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Research on Interaction Design of a Touchless Gate

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The Frontier Service Development Laboratory is considering a touchless gate with the aim of creating a ticket gate system to form an amenity-rich station space. This is done based on the concepts of "high levels of convenience", "easy operation" and "accessibility".
     In this study, we examined interaction design for passengers with a touchless gate in a comprehensive manner from a perspective of vision and hearing. In addition, we organized the issues that came up and verified the touchless gate prototype based on the study results as required to build a stress-free touchless gate system.

●Keywords: Touchless gate, User interface

1 Introduction

The Frontier Service Development Laboratory is considering a touchless gate with the aim of creating a ticket gate system to form an amenity-rich station space. This is done based on the concepts of "high levels of convenience", "easy operation" and "accessibility".

A "touchless" (contactless) gate is a ticket gate that can examine tickets to allow passengers to pass through without touching an IC card or inserting a magnetic ticket to the gate.

Past research showed that, for effective use of touchless gates, it is important to determine the required elements and configuration of a touchless gate and identify what is the optimal interaction between passengers and a touchless gate (behavior of the total gate system and two-way communication with passengers).

The aim of this research was to sort out the issues for considering the required interaction design. To do that, we manufactured a prototype touchless gate with which we evaluated the interaction with passengers.

2 Overview of the Prototype Touchless Gate

In order to find out the optimal interaction with passengers of a touchless gate, we manufactured a prototype touchless gate as shown in Fig. 1 based on the configuration of the current ticket gate body.

As shown, the prototype has an LCD monitor on both the front and the top to allow multiple indications to be compared and checked. It also has a built-in speaker for guidance sounds, and it can open and close gate doors using a stepping motor. To make the prototype function according to the distance of the test subjects, it is equipped with a motion sensor that detects the position of test subjects.
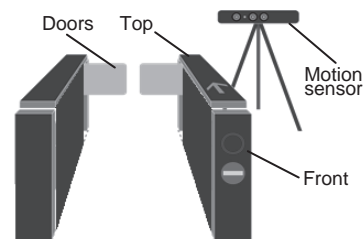

Fig. 1 Prototype Touchless Gate

3 Creation of Interaction Design

Current ticket gates obtain the information on whether or not entry/exit of a passenger is to be allowed by the passenger touching an IC card or inserting a magnetic ticket when though passing the gate. On the other hand, a touchless gate notifies passengers of the judgment on authorization to enter/exit without touching an IC card. We thus supposed that passengers would likely feel stressed or anxious until the judgment result is notified. We thus aimed to alleviate such stress and anxiety by adopting interaction design in the evaluation where the prototype notifies test subjects by LCD monitor indication and sound that it has successfully detected the passenger as the first phase of the judgment. Fig. 2 to 4 show the interaction designs we created in this research.

Fig. 2 shows the design where the prototype lights an arrow as used with the current ticket gates. This was adopted to aid understandability in use for passengers.

Fig. 3 shows the design with visual guidance using a solid circle as the position of the passenger and an empty circle as the location of the front of the prototype. The solid circle moves as the test subject moves forward, allowing the test subject to visualize his or her location in relation to the gate.

Fig. 4 shows the design with minimum visual guidance using flashing and illumination of lights. This design took into account the possibility that the space for a LCD monitor is limited as the body of the touchless gate may become more compact than current ticket gates in future practical use.

The prototype system with each interaction design starts guidance on the test subject being detected at 2 m in front of the prototype and guidance regarding judgment on authorization to pass at 0.2 m.

	Waiting	Test subject detected	Judging authorization to pass	Test subject passing	Test subject passed
Top			On	On	
Front	Off	On	On	Off	Off
Doors	Closed	Closed	Opens immediately after judgment	Opened	Closes after subject passes through
Guidance sound	None	Pulse	Beep	None	None

Fig. 2 Guidance with Arrow

	Waiting	Test subject detected	Judging authorization to pass	Test subject passing	Test subject passed
Top				*1	
Front		*1			
Doors	Closed	Closed	Opens immediately after judgment	Opened	Closes after subject passes through
Guidance sound	None	Pulse	Beep	None	None

*1: The solid circle moves upward or forward as the passenger moves.

Fig. 3 Guidance with Circles

	Waiting	Test subject detected	Judging authorization to pass	Test subject passing	Test subject passed
Top				*1	
Front	Flashing	Flashing	On	On	Flashing
Doors	Closed	Closed	Opens immediately after judgment	Opened	Closes after subject passes through
Guidance sound	None	Pulse	Beep	None	None

*1: The area lit increases in upward and forward directions as the passenger moves.

Fig. 4 Guidance with Light

4 Evaluation of the Prototype Touchless Gate

We tested the prototype touchless gate with the interaction designs shown in Fig. 2 to 4. In the tests, test subjects actually passed through the prototype and evaluated their experience. Tests were done by a questionnaire survey of ordinary visitors to the Railway Museum in Saitama City, Saitama Prefecture, and interviews of people at a disadvantage in terms of transport and experts in accessibility.

4.1 Questionnaire

(1) Purpose

The purpose of the questionnaire was to identify the effectiveness of and users' impressions regarding interaction between passengers and the prototype.

(2) Respondents

The respondents were 288 ordinary visitors to the Railway Museum. The attributes of the respondents are shown in Fig. 5 and 6.
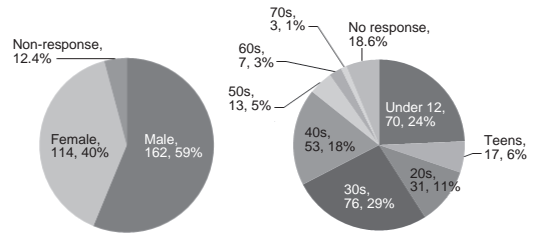

Fig. 5 Gender of Respondents   Fig. 6 Age of Respondents

(3) Questionnaire Items and Results

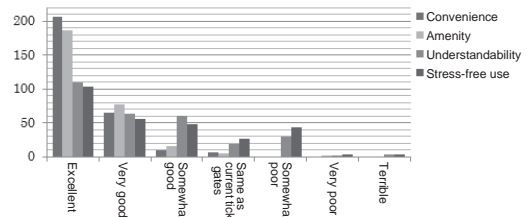(i) How the respondents felt when they passed through the prototype

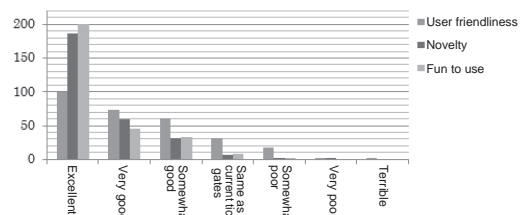Fig. 7 Views on Prototype Touchless Gate (1/2)

Fig. 8 Views on Prototype Touchless Gate (2/2)

For all seven evaluation items, the reply we received most was "Excellent" compared to the current ticket gates. The results show the possibility that touchless gates could be accepted well as a new service. However, some replied "Slightly poorer (than current ticket gates)" in terms of "understandability" and "use without anxiety".

(ii) Indication type users felt was easiest to use and reasons for that

Arrow   Circles   Light
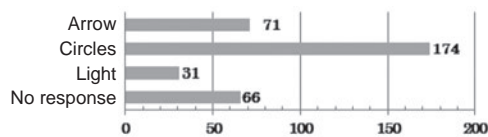
Fig. 9 Type of Indication

Fig. 10 Type of Indication Respondents Felt Was Easiest to Use

Arrow 71
Circles 174
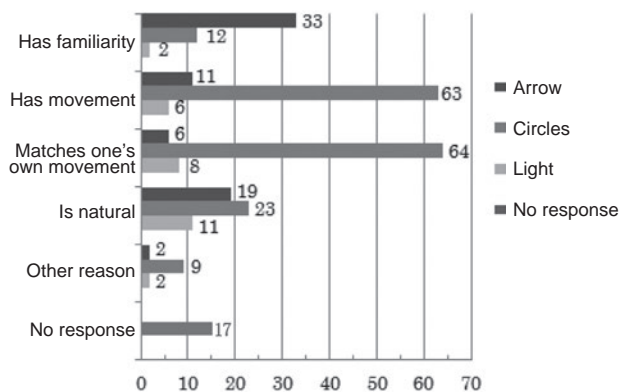Light 31
No response 66

Fig. 11 Reasons Respondents Felt Specific Indications Were Easiest to Use

Many respondents replied that they appreciated the indication with circles because "the indication has movement" and "the indication matches one's own movement". That result seems to show that it will probably be effective to notify users that the touchless gate detects and recognizes them. The next most chosen reason was that, for the indication with an arrow, "the indication had familiarity".
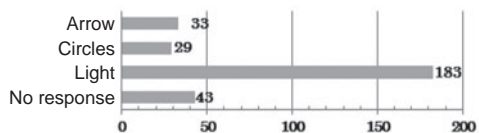

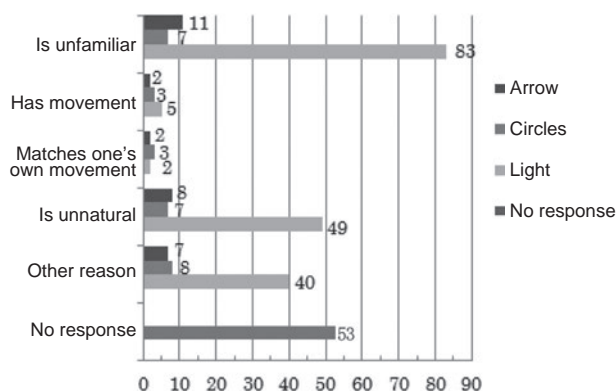Fig. 12 Type of Indication Respondents Felt Was Least Easy to Use

Arrow 33
Circles 29
Light 183
No response 43

Fig. 13 Reasons Respondents Felt Specific Indications Were Least Easiest to Use

(iii) Indication type users felt most uneasy with and reasons for that

Many were uneasy with indication with lights, and a remarkably large number of the respondents chose as the reason that "the indication is unfamiliar." For the indication with lights, we also received many free comment replies under "other reason". Those comments largely varied, including "difficult to notice the light at rush hours", "not easy to understand," "felt unpleasant from

flashing", and "could not understand whether it was OK to pass through".

(iv) Views and opinions on passing through the touchless gate
We received free replies from 253 respondents. They translated to a total of 302 views and opinions as some people gave more than one reply. Those are classified into 235 favorable opinions and 67 unfavorable opinions.

Notable views and opinions are listed in Table 1.

Table 1 Notable Views and Opinions on Use of the Touchless Gate

Favorable opinions	· It would be very convenient when carrying lots of baggage or my hands are full. · It would be very helpful when pushing a stroller or when with a young child because it is troublesome to take an IC card out in such a case. · It would be convenient to not need to take my pass out of my bag or pocket. · Very convenient for left-handers. · The moving indication is fun, like a theme park attraction.
Negative opinions	· I am somewhat concerned about double charging of fares, etc. · I am concerned about being unaware of insufficient stored fare amount when running through the gate. My authentication being messed up in an error due to the passenger before me or when the passenger after me moves overtakes me is also a concern. · Fare collection not being completed correctly is a concern. · When multiple persons pass through the gate together and the gate catches one, can it identify the person who is caught? · More people may run through the gate, so more troubles will occur between people running and people walking slowly at rush hours. · There could be safety problems where people run in to each other when crowded.

Many of the favorable opinions were probably received from the test subjects who felt touching an IC card to the reader was difficult or troublesome when both hands are full.

On the other hand, we also received unfavorable opinions showing concerns over double charging of fares, whether or not fare collection is correct, and an increase in the number of troubles when more than one person passes through the touchless gate at once in situations such as at rush hours. Those suggested the possibility that the convenience of the touchless gate could create new inconveniences.

4.2 Interviews
(1) Purpose
The purpose was to hear comments on the prototype touchless gate taking into account the inconvenience for disabled people in using the current ticket gates and the installation of accessible facilities.
(2) Interviewees
The following three persons were interviewed.
· A person with weak eyesight (right eye: can only detect light, left eye: 20/1000 (0.02) vision)
· A person with physical handicap (no sensation in the right arm and leg, using a cane to walk)
· An expert in accessibility (in charge of creation and promotion of standards for making station facilities accessible)
(3) Interview Results
We heard comments from the interviewees. Table 2 shows important comments received in the interviews.

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Table 2 Notable Opinions Received in Interviews

Person with weak eyesight	· It would be helpful on rainy days when my hands are full with a cane and an umbrella. · I am afraid of bumping into other people at the ticket gates at rush hours. There is a possibility that my cane may break or someone stumbles over my cane. So, I will choose the touchless gate if it is safer. · Some persons with weak eyesight can see the indication with an arrow (Fig. 2), so an indication method combining shape and color could be effective, provided that information on the indication is given in advance. The guidance with light (Fig. 4) was difficult to understand because I could not tell the difference between different lights.
Person with physical handicap	· It will be useful for passengers who want safe entry/exit to modify the wider type of current ticket gates to be touchless gates, even if longer ticket examination time is needed. Such passengers could include visually impaired persons, persons using a stroller, and persons having difficulty in walking. · I am concerned about what would happen if the user after me overtakes me while I am still in the gate after my ticket is examined. · I thought that the guidance with an arrow (Fig. 2) was most understandable. The guidance with circles (Fig. 3) is not necessary. The guidance with light (Fig. 4) was not understandable.
Expert on accessibility	· It would be good for users to be able to see the position and timing of detection in advance, as in the test this time. That could overcome the anxiety of some passengers when using. · It is difficult to judge only with sound whether passengers may go through or not. · It might be difficult to understand which gate to go through when there are many touchless gates in a line as they may look just like one large neon sign. · Passengers with color blindness cannot distinguish between meanings of indications using only one shape in different colors (Fig. 4). Use of the shapes ○ and × is recommended.

The interview results revealed that an important judgment standard for those people when using the touchless gate is safety, which they place more importance on than time and convenience. It was also found that indication where the situation could be clearly determined is preferable than complicated indication.

5 Conclusion

In this research, we carried out a questionnaire survey and interviews on the experience of using the prototype touchless gate.

In both, we received many comments that the guidance using lights (Fig. 4) was not easy to understand, demonstrating that guidance with a small volume of information is insufficient.

The guidance using circles (Fig. 3) was well accepted in the questionnaire survey, while the guidance using an arrow (Fig. 2) was more accepted in the interviews. Such divided results suggest that the interaction design required for a touchless gate differs according to the physical condition of users.

On the effectiveness of the touchless gate when users have difficulty or inconvenience in touching an IC card to the reader, we received common favorable comments both in the questionnaire survey and the interviews. This demonstrates that touchless gates would be effective for those who experience some difficulty in using the current type of ticket gates.

We did, however, receive some opinions expressing concern about using a touchless gate, such as double charging of fares and troubles occurring at rush hours. From those comments, we found that more in-depth research on the interaction design is needed.

In light of the results, we found that the following three points are the issues to overcome from the perspective of interaction design in order to achieve practical use of touchless gates.
(1) Clearer definition of target users
We need to clarify the image of who the target users of the touchless gate are and specific barriers to overcome for such target users.
(2) Alleviation of new barriers
We need to find and overcome new barriers that may be created by the accessibility that will be achieved by the touchless gate.
(3) More in-depth interaction design of the touchless gate taking into account safety
We need to consider easy-to-understand and effective interaction design for customers from the perspective of layout, visibility, and legibility of the indication while taking into account safety.

Reference:
1) Kenryu Nakamura, Satoshi Fukushima, *Barrier-free Conflict* [in Japanese], (University of Tokyo Press, August 2012)