ``moving'' is considered so difficult is because that it is very difficult to get information about ``orientation'' if they cannot utilize visual information. We think that the participants evaluated the system as (a) and (b) above, because the information about orientation is given by the system easily. As a common opinion, they told that "I want to carry this system and use large stations alone even if I am not familiar with the stations."
7. Conclusion

In this paper, we have introduced a new personalized information system for visually disabled passengers and reported the results of evaluation tests. By observation and the hearing of participants of the tests, we have confirmed the advantage of the system and the problems to be solved. In order to perform more objective evaluation on the validity of the system, we think it is necessary to execute the several examinations for evaluating the improvement of the efficiency of moving, the mitigation of mental stress and the improvement of safety etc. Although the technical problems have been resolved considerably, we think that it is necessary to execute a long term field test to find the problems from another point of view. This new guide method can be applied not only to visually disabled persons but also to other handicapped persons and ordinary passengers, so we will continue to research for them. The development of this system is furthered by the state subsidy. Finally, we are very much thankful to those who have cooperated with us for the evaluation of the system.

References