Special edition paper

Development of an Information Service System for Individuals Using Smartphones and Proving Tests of the System (JR × AR)

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JR East is working to increase convenience of stations by means such as *ekinaka* in-station commercial spaces and barrier-free equipment. While Tokyo, Shinjuku, and other large stations gain improved convenience by adding facilities and the like, many people become lost in such stations with their complex layouts. Personalized guidance to destinations is therefore demanded. GPS devices and compasses, however, do not work properly in stations with underground structures, making location detection for individuals difficult. We are working on R&D for a new concept station guidance system using passengers' smartphones as a solution to that situation. This article reports on the effectiveness of such a system for which proving tests were held from April through June 2012 and challenges in introducing such a system.

●Keywords: Augmented reality (AR), Smartphone, Navigation

1 Introduction

The convenience of stations is being further heightened in recent years with the increase in convenient facilities centered on stations, such as in-station shopping areas and attached sport stadiums. Large terminal stations where many people come together have often had complex layouts even in the past, and users have struggled to find their destinations. In light of the situation, we need to provide information in an appropriate and easy-to-understand manner for diverse facilities so that passengers can make the most of in-station facilities and enjoy the convenience of those.

Smartphone use has skyrocketed in the mobile phone market in recent years. One report states that they are expected to outnumber ordinary mobile phones in Japan by the end of fiscal 2014, reaching 81.19 million subscriptions (67.3% of total subscriptions) by the end of fiscal 2017.[1)]

In light of that situation, we have started R&D on a station guidance system that incorporates new technologies based on smartphones that are widely used by passengers. That will allow us to provide in-station guidance and information in a simple and appropriate manner according to individual needs. Through proving tests in actual stations, we are assessing effectiveness and extracting issues in terms of putting it into practical use.

1.1 Information Services in Stations

The following are the two main issues in terms of providing information for passengers in terminal station guidance.

1) Arranging complex information on stations layouts

Commercial facilities in the ticketed area of many JR East terminal stations are on the increase. The number of facilities catering to individual passenger needs such as multi-purpose restrooms and information counters for travelers from abroad are also increasing.

Maps and other signage are possible ways to provide the large amount of information to passengers regarding those facilities, but the layout becomes complicated when including that all in a single station map. Moreover, including multiple languages and details on in-station shops leads to information saturation, and such signage ends up being difficult to figure out for people searching for information with a specific objective.

We therefore need to consider ways of providing in-station information in an easy-to-understand for terminal stations with their diverse demands for information and complex layered structures.

Fig. 1 In-station Commercial Space Shops at Tokyo Station

2) Providing information for individuals (identifying location)

One way to provide information according to individual passenger needs is by to provide that directly to their smartphones. Many of the questions passengers have in stations are about destinations such as location of the restrooms, ticket gates, or coin-operated lockers. People can give easy-to-understand guidance in relation to the current location and direction facing, but smartphones must identify that information to mechanically give guidance to a destination. However, it is difficult to identify one's actual location in stations with underground structures because GPS devices and compasses often lose functionality there. In order to overcome those issues, we conducted technical surveys and preliminary studies on the possibility of utilizing smartphones.

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2 Technical Surveys and Preliminary Studies

2.1 Positioning technology (use of AR technology)

Positioning by GPS and Wi-Fi are typical means of positioning by smartphone. But as of 2012, GPS cannot be used underground and accuracy of positioning according to Wi-Fi strength is rough, meaning they cannot be used for guidance in stations. We have therefore focused on augmented reality (AR) technology that is gaining attention for uses such as in promotions for smartphones.

AR is technology whereby recognizing a certain image with a smartphone camera as shown in Fig. 2 allows electronic information such as text, voice, and images to be added according to the scene seen by the camera. In that way, information can be provided in an intuitive manner.

Application of AR technology to positioning

Fig. 2 Image of AR Use by Smartphones

2.2 Preliminary studies on information services using AR technology

We developed a prototype application for preliminarily studies on AR technology, conducting those studies in fiscal 2010 at the Smart Station laboratory building, a mockup station testing facility at the Research and Development Center of JR East Group.

Image-recognizing AR technology performs recognition of images through a camera, so we need to survey recognition rate by the feature value of the image itself, distance between subject and user, and brightness of the ambient environment. Ease of use also needs to be surveyed. We tested the following two patterns and extracted issues that we would face when a service is actually put in place.

1) Using markers with distinguishing designs

As the markers have a large feature value, misrecognition did not occur at a distance of up to two meters. Passengers were also able to easily tell that those were objects they should record with a camera. An issue that was brought up, however, was ability to secure space in existing stations to set up those markers.

2) Using actual scenery as a recognition image

An ID is recognized from feature points of existing equipment (guide signs, etc. in stations) in this method without setting up specific markers. As the feature value is less than with markers, misrecognition increases at distances of greater than 1.5 meters. Possible issues are that recognition rate is inferior to with markers and that passengers need to know in advance what signs to record to activate AR.

Fig. 3 Testing at the Smart Station

The results of the studies showed that we need to have many passengers try out the services. In light of those results, we decided to adopt the marker method as image recognition rate is high and it is easy for passengers to recognize that they are objects they should record with a camera. It is also worth noting that we entered this station space guidance system prototype in the 2010 Good Design Award contest, winning the contest (Fig. 4).[2)]

Fig. 4 2010 Good Design Award Ceremony

3 Development of a Station Information Service Application for Smartphones (JR × AR)

Based on the results of the preliminary studies, we developed an application for field tests. The following covers the events leading up to field tests.

3.1 Development of Specifications

3.1.1 Station Selection

We selected Tokyo Station as the location to conduct tests to assess the effectiveness of the application. The reasons for that selection were that it has a complex layered structure and close to 200 shops within the ticket gates (as of 2012) and that there is a much demand for information services in the station. Moreover, needs of passengers are diverse, including those for commuting, shopping, and travel. In light of such features, we felt it would be the most appropriate station.

Fig. 5 Tokyo Station Map (1st Floor)

3.1.2 Selection of Information to Provide

Railway-related information provided included AR guidance, station maps, operational information, route searching, timetables, and line maps. In-station commercial facility information provided was shop lists and recommendations. (Fig. 6) Detailed information is provided later in 3.3 (Interface Design).

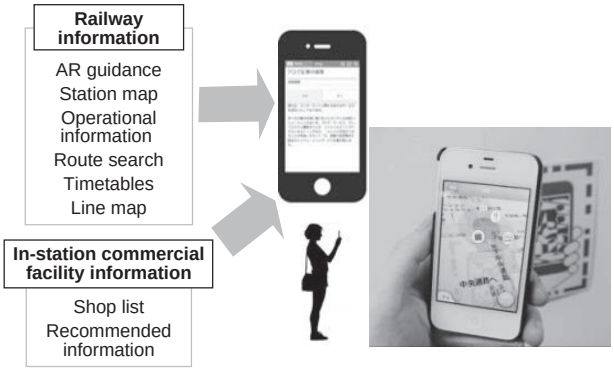


Fig. 6 Information Provided by Application

3.1.3 Service Name Selection

Many passengers would need to use the service in proving tests, so we thought up a name that would be catchy. We called it "JR × AR" to express that it uses AR technology and to be a name with a nice ring to it.

3.2 System Composition

With information for smartphones, data (station maps, timetables, etc.) is either stored in the application itself or on a server to be retrieved by and displayed on the smartphone when needed. The following is a brief explanation of the merits and demerits of the individual methods.

1) Data held in the application itself

As data does not need to be acquired by the application from an outside source, it can be displayed quickly. However, data updates may be delayed, so content that does not face such problems needs to be applied to the system. In the content used with the developed system, AR guidance, station maps (base maps), and route maps are held in the application.

2) Data held on a server

By acquiring the latest data through communications each time the user views information, the information can be provided almost in real time. The time required to display that information, however, reduces its ease of use. Taking into account the merits and demerits of the individual methods, we built a network system as is shown in Fig. 7.

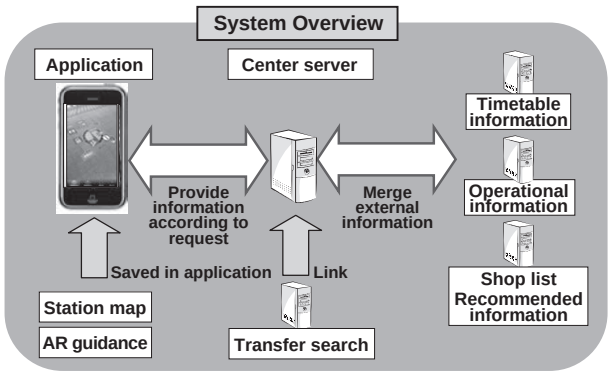


Fig. 7 System Overview

3.3 Interface Design

Nine icons are shown on the top screen to allow information to be selected by individual objective. To make AR markers easier to find, we gave common traits to the distinguishing characters on the markers, AR screen, and top screen.

Fig. 8 Top Screen, AR Screen, Marker

1) AR Guidance (in-station guidance)

AR markers were set up in a total of 27 locations in the station. So as not to block the flow of foot traffic, we set them up in places such as columns called general information boards and on the floor.

Fig. 9 Locations of AR Markers (wall, floor)

The camera and image recognition engine start when the function is selected, and information on the current location and the direction faced are provided by recording any of the AR markers set up in 27 locations. Other functions include that, when a marker is recorded, plot the current location on a station map and give information on surrounding shops.

Fig. 10 AR Display Content

The AR guidance prepared shows three-dimensional views of maps of surrounding areas and views of underground levels where the floor is translucent.

2) Station Map
In addition to displaying a station map, the system has a function where selecting the name of a desired shop or facility from the pull-down menu highlights its location.

Fig. 11 Station Map and Display List

3) Operational information
Information by individual line on train operation status
4) Route searching
Function for searching routes from Tokyo Station
5) Timetables
Times for trains arriving at and departing from Tokyo Station

Fig. 12 Operational Information, Route Search, and Timetable

6) Line map
Map of lines in the Tokyo area
7) Shop list
Function for searching for shop information by genre such as eateries, box lunches, and snacks
8) Recommended information
Information on recommendations from companies managing in-station commercial facilities, for JR East travel products, and more

Fig. 13 Line Map, Shop List, and Recommended Information

4 Proving Tests at Tokyo Station

Proving tests for the system were held within the ticket gates of Tokyo Station from April 16 to June 30, 2012.

4.1 Announcement

Posters and pamphlets announcing the tests were produced to prompt as many people as possible to participate. They included information such as how to download the application, how to use it, and its functions. A website with the same information was also produced and promoted to further broaden the reach of the announcement.

Fig. 14 Announcement by Posters

4.2 Release of Application

An application was developed for both Android and iPhone smartphones and released free of charge on Google Play and the Apple App Store.

4.3 Questionnaire Survey

A questionnaire survey was conduced about a month after the start of the proving tests, from May 19 to July 19. To limit survey participants to only those who downloaded the application, a questionnaire form was set up within the application through which replies would be submitted. The survey covered the following three items.

1) Attribute information
2) Assessment of content
3) Current and potential demand, areas needing improvement, requests

5 Results of Proving Tests

5.1 Usage Trends

Data on usage trends with the JR × AR application is as follows.

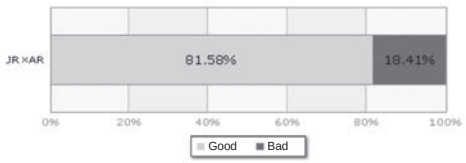
◇Application accesses 516,272	(Daily average) 6,535 (Max. use in one day) 11,397 [April 16]
◇Total application downloads 18,402	iOS 15,682 Android 2,720
◇AR loads 8,398	(Time of maximum loads) 3 to 4 pm
◇Registered users 15,628	(Attributes with largest number) Male, 30s, company or government employee

Fig. 15 Application Use Trends

The application was accessed a total of about 500,000 times and downloaded about 18,000 times, demonstrating that a large number of people cooperated with the tests.

Opinions on SNS sites (Twitter, blogs)

We tabulated the reputation of the service on SNS sites using a search function. Keywords searched included "JR × AR," "AR," and "Tokyo Station." In assessments, most opinions on the new efforts were positive as shown below. Negative opinions included that the AR technology was not used as expected and that AR markers could not be found in Tokyo Station when attempting to try out the service.



	Good reputation	Bad reputation	Total
JR× AR	93	21	114

Fig. 16 Opinions on SNS Sites

5.2 Questionnaire Results

Number of participants: 693
Male: 531
Female: 136
(26 people did not reveal their gender.)

Excerpts from questionnaire replies

Opinions given in the questionnaire submitted via the application are shown in Fig. 17.

Positive

- Large stations are like a maze and are hard to figure out, so further deployment of the service would be helpful.
- It is very helpful to have a route map and station map at hand.
- The concept is futuristic. AR in more places than just the station would be beneficial.

Negative

- I expected AR to be more fun, but just guidance was not what I expected.
- Markers were hard to find, making the service inconvenient.
- I would prefer to automatically find my location without using AR (like with GPS).

Fig. 17 Opinions Given in Questionnaire (excerpted from a total of 462 questionnaire responses submitted via the application)

Like with SNS, opinions extracted from questionnaire replies were that the information service for smartphones was helpful.

Results of a survey on content users felt was particularly helpful is shown in Fig. 18.

Line map (59.5%), operational information (58.0%), station map (50.8%), and AR guidance (42.4%) were given high marks. In addition to AR guidance, the results demonstrated the usefulness of information services for smartphones along with those by posting in stations and on websites.

Relatively low marks were given to shop lists (34.5%) and recommended information (20.8%). That was possibly due to infrequency of information updates and lack of coupon information and other content desired by users.

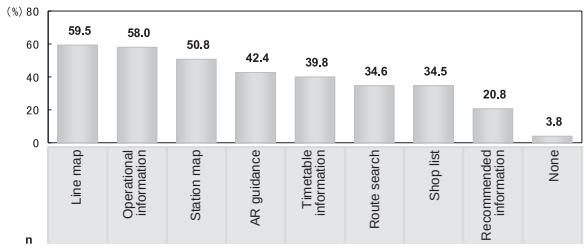


Fig. 18 Content Viewed as Being Helpful

6 Observations

A number of issues were found in terms of making the service ready for practical use through development of a system for providing information to smartphones and proving tests at Tokyo Station. Major issues are as follows.

[Image recognition AR]

· Markers were discovered to be difficult to find in busy corridors and the like as they did not stand out as initially expected.

· Some people felt resistance to pointing a camera in crowded spaces like stations.

⇒To counter that issue, the markers could be changed to a large design that stands out. In regard to difficulty of finding markers, a larger number of them can be set up and existing signage can be included among the images that are recorded.

[Update and maintenance of station information]

· In the proving tests at Tokyo Station, the location and name of many facilities and shops were changed due to restoration of the Marunouchi stationhouse and renovation of the central corridor. As update information for those is sent by multiple departments, much labor was required in arranging it, demonstrating that information update is an issue that needs to be handled for actual introduction of the service.

⇒One possible way to counter that issue is to use a station map platform where the person in charge of each area or each business itself can apply changed information to the system. While not done in the tests, close to real time information such as information of the day and information on limited-time sales can possibly be provided.

[Effectiveness of information services]

· In terms of effectiveness of information services, the reach (page views) with access by an application such as that designed for the tests is not of the level of websites because the only people who can view information are those who downloaded the application. As shown in Fig. 19, the service was composed of content with an emphasis on navigation (station guidance) and information (operational information and shop information) as this development was for experimental purposes, but we need to select an information delivery system by which more people can view the information in actual introduction of the service.

⇒One possible way to counter this issue is to not be limited to access from an application. By designing for an efficient means of providing information such as one-source, multi-use (channel) that includes combining with websites and display on large-screen monitors, effectiveness in relation to development cost can be raised.

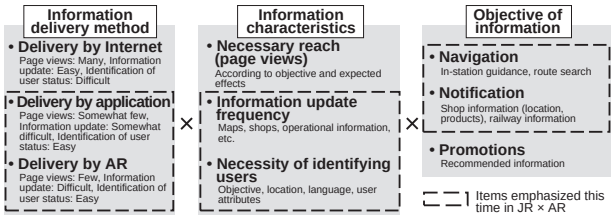


Fig. 19 Items Emphasized in JR × AR

[Displayed content]

· The questionnaire showed demand for more detailed real-time information from the station and in-station commercial facilities, information on individual train delays, and for station departure information boards. We therefore need to make efforts in the future to provide information for which demand is high.

7 Conclusion

AR technology can display information by recording visible objects with a camera, so it is simple and intuitive as well as being visually easy to understand. Therefore, its effectiveness for a wide range of passengers regardless of age or gender can be expected in stations where diverse people come and go.

In the future, we will work to overcome issues discovered in R&D up to this point ahead of introduction of services. We also intend to continue with R&D for practical use of technologies so as to be a more convenient and effective means of guidance and providing information for passengers.

Reference URLs:

1) "Smartphone no Shijo Kibo Yosoku," MM Research Institute, Ltd., http://www.m2ri.jp/newsreleases/main. php?id=010120120313500

2) Overview of Good Design Frontier Design Award, http://www.g-mark.org/award/describe/37072