World Academy of Science, Engineering and Technology
International Journal of Transport and Vehicle Engineering
Vol:6, No:11, 2012

Context Aware Navigation System for Using Public Transport on Smartphone

Satoru Fukuta, Masaki Ito, Takao Kawamura, and Kazunori Sugahara

***Abstract*—**Recently, many web services to provide information for public transport are developed and released. They are optimized for mobile devices such a smartphone. We are also developing better path planning system for route buses and trains called "Bus-Net"[1]. However these systems only provide paths and related information before the user start moving. So we propose a context aware navigation to change the way to support public transport users. If we go to somewhere using many kinds of public transport, we have to know how to use them. In addition, public transport is dynamic system, and these have different characteristic by type. So we need information at real-time. Therefore we suggest the system that can support on user's state. It has a variety of ways to help public transport users by each state, like turn-by-turn navigation. Context aware navigation will be able to reduce anxiety for using public transport.

***Keywords*—**Navigation, Public Transport, Smartphone, User Experience.

I. Introduction

PUBLIC transport is important infrastructure for modern society. It is able to contribute to save environment. For example, reduce carbon dioxide, improvement for traffic problem, and keep more fossil fuel. Therefore it has many advantages. But it is difficult to use public transport when someone goes to destination. He/she needs to learn how to buy a ticket, how to ride, how to read a timetable, and how to change another transport. If he/she uses different types of public transport such as bus and train, he/she needs to learn more. If he/she is a stranger, he/she will face much more difficulty.

Nowadays, many web services provide information about public transport. Some of them provide path information. Others show diagram information, or provide information of public transport situation. For example, "NAVI-TIME"[2] and "Google Maps"[3] are providing path planning using public transport. We also develop such supporting system named "Bus-Net". This system has some function, fastest path search and planning, display timetable, and show location of buses. However, these systems only provide static data such as path information or timetable. Public transport user needs information in real-time. Therefore this paper suggests real-time navigation system build on concept of state-by-state navigation for using public transport.

S. Fukuta is with the ME student in Graduate School of Engineering, Tottori University, 4-101 Koyamacyho-Minami, Tottori-Shi, Tottori 680-8550, Japan (e-mail: s072041@ ike.tottori-u.ac.jp).

M. Ito, T. Kawamura, K. Sugahara are with the Graduate School of Engineering, Tottori University, 4-101 Koyamacyho-Minami, Tottori-Shi, Tottori 680-8550, Japan (e-mail: {masaki, kawamura, sugahara}@ ike.tottori-u.ac.jp).

II. Users State of Using Public Transport

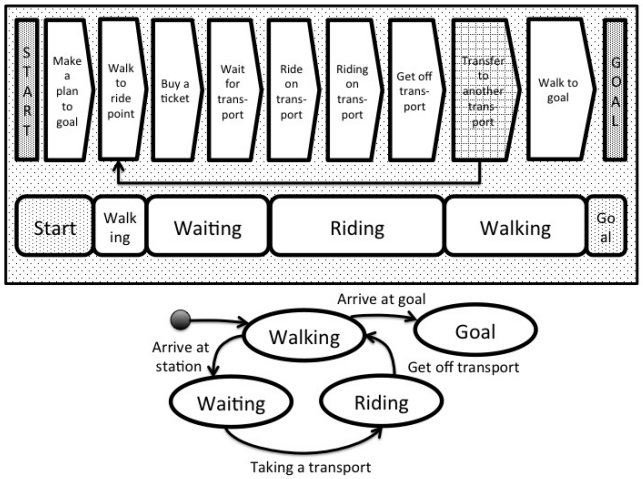

Fig. 1 A passenger activity and his/her state

A passenger taking public transport has many activities on using public transport. Fig.1 illustrates passenger's activity and his/her state at that time. Firstly, he/she plans how to go to his/her destination. Next, he/she walks to the bus stop or station. After that, he/she buys a ticket and wait for his/her vehicle he/she is planning to ride. He/she takes the vehicle soon after arriving the vehicle at the point. Finally, he/she gets off from the vehicle at the final bus stop or station, and walks to the goal. If he/she needs to transfer to another line, he/she waits for the vehicle. This paper classifies these activities into following four states.

A. Walking State

When a passenger is walking to riding point, he/she is being on this state. In this state, the user needs information of his/her location, or map information around his/her location. Other information is location of using transport, timetable of riding point, etc.

B. Waiting State

When he/she arrives at riding point, step into this state. On this state, a passenger doesn't have to need map information so. But information when a transport comes is more important that walking state. If he/she thinks that get his/her seat, it is important that congestion degree.

C. Riding State

When a passenger rides on the transport, he/she changes his/her state to Riding". In this state, the most important information for the rider is the time to get off. In addition, a passenger needs information of the destination to get off vehicle.

D. Goal State

When a passenger arrives at the destination, he/she changes his/her state to "Goal". At the state, the passenger does not need information about transit anymore.

As noted above, there are four states of riders of public transport. At each state, a passenger needs information about public transport in different manner. Just providing much information about public transport to the rider does not satisfy the rider. A system to support using public transport should provide information to the user considering the state the user is in. We show five examples in the following.

A. Location of Ride/Get-off Points

It is the most important problem where the riding point to take is. A passenger who lives nearby may know the location of the bus stop or the station to take to the public transport. But if he/she is a tourist or a stranger there, he/she does not know the exact location of the bus stop or the station. In this case, he/she needs to know the location of the bus stop or the station in advance, and prepare the map or ask someone else the way to the bus stop or the station.

B. Information of Routes

Information of routes includes name, course, kind of transit, and fare. Characteristic of course is different by kind of transit. Train runs on static rails that are usually illustrated on a map. But a passenger cannot know bus's course easily because bus can run on any street. When he/she takes public transit, he/she have to know name of route that include ride point and get off point.

C. Timetable at Ride Point

A passenger should know when he/she could ride a vehicle. So he/she know timetable of the transport at the ride point. If he/she does not know well about the timetable, he/she would miss the vehicle.

D. Timetable at Get Off Point

Timetable at get off point is important. When a passenger goes far with using several transports, he/she has to transfer to other transport at point by point. If he/she does not know arrival time at that point, he/she would miss the transport.

E. Area Information at Ride/Get-off Points

A passenger has to walk to the next riding point after getting off the vehicle if he/she needs to change to another vehicle. Then he/she must know how to go to the next ride point. On that time, he/she needs information at that area. The best way to get information is getting a detailed map. At least, he/she should know information of main-street and information of some landmark as his/her guide.

III. Related Works

A. Systems to Support Using Public Transport

Recently, many systems to provide information for public transport are developed and released [4][5]. Some systems provide a path to go destination. Fig. 2 shows the result of path planning on our system called "Bus-Net"[6][7]. It shows how to go to "Uradome coast" from "Koge station". It is difficult to understand such information since it contains too much information.

Fig. 2 Result of searching path using "Bus-Net"

Most users do not know well about this area. So he/she needs map information to find the route from his/her current location to the next bus stop or the station. However it is much information to show other information such a map on this path information. It is convenient for user who usually taking public transport likes such a Fig.2 system. If possible, such a system provides information to a user little by little when he/she needs. In fact, many famous systems have a link to get map information of station or timetable for using another time [8][9]. Other functions like printing page are same that too. In addition, there are some innovations on the system what have too many functions. For example, the system shows a different screen for every device to access. Then that system provides a little information. If a user needs other information on that system, he/she may just push button to download another information. On such a systems provides good information, but it is static providing. On the other hand, the system can provide information to user dynamically is navigation system.

B. Navigation System

Recently, navigation system using mobile device is very popular technology [10][11]. A lot of people use that system on smartphone with that technology. Needless to explain, when a

user goes another place without information of that area, he/she often uses navigation system. The system makes to guide a person who doesn't know information of that area. The system is used on driving with a high frequency. Therefore there are many functions on that system such several methods to input data. For example, a user could input to use map on touch display. Needless to say, he/she also could input destination name by text on virtual keyboard. And the important thing to remember is a driver cannot input data with his/her hand, and cannot look display so every time. For this reason, almost systems have voice input. It is assiduities for driver's safety.

Fig. 3 Google Maps navigation

Nowadays, there are many users who use navigation system on here and there. Not only on drive a car but also on walking, and going for a bicycle ride. Car navigation is famous system for a long time. Today, people have portable devices on GPS receiver such a smartphone, they often use map application with function of navigation such a "Google Maps App for Android" (Fig. 3). This and other system navigate user on turn by turn. It is one of navigation way to tell users direction to go next. Navigation systems contribute to reduce user's uneasiness.

C. AR Navigation System

The technology of augmented reality (AR) is being suited for real information. This technology can pile information on display showing real-time movie from camera. Therefore we developed to support bus users with AR technology [12]. This system provides information about bus-stops around user. And it provides information of buses coming close in the user. This system can reduce anxiety about buses. For example, it is anxiety about the bus late more then average when the bus comes. In addition, it is more instinctive to understand for showing information on real view. It is simple to use this system on smartphone. If user wants to know information, he/she has to hold the device only. Thus AR navigation is one of the ideal way at real-time navigation.

Fig. 4 AR navigation on "Bus-Net" system

IV. Problems of Navigation System

As noted in section III, a navigation system is convenient when a user goes to somewhere he/she wants to go. The system gives a user the best route to the destination. However existing navigation systems have several problems. First, a user needs to operate the system even while moving to the destination. For example, an AR navigation system requires a user to hold the device all the time. If there are many people using AR navigation on a street, an accident may be happen.

Second, existing navigation systems are not optimized to the user of public transport. Most navigation systems provide a path to the destination by a turn-by-turn manner. It is suitable to guide a user who is simply following a street. However, a situation of using public transport is not so simple. When a passenger arrives at the station, he/she has to go to the ticket counter and buy a ticket to the next destination. After that, he/she goes to a platform, wait a train, and ride the train. If he/she has to change to another train, he/she repeats the sequence. In the sequence, a passenger needs various kinds of information. For example, location of ticket counters, fare information, location of entrance gate, platform, and timetable. Therefore it is difficult to guide a passenger of public transport with a simple navigation system.

V. Context Aware Navigation System

As we discussed in the previous section, a simple navigation system cannot satisfy a public transport user. Thus we developed a context aware navigation system for public transport users. The navigation system recognizes user's situation, and provide suitable information. We classified the state of a public transport user into the following three states; walking state, waiting state, and riding state. The system provides different information for each state.

A. Navigation on Walking State

When a passenger is walking, the system provides a map and shows a route to the bus stop where the user ride a bus. The basic features of the navigation in the state are almost the same as the existing navigation systems. However,

Fig. 5 Navigation on walking state

our system gives more specific information about public transport. Fig. 5 illustrates the user interface for the walking state.

B. Navigation on Waiting State

On the waiting state at the bus stop or the station, a passenger is not just waiting with doing nothing. At first, if he/she takes a train, he/she must buy a ticket before riding the train. Secondly, he/she must go to the platform to ride a train. In addition, if he/she wants to drink something, he/she might go to the vending machine. Our system shows a map of the station, location of a vending machine or a store around the user, and countdown the departure time of the train. Figure 6 illustrates a user interface for the waiting state.

Fig. 6 Navigation on waiting state

C. Navigation on Riding State

After the user ride a public transport, the navigation system goes to the riding state. On the state, the system shows a map and progress to the destination. When a passenger is arriving at the destination, the system alerts the user to get off. If he/she must transfer another transportation at that point, the system shows the way to move to the next point and information of the next transport. Figure 7 illustrates a user interface for the riding state.

Fig. 7 Navigation on riding state

As dividing a user's sequence of using public transport into three states and providing different information for each state, we accomplished a useful navigation system for public transport users. In Japan, there are various methods to take a route bus or train. For example, some route bus asks a user to pay before riding, but other route bus asks to pay when getting off. Our navigation system gives a different guidance for a user in each route bus. A user is never confused by the complex public transport system.

VI. Future Work

The proposed context aware navigation system has several problems need to be solved. The most important problem is judgment to change the state of the navigation system. There are various possible information to recognize user's state such as user's location, transport's location, delay of transport, arrival time at the transport, distance from user's location to next point. We are using only user's location and arrival time of public transport now. User's location suggests his/her state with high accuracy.. However, we can infer user's state more accurately by using other information.

Additionally, if a user misses his/her bus or deviates from the suggested route, the system should give new route information like general navigation system. However it is difficult to judge if the user deviates from the given route. After solving the problem, our system will be more practical navigation system.

VII. Conclusion

In this paper, we developed a navigation system for using public transport. It is difficult to guide a user of public transport, since a user needs different information in each stage of moving with public transport. However, dividing user's action into three states in using public transport, it is able to meet user's demand. The navigation system provides detailed guidance for a user in each state. A user needs not to care for the difference of public transport system, which is complicated system in Japan. In addition, in case a user deviates from the proposed route, the system provides a new route to the destination from the user's location.

There are several problems on the system. For example, the technique to estimate the state of public transport user can be

more accurate. There is much possible information to estimate the state more accurately such as a location or time. We will solve these problems, and develop a more practical navigation system in the future.

ACKNOWLEDGEMENT

This research is supported by Strategic Information and Communications R&D Promotion Programme (SCOPE), Ministry of Internal Affairs and Communications, Japan.

REFERENCES

[1] "Japan Trip LLP:Bus-Net.", http://www.ikisaki.jp.
[2] M. Arikawa, S. Konomi, and K. Onishi, "NAVITIME: Supporting Pedestrian Navigation in the Real World," IEEE Pervasive Computing, pp. 21–29, 2007.
[3] Google Inc. Google Maps and Google Maps API, http://developers. google.com/maps/, Seen: 2012-06-29
[4] B. Ferris, K. Watkins, and A. Borning, "OneBusAway: Results from Providing Real-Time Arrival Information for Public Transit", ACM Conference on Human Factors in Computing Systems, pp. 1807-1816, 2010, Georgia, USA
[5] S. Carmien, M. Dawe, G. Fischer, A. Gorman, A. Kintsch, and J.F. Sullivan Jr., "Socio-Technical Environments Supporting People with Cognitive Disabilities Using Public Transportation", Transactions on Computer-Human Interaction, vol. 12, no. 2, pp. 233-262, 6 2005,
[6] T. Kawamura, G. Kusugami, and K. Sugahara, "Path Planning System for Bus Network including Walking Transfer," IPSJ Journal, vol. 46, no. 5, pp. 1207–1210, 5 2005.
[7] T. Kawamura and K. Sugahara, "Practical Path Planning System for Bus Network," IPSJ Journal, vol. 48, no. 2, pp. 780–790, 2 2007.
[8] Ekitan & Co., Ltd. http://ekitan.com/, Seen: 2012-06-29
[9] Jorudan Co.,Ltd. http://www.jorudan.co.jp/, Seen: 2012-06-29
[10] J. Baus, A. Krüger, and W. Wahlster, "A resource-adaptive mobile navigation system", International Converence on Intelligent user interfaces, 15-22, 2002, New York, USA.
[11] A. Brush, A. Karlson, J. Scott, R. Sarin, A. Jacobs, B. Bond, O. Murillo, G. Hunt, M. Sinclair, K. Hammil et al., "User experiences with activitybased navigation on mobile devices," in Proceedings of the 12th international conference on Human computer interaction with mobile devices and services. ACM, 2010, pp. 73–82.
[12] N. Kanatani, M. Ito, T. Kawamura, and K. Sugahara, "Take Me to the Bus Stop: AR Based Assistance System for Public Transit Users", International Conference on Embedded and Ubiquitous Computing, pp. 1831-1835, 2011, Venice, Italy.