Interactive guidance system for railway 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 radio tag-installed Braille blocks. The tag reader at the tip of the cane reads the location data 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 interactively acquire the messages by communicating with the 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 good availability of the system.

1 Introduction

Recently, realization of a “barrier-free” environment for public transport is increasingly drawing concerns of the society. At a number of Japanese railway stations, elevators and escalators have newly been installed to help passengers in moving. Nevertheless, there still remain different barriers to be removed for handicapped persons to obtain 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 passengers equally, so it is not possible to answer a particular question asked by a particular passenger. Passengers who want to have some particular information must find where the information is given by their own efforts except in the case where they can ask a station crew. Namely, a user must find the necessary information among a lot of information and make some decision to utilize the railway. Passengers normally perform this task almost unconsciously in the normal situation. However, the information provided when an accident has occurred is generally not sufficient, so they are dissatisfied with the current information services, or may suffer from the lack of information. This situation is considered to be more serious for the aged and handicapped people.

The information necessary for utilizing railways is as follows.

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

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

![Figure 1: Image of interactive guidance system](image-url)
3 Guidance system for the visually disabled

3.1 System composition

Based on fundamental research, we have developed a guidance system for visually disabled persons who are in the most inconvenient situations at railway stations. Since it is difficult for visually disabled persons to acquire visual information, the following 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 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 to prevent walking in the wrong direction.

To satisfy the above requirements, we have studied several technical issues and built up a trial interactive guidance system (Figure 2). This system consists of three main components, a cane, a portable information terminal and radio tag-installed Braille blocks (Figure 3). The radio tag is a small electronic device having memories and a radio communication function. The data in the tag used as the location information of the user are read by the tag reader at the tip of the cane and transmitted to the portable terminal by radio. The information about the current location of

Figure 2: System components
the user is offered vocally by the portable terminal by using a station map stored in it. When the user indicates the 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 thereafter.

(1) Portable information terminal

The portable information terminal consists of a main unit and collar unit (Figure 4). It is assumed that the user carries the main unit in a pocket.

![Figure 3: System composition](image)

![Figure 4: Composition of portable terminal](image)
and puts the collar unit on the collar of his/her clothes. Since the system is made as wearable, the user can use it in a hand-free manner. The main unit has a CPU, batteries, main electronic board, etc. and the collar unit has a microphone, speaker, demand switch, etc. The main unit also has a microphone for canceling the environmental noise of the station to improve the voice recognition performance. As the portable terminal should be routinely carried by the user, it must be small, light and power-saving as much as possible. The size of the trial version of the terminal is 145×80×20 mm, and the weight is about 240 g. The terminal can work about three to four hours continuously with two batteries of the type AA.

(2) Cane

The inside structure of the cane is shown in Figure 5. The cane reads the location data from the tags installed in Braille blocks with the antenna at the tip and transmits them to the portable terminal by radio. If the cane reads the data indicating that the place is dangerous, it excites an internal vibrator to alarm the user. The cane looks and feels like a normal cane for the visually disabled. It weights about 250 g and is 105 to 125 cm long with a handle of 17 mm around. The cane works about four hours continuously with two batteries of the type AA. The cane sends the data from the tip unit to the grip unit by FSK communication so that it can be folded.

Figure 5: Composition of cane

(3) Braille block

There are two types of Braille blocks. One is made of concrete and the other is the sheet type made of vinyl chloride. The concrete type Braille block is usually laid indoor and the sheet type is laid outdoor. When the concrete type Braille blocks are used, tags molded by plastic are laid underneath.
As the sheet type Braille blocks, special type blocks are used. The Braille block looks like a normal sheet type Braille block, but it has an about 10 mm-long battery-less tag and simple coil in it. When the tag reader at 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 Braille block and the vertical transmission distance is about 20 cm. As the transmission area is sufficiently large, the user can move the cane somewhat in a rough manner. As the tag can work without batteries, the maintenance of the tag is unnecessary after it is buried under the Braille block. These Braille blocks with tags are installed at important points in the lines of Braille blocks throughout the station to provide guide information to the visually disabled.

3.2 User functions

The functions of the system for users are shown in Table 1. All functions are performed by voice command exchanges. Whenever a user has the needs to use the system, it can be set up to provide an appropriate answer. The method 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.

<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>
</tr>
<tr>
<td></td>
<td>Location inquiry</td>
<td>Indication of the current location by inquiry of the user.</td>
</tr>
<tr>
<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 nearby ticket machine 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 a 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>
When the user tells the terminal where he/she wants to go, the best route is computed and presented to the user. When he/she tells “I want to go to platform No. 3,” for example, then the system will recognize the words and set the platform No. 3 as the destination. It also gives messages such as “Please turn to the right and go ahead 30 m.”

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.”

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.

If the user misses the last message, the user can say “Once more,” then the system tells the last message again.

4 Field tests

4.1 Infrastructure for field tests

We have conducted an investigation about the passenger flow at a number of stations, and chosen a large terminal station in Tokyo as the place of field tests. Radio tags were embedded in the mortar layer under concrete type Braille blocks in the station. Since this method is almost the same as the method used for installing Braille blocks without tags, it has the advantage that the same reliability can be ensured. However, in the case of stations where the business time is long, it is difficult to secure a sufficiently long time to install the tags, so the efficiency of work is not high. If Braille blocks are installed newly, no extra construction work is necessary since tags can be embedded together with Braille blocks. Although we embedded the radio tags under the Braille blocks, we have confirmed that the communication capability is sufficient for practical use.

4.2 Results of field tests

The participants in the field test for estimating the system were 10 visually disabled people. We did not change or control the conditions of the environment of the station, such as the train operation schedule, broadcasting voice messages and passenger flows. However, in the case where there was a dangerous situation such that another passenger may hit the disabled person, we intervened in to guard the disabled person. Before starting an examination, the participants were given the information about the improved 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 to: (a) walk from a place outside the station to another place which is positioned in front of a train door on a platform (there are steps in the route), (b) walk using two kinds of guidance levels which differ in their details of...
guide messages and compare them, and (c) use the function by which the system gives the users the information where they are now. During their test walks using the system, we took videos with two video cameras, and recorded the guide messages and the reactions of users on notebooks by walking with them. A scene of the test is shown in Figure 6.

Figure 6: Field test by a visually disabled person

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 a point before ticket vending machines to the point in front of a specific train door on a platform. This route is about 100m long and there are ticket-checking gates and descending steps on the way. We have confirmed that the user can arrive at the destination by 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 along the same route in the concourse without using the system. The mean speed in this 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 become more familiarized with the usage of the system.
(2) Arrangement of radio tags

The radio tags are embedded at intervals of less than 5 m along the straight line of Braille blocks. On the turning point, in order to guide them quickly, tags are embedded in the blocks adjacent to the turning point. Consequently, it was sometimes observed that detecting the tag at the center of turning point is difficult for the user who has stopped at the turning point. So it is considered that tags should be embedded in the Braille block positioned at the center of the turning point.

(3) Guidance level

The system has two guidance levels, the detailed level and the simple level. At the detailed level, the system tells the user the distance to the destination and the distance to the next right- or left-turning point. At 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 opinion on which level they prefer differs from person to person, most comments can be summarized as “I want to select either of them depending on the situation whether I am familiar with the station or not.” Moreover, all participants estimated the function as “it is very good for users to be able to select the guidance level according to their will, like with this system.”

(4) Human interface

In order to evaluate the human interface of the system, we asked participants to operate the system by themselves. The operations they performed are setting destinations, selection of a guidance level and setup of a voice pitch of messages offered by the system. As a consequence, we have confirmed that even aged participants can use the system without special training. In the hearing session after the test, they answered that the operation by 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 more clearly how it works when he/she operates the small volume dial attached to the portable terminal.

(5) Mental stress and resource for attention

In the test at the actual station, noise from the environment, such as announcement, voice of other passengers and noise generated by trains, differs from that of the test field at the institute. In addition, visually disabled persons get more stresses 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 other 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 stresses and resource for attention. All of them answered that it is possible to pay attention to the surroundings
and sense dangerous points. They also said that they could get information from this system easily even when a train was approaching.

(6) Others
The points that many participants estimated as good about the functions are as follows; (a) Although there is a restriction that they must use it only on Braille blocks, 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 misses the route, the system offers a message to correct the route. (c) The system gives the opportunity for them to use various equipment and utilities at large stations effectively as they can receive appropriate information.

5 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 hearing from participants in the tests, we have confirmed the advantage of the system and the problems to be solved. In order to perform more objective evaluation of the validity of the system, we think it is necessary to execute several examinations for evaluating the improvement of the efficiency of moving, mitigation of mental stress and 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 other passengers, so we will continue research as on these issues. The development of this system has been assisted by a state subsidy. Finally, we are thankful for those who have cooperated with us for the evaluation of the system.

References