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A Study of the Assistant Application for Tourists Taking Metros

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***Abstract*—**With the proliferation and development of mobile devices, various mobile apps have appeared to satisfy people's needs. Metro, with the feature of convenient, punctuality and economic, is one of the most popular modes of transportation in cities. Yet, there are still some inconveniences brought by various factors, impacting tourists' riding experience. The aim of this study is to help tourists to shorten the time of purchasing tickets, to provide them clear metro information and direct navigation, detailed schedule as well as a way to collect metro cards as souvenir. The study collects data through three phases, including observation, survey and test. Data collected from 106 tourists totally in Wuhan metro stations are discussed in the study. The result reflects tourists' demand when they take the metro. It also indicates the feasibility of using mobile technology to improve passenger's experience.

***Keywords*—**Mobile App, metro, public transportation, ticket, mobile payment, indoors positioning, tourists.

I. Introduction

PUBLIC transportation plays significant role in development of urban tourism, especially for the first-coming tourists. The metro is one of the most popular moods of public transportation. As mobile services filtered into every aspect of people's lives, the public transportation of cities begins to think about utilizing mobile applications as a means of improving tour traffic.

Based on features of smart phone like portability and popularity, almost everyone can go to everywhere with it. With the rapid development of wireless networks, equipped with outstanding positioning functions well as mobile payment applications, smart phones could provide more and more services without any extra burden.

This paper introduces a mobile metro app which helping tourists' trip experience by providing them with clear metro information and direct navigation, simplifying steps of taking the metro as well as helping tourists plan their time and route reasonably.

II. Background

Metro is one of the most popular mode of transportation in cities. According to the statistics, among all Chinese tourists to Korea in 2015, 62.37% tourists chose metro as their transportation tool to main attractions in Seoul [1]. Among all tourist to Munich in 2014, 88% tourists chose utilizing the metro for tourism [2]. Taking metro, which has advantages of fast, punctuality and safe, tourists would not face the problem of traffic jam. Meanwhile, as a kind of public transportation, metro is more economic than other forms of transportation. In Beijing, the flag-down fare of metro is 3 yuan in 6 kilometers. Yet, the counterpart of taxi is 13 yuan in 3 kilometers. Though the flag-down fare of bus is 1 yuan cheaper than that of metro, when exceed 5 miles, taking bus would cost more. Furthermore, metro systems often have wide coverage and have stations in popular spots, which makes metro a convenient option for tourists. Figs. 1 and 2 show the distribution of popular scenic spots in Beijing and Tokyo, respectively. The red circles on maps represent local famous scenic spots. It is clear to see that almost all famous spots have metro stations nearby. Thus, for tourists, metro plays a quite significant role. However, in reality, the construction of metro would be restricted by multiple factors such as the passenger volume, soil condition, water table, terrain type, existing underground pipelines and buildings. Cooperation with local commercial amenities, the existence of military sites could also be factors that impact the plan of the route [3]-[5]. These restrictions make the construction of the metro could not be entirely user-orientated, such as the complex transfer route of Beijing Metro System. Besides, complex management systems in some area, such as Japanese intricate railway networks, would confuse tourists, especially overseas tourists. Fig. 3 shows that there are so many people waiting in the queue to seek for guidance, which shows the cost of learning how to take metro needs to be reduced badly. The inconvenience brought by the restrictions, like the outdated ticketing systems, congestion in rush hours and ambiguous signs in stations, are causing the loss of potential customers.

A. Features of Tourists

In the era of the Internet, tourists' way of traveling has embraced much more brand-new features. Firstly, tourists require more information and use different sources. Secondly, they are highly dependent on Internet Applications and social media [6]. Then, more and more tourists are seeking personalized, differentiated souvenirs [7]. Besides, younger tourists like to share their travel experiences with pictures via the Internet. According to a survey of Chinese tourists in 2017 shows that 66% tourists would buy souvenirs and 35% of them buy souvenirs for memorizing.

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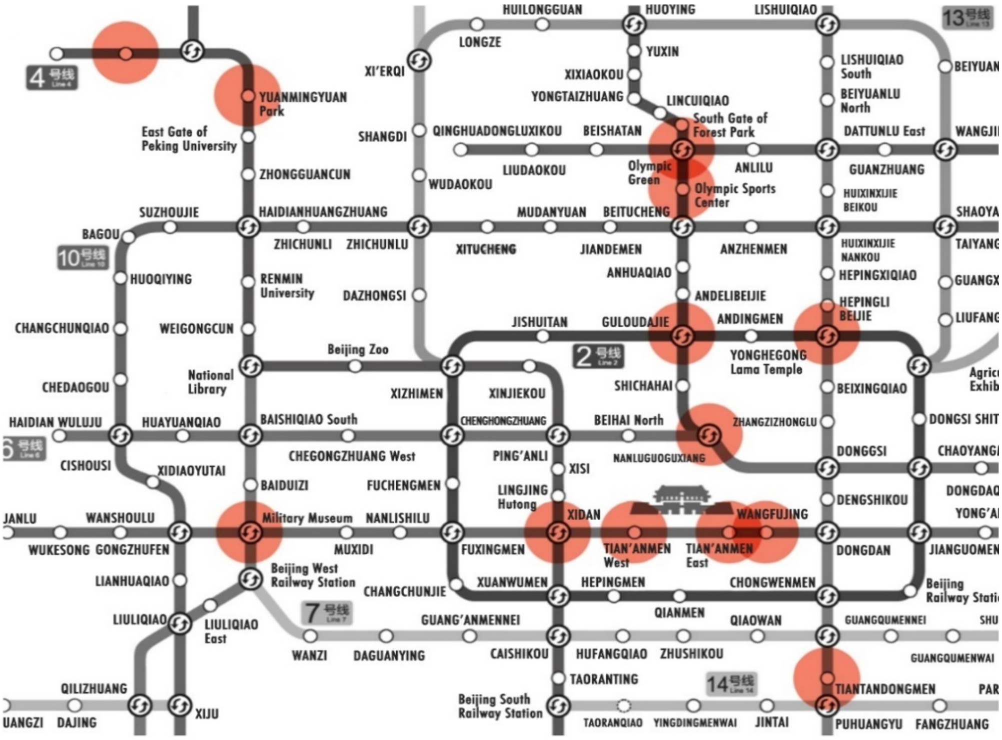

Fig. 1 Distribution of famous scenic spots in Beijing

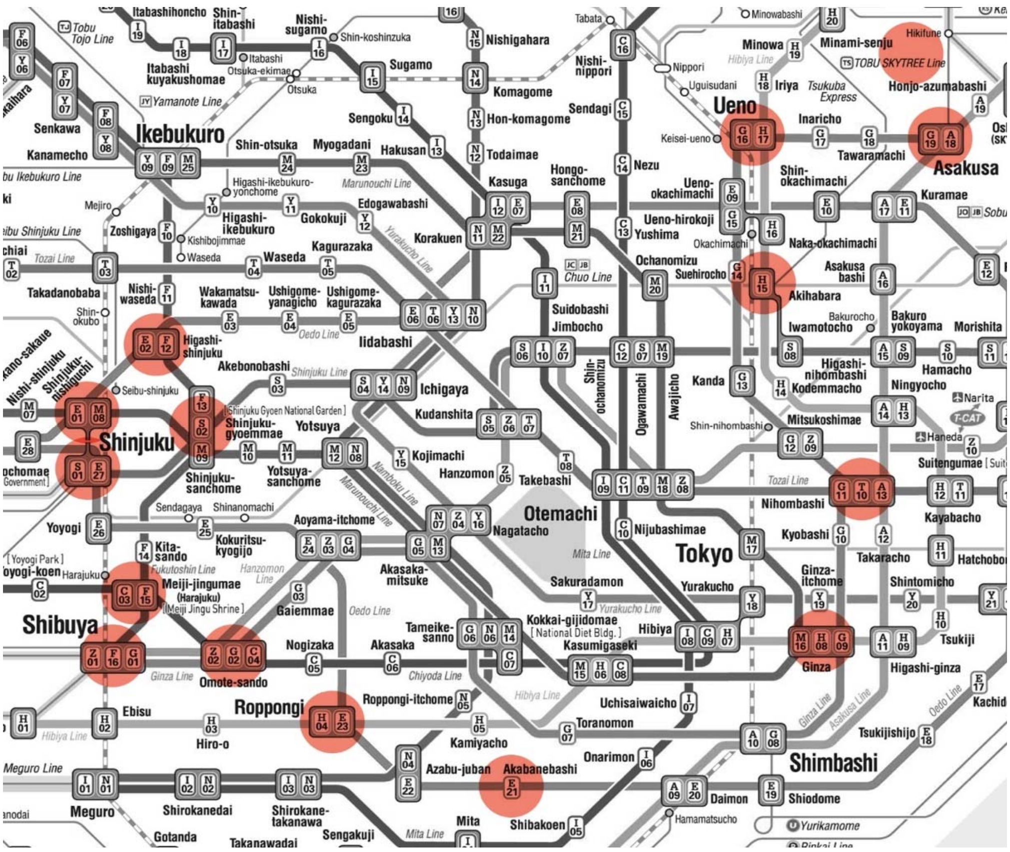

Fig. 2 Distribution of famous scenic spots in Tokyo

Fig. 3 Large inquiries present in metro stations

B. Advantages of Mobile Devices

Fortunately, mobile technologies might help to alleviate these problems encountered when tourists use metro. Nowadays, almost everyone has a smart phone. According to the survey, global smart phone ownership ratio could achieve 88%. Contribute to their advantages of being portable, people take smart phones with them almost anywhere at any time. With the proliferation and development of mobile devices, smart phones are equipped with more and more kinds of sensors such as Bluetooth, gyroscope, barometers and more, enriching the function of smart phones greatly. In this way, utilizing smart phone itself could satisfy people's need. And also, with the support of the hardware and the utilization of wireless networks, various kinds of applications are available. In recent years, applications have covered a wider range than ever before with a better market system, especially positioning technology and mobile payment which has made tremendous progress for the past few years.

C. Indoor Positioning Technology

The most typical way of obtaining location information is to use the GPS (Global Positioning System) service [8]. However, GPS's functions cannot be performed properly in internal spaces within buildings, underground, or tunnels, where most railway transit stations in cities are [9]. Meanwhile, these indoor spaces lack external references such as particular buildings or the sun. Then, we have to figure out the right exits or platforms to go by various kinds of signs. However, in many metro stations, signs are always confusing or sparse, especially foreign tourists who might have the language barrier.

Fortunately, in recent years, with the continuous appearance of new technology, the field of indoor positioning has obtained great progress. Thus, we can take advantage of indoor positioning technology to realize navigation in metro stations. In 2013, Jack Cox et al. in [10] proposed a new indoor location method via Wi-Fi and Apple Maps to position in Metro stations with a precision of 20 feet. Their technology also utilizing MapKit and Dijkstra's least cost routing algorithm to realize navigation in the station and find the shortest path. Kumareson, Danis and Cabarkapa come up with technologies using Bluetooth in smart phones or Bluetooth beacon to position indoors respectively (Fig. 4) [11]-[13]. In 2014, Stockx et al. in [14] proposed SubwayPS, based on accelerometer and gyroscope equipped in smartphones, to calculate the metro's position in the subway tunnels as well as the remaining time to a specific stop. In 2015, H. Xia et al. in [15] proposed a technology which could detect which floor one is located for indoor positioning by smart phones with built-in barometric sensors (Fig. 5). That provides a way to navigate between different floors. The development of indoors positioning and underground navigation technology makes navigating and positioning in the metro stations possible.

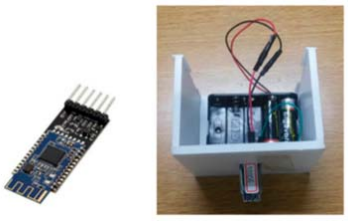

Fig. 4 Using Bluetooth module to locate indoors

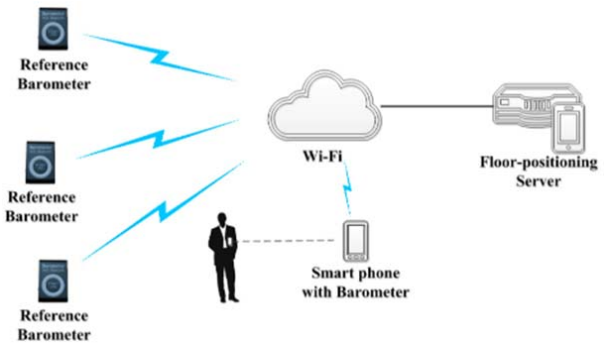

Fig. 5 Using barometers to detect which floor you are

D. Mobile Payment

Since the advent of electronic payment system in 1990, people's life style has changed a lot [16]. In the past few years, the emergence and popularity of mobile payment application such as Alipay and Apple Pay promises the upcoming cash-less era. Nowadays, thanks to the convenience of mobile pay, people are ready to leave their wallets at home and only use smartphones to perform all financial performances [17]. It is estimated that around 70 percent of American mobile phone users will make a mobile payment before the end of 2017. The change of people's payment challenges traditional ticketing system which uses cash payment.

Navigation and mobile payment have been utilized in transportation for several years. In the area of transport, mobile applications have solved various problems. Indoor positioning apps help people to navigate in metro stations. Mapping apps assist in people choosing metro lines and complete route planning. Mobile payment apps reduce the time of purchasing tickets, solving tourists' problem of having no changes with them as well. Table I lists several examples of mobile apps used in transportation.

According to the research in 2017, 686 million Chinese passengers often use mobile navigation applications such as Amap [18], which demonstrate the broad prospects for development of mobile apps in the domain of transportation.

TABLE I
EXAMPLES OF MOBILE APPS USED IN TRANSPORTATION

Type	Application	Time	Function
Indoor positioning application	Shibuya Pedestrian Navi App	2016	The Boxyz Corporation designed Shibuya Pedestrian Navi app for navigating in Shibuya Station, one of the most complex rail stations in Tokyo, by utilizing Bluetooth beacons.
Map application	Google Maps	2005	Map apps such as Google Maps and Amap could help us get transfer information as well as select correct rail lines and stations.
	Amap	2010	
Mobile payment application	Hangzhou Metro Application	2017	In China, several cities, such as Hangzhou and Shanghai, had implement new kind of ticket machines or turnstiles which support mobile payment.
	Shanghai Metro Application	2018	

The study focuses on the design of a mobile app for tourists at metro stations in Wuhan. Wuhan, the provincial capital of Hubei with huge population, is a major communication and transport hub in China. It has many famous scenic spots which attract tourists from all over the world. In 2017, Wuhan had attracted 257 million domestic tourists and 2.5 million foreign tourists. Fig. 6 shows the growth trends of the amount of tourists to Wuhan. The city also has a dependable metro system with seven metro lines and a huge passenger volume. In 2017, the average daily passenger volume of Wuhan's metro system had reached 2.7 million. The daily volume of passengers in 2017 reached the highest point at 3.31 million. Yet congestion frequently occurs in the city's metro stations, especially at the ticketing area. Limitation of amount of stuffs in the station and lacking of efficient diversion measures cause disorder in the stations. Besides, ambiguous information provided by signs in the station confuses tourists, making them hard to plan time.

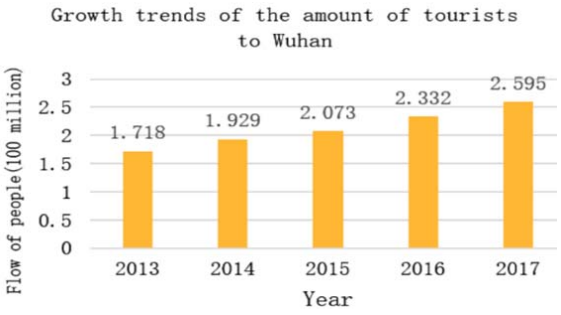

Fig. 6 Growth trends of the amount of tourists to Wuhan

The design of the mobile app was a convenient, economic way to help users to reduce those problems and improve tourists riding experience.

III. OBJECTIVE

The objective in this study is to help tourists to simplify the process of purchasing ticket, provide tourists a detailed time estimate as well as straightforward navigation, and assign collectible value to metro cards, making them convenient for collection. Four fundamental questions guide the study: How to shorten the time of purchasing tickets and reduce the incorrect operation rate? What kind of time information do tourists need? What kind of route information does tourists need and how to display them? How do tourists deal with their metro cards when they are going to leave the city?

The metro is one of the most popular mode of transportation, which could benefit tourists' trip around the city. However, most tourists chose purchasing one way tickets and often costed plenty of time at this step. Meanwhile, many tourists were hesitating and confusing while transferring or finding platforms, especially foreign tourists who might have language barriers.

The aim of the mobile app is to provide a convenient way for tourists to get metro ticket easily and quickly. It also needed to provide tourists detailed schedules, clear navigation and reasonable route planning. Besides, the app should offer tourists a new way to collect their metro tickets as a kind of souvenir.

IV. METHOD

This study included three phases: tourist observation, survey and user testing. The goal of *Phase 1* was to capture tourists' behavior and duration of each behavior during the process from entering the station to boarding the metro. The goal of *Phase 2* was to obtain tourists' thoughts and practical needs during the process, such as what kind of time information or navigation they need. Then the app was designed based on these results and tested with tourists in *Phase 3*.

A. Phase 1-Observation

In this phase tourists in metro stations were simply observed, without any conversation and interference. Since the target group are tourists, to ensure samples' effectiveness, the study observed tourists' behavior from one spot to another one during holiday, in stations near popular attractions, Central Business District (CBD) and the railway station where tourists gathered. Meanwhile, the CBD of the city is a transfer station, where tourists' behavior during transfer could be observed. After observation of one sample, he would be asked whether he is a tourist or not.

When tourists entered the station, the time was recorded. Activities before tourists entered the metro were timed and their movement in metro station were sketched on an exhibit map as shown in Fig 7.

The tourist observation in metro stations includes four parts: tourist information, activities they performed, time spent for each activity in this process and the motion trail in the metro station. Tourists' information record tourists' age group, gender, whether they come with group and the group umbers. This part gained data about how most tourists come to metro stations and which age group prefer taking the metro. Tourists' activities include things like: What kind of activities they have? Which route did they choose in stations? Did they encounter any barrier during each activity. How long did tourists spend on each activity? This part revealed the most time-costing activity

and the potential barriers during these activities. The movement map indicated how tourists move in the station.

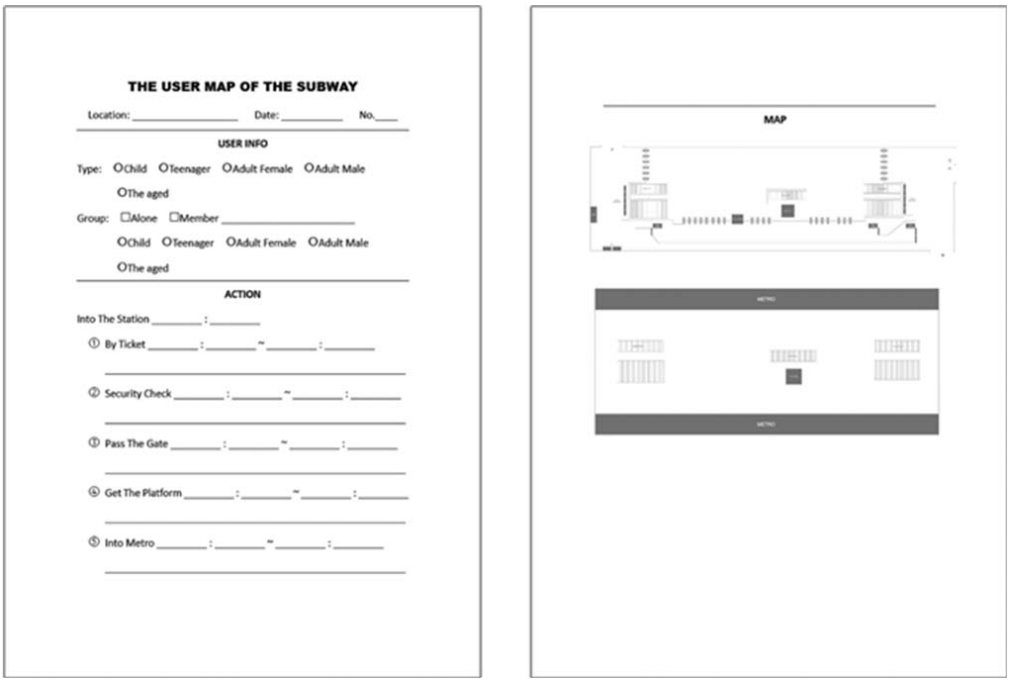

Fig. 7 The user map

B. Phase 2-Survey

This phase consisted of four surveys: Purchasing ticket (Survey 1), Route information (Survey 2), Time planning (Survey 3), Concept of memorizing (Survey 4). To ensure sample richness of the survey, respondents should belong to different groups, such as being alone, with a group, with children. As a result, the study interviewed 32 tourists who were divided equally into four groups to participate four surveys, respectively.

All the respondents were aged 16-50, with the gender ratio around 1:1.

Survey 1 asked 5 questions about purchasing tickets: which kind of tickets they usually buy; why they choose that kind of ticket; what are those inconveniences they encountered during purchasing tickets; what kind of methods to get tickets do they want; what kind of information do they want in the purchasing process. Survey 2 include 5 questions about obtaining route information such as: do they think information provided by signs is clear and enough; what information they want to know according to the signs; how they want to get that information; do they need guidance about choosing metro lines. Survey 3 focused on time planning. It contained of three questions: can they estimate the time cost accurately; do they want more detailed time to estimate and what kind of time information they want to know. The last art of the survey concerned about memorizing. It included two questions: how do they deal with their metro cards when they leave the city; do they want metro tickets or cards more memorable.

All the respondents would be asked the question that whether they would be willing to download an app if the app provide these functions after they finished other questions.

C. Phase 3-App Testing

In order to make sure whether the product's functions and appearance address the needs of real user, the phase of app testing is an essential part of the study. *Phase 3* focused on needs derived from the former 2 phases. 20 subjects participated in this phase. First put the core goal of saving time in the context of related work. Then, let participators use the app in metro station. After they finished the task, a survey of the appearance and functions about the app would be completed.

There were 12 questions in the survey in all. Questions about the app's appearance included questions about the interface, readability, looks and the design of metro card. The questions about the apps functionalities consisted about questions about whether the app included all of the necessary functions, if functions were easy to find and use, if language support was adequate, if all the information needed was provided and clear.

V. Results

A. Phase 1-Observation

Population

In *Phase 1*, 72 samples were observed during the National Day holidays and 3-day New Year's Day holiday, respectively. Among those samples, 54 of them are valid samples and the group with them had a total number of 134 people. Fig. 8 shows the age composition of the samples.

Fig. 9 shows that among 54 tourists, 96% of them are with groups. 74.17% of tourists took the metro were adults. In their groups with the samples, 5% of them are children, 5% are teenagers, and 45% are adult females, 35% adult males and 10% the aged people. Fig. 9 shows the groups.

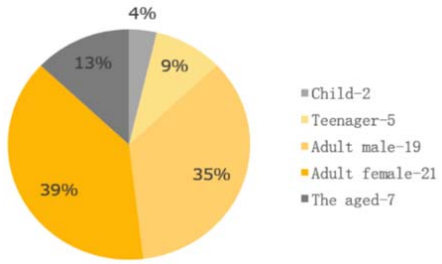

Fig. 8 Age composition of tourists

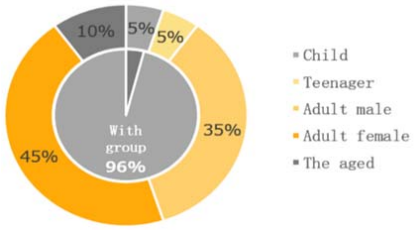

Fig. 9 Tourists' group composition

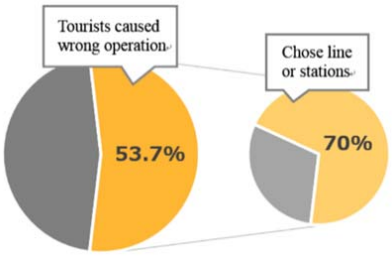

Fig. 10 Statistic of tourists who have problems while purchasing tickets

Tourists participated in four activities before they enter the metro: purchasing tickets, security check, passing the auto-gate and finding the platform. Among these four activities, purchasing tickets and finding way to correct platforms took the longest time. More than three quarters tourists chose to purchase one-way tickets instead of local traffic One-Card. Tourists who chose one-way tickets spent a lot of time waiting in line and operation on ticket vending machine. Hesitation occurred and errors when many tourists searching for the platform, which impact the riding experiences.

According to the result of the observation, the three main barriers identified were barriers to operate ticket vending machines, fumble for change and understanding signs in the station.

Operate Vending Machines

Fig. 10 shows that more than 53.7% of them caused wrong operation while purchasing tickets. Of the 53.7%, 70% caused wrong operation when they chose lines or stations. 40.7% tourists cost more than 1 minute and a half. 13% tourists panicked at the wrong operation.

Fumble for Change

Around 33.3% tourists found they didn't have changes in certain denominations. 13% tourists' bills had been returned several times. 9.2% did not know where to change money. More than 7.4% had been rummaging through their baggage for a long time to find money.

Understand Signs in the Station

38.9% tourists got to the wrong place while searching for the plat form and waiting for the opposite metro. 31.5% hesitated when they chose certain exit of the station and sought help from others.

B. Phase 2-Survey

During the National Day holidays and 3-day New Year's Day holiday, 32 tourists were interviewed at Wuhan high-speed rail station, Optics Valley Square (the CBD of Wuhan) and Jianghan Road (a famous tourist attraction). The group of tourists who prefer to take the metro mainly range from 18-29, accounting for 53% of the total.

Purchasing Ticket

When it came to the payment, 75% participators chose one-way ticket while 25% chose local One-Card. Tourists chose one-way ticket for the various kinds of reasons such as short residence time or the difficulty to refund the rest. 37.5% said they didn't have changes in certain denominations with them. 25% claimed that they had a hard time operating ticket vending machine. 12.5% thought the recognition rate of the machine is too low.

Route Information

37.5% tourists preferred to obtain information via signs and maps in station (Fig. 11). 50% tourists thought information offered by signs is not clear enough. 37.5% of participators have had a hard time finding the correct platform and 50% were confused during the process they transferred. Around 62.5% tourists said that they often got the wrong place when seeking for certain entrances of metro stations. 75% tourists wanted clearer transfer instruction. Of this 75%, 87.5% wanted to have the instruction on mobile devices.

Time Planning

25% tourists thought they had a hard time planning their time since the congestion in some stations. 62.5% said that they need more detailed schedule. 25% tourists wanted to know the time cost from entering the station to getting on the metro. 37% wanted to know how long it would take on the metro from the station to the destination. 62.5% tourists wanted to be reminded at the destination.

Concept of Memorizing

Among the participators, 12.5% decided to collect the metro card as a kind of souvenir, 12.5% said he/she would return the card to get refund, 25% tourists said they might discard it

somewhere since they do not like the design of the city's One-way card. 87.5% of them said if the ticket or card was well designed, they would like to collect that as souvenir.

The last question in the surveys asked whether they would be willing to download and use an app. Fig. 12 shows the result of the question which suggested whether the app was regarded as useful. All of them would download it for purchasing tickets in a convenient way. 50% participators would download it for getting more detailed estimated time in station. 59.37% would download it for the feature of route planning and AR navigation. Around 46.9% participators would download it for collecting electronic metro tickets as souvenir.

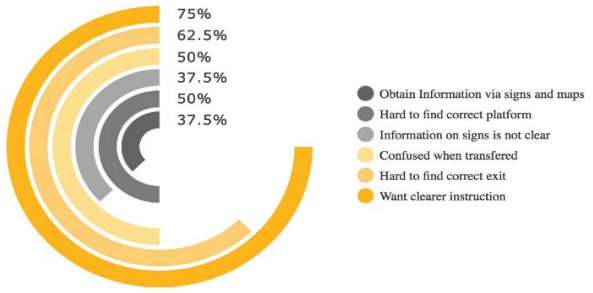

Fig. 11 The number of participants (n) who will download the App

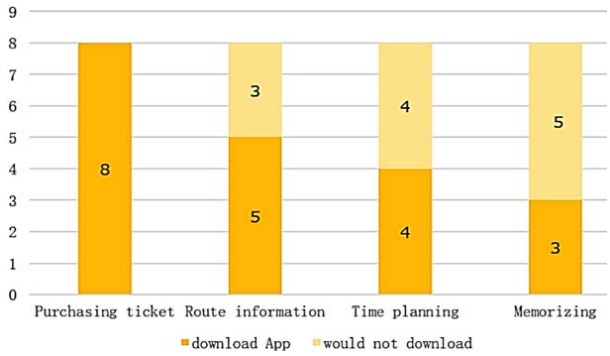

Fig. 12 The number of participants (n) who will download the App

C. Phase 3-App Testing

Application was designed based on initial phases. Fig. 13 shows a mockup sketch of the app. 20 participators tested the application and provided a feedback by participating a survey which includes two types of questions.

The first type of questions of the survey asked about the App's appearance. Among 20 participators, 17 of them like the main color of yellow, three participators preferred a blue background. For the font size, 15 participators thought information is easy to read, while five thought the font size of the route information page was small. When it came to the size of icons, 19 participators thought the size of icons is nice, only 1 thought icons at the top of the AR navigation page is not obvious enough.

The second type of questions asked about the App's functions. When asked about the payment, all participators wanted the function of using the QR code entering gate and all participators thought that the function of refunding at any time is essential. 14 of them thought they prefer utilizing a third-party payment option than saving money in the account of the application. Eight participators regarded the function of time estimate as useful and 13 want the AR navigation in the station. 19 of them liked the metro cards and the share capability. 18 thoughts functions are easy to find and use, 13 participators thought it is necessary to have multiple language support.

VI. Discussion

Phase 2 collected data about barriers emerged in process from entering the station to boarding the metro.

If tourists need transfer in on trip, while they are purchasing tickets, they need select the metro line where the destination station is on the ticket vending machine directly. Yet the homepage of the machine is the metro map of the line where the departure station is, which confused tourists who rarely took metro. In this case, many tourists selected the transfer station instead of the destination stop. The user graphical interfaces of ticket machines are confusing with little guidance. Many tourists, especially those aged over 45, showed obvious hesitation while operating the machine and panicked when wrong operation occurred. However, there are few stuffs in stations to offer guidance. And once passengers in front of the line had difficulty purchasing tickets, the queue lengthened, extending the waiting time.

Most ticket vending machines only support cash payment with restricted kinds of denominations. Many tourists found that they did not have changes in certain denominations. Some users' bill had been returned several times due to the low recognition efficiency. In these cases, tourists had to change money at artificial bar in stations and queued again.

In many metro stations, the density of signs is either too small or too intensive, which often confuses tourists especially foreign tourists whose language barrier could become the biggest obstacle. Information contained in maps in metro stations is limited. Some tourists have hard time understanding these maps and often get out from wrong exits.

Based on the results from analyses, the app should provide information about: the metro card (in the form of QR code), AR navigation in the station, information of the metro lines of the trip, correct direction of the metro, the total estimated time, the estimated time of each stage, the cost of the trip. The app should have the capability of fuzzy computation, offering tourists the nearest metro station and a certain entrance to the departure point and the destination. It should remind tourists when arrives the destination and tell them which door would open. Besides, the app should also have the function of collecting metro tickets as souvenirs and share online. Fig. 14 shows the mind map of the app.

When users open this app, firstly they can login or register, then enter the Homepage. Homepage has three options: enter the Guide, open the Metro Ticket to use the QR code entering gate, and open the Drawer. After entering the Guide, users can enter the starting point and destination to see the cost of the trip, the estimated time of the whole journey, the estimated time of each stage, the metro route information, the transfer

information, and the station information of the departure and destination stations. Click on the button Go on the screen to enter the AR navigation in the station. In the Homepage and the process of in-station navigation, user can click the Metro Card at the bottom of the screen to enter the Mero Ticket page, which contains the QR code of the bus entry and exit.

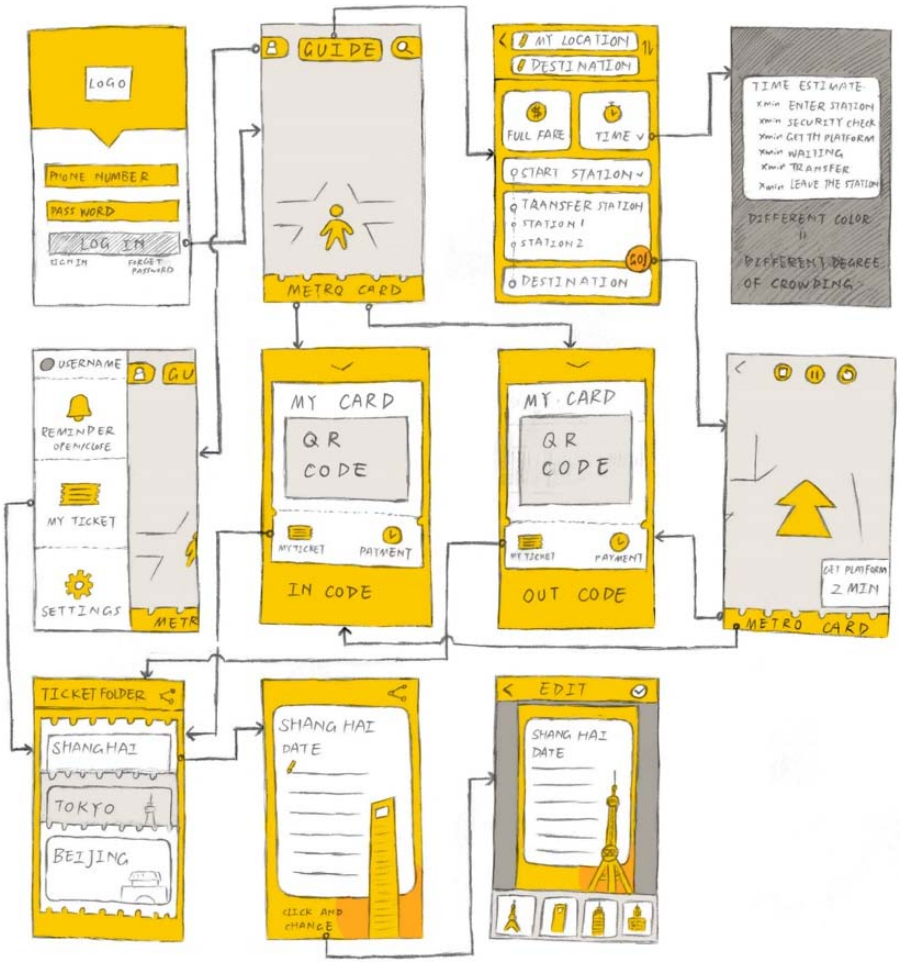

Fig. 13 Mockup app sketch

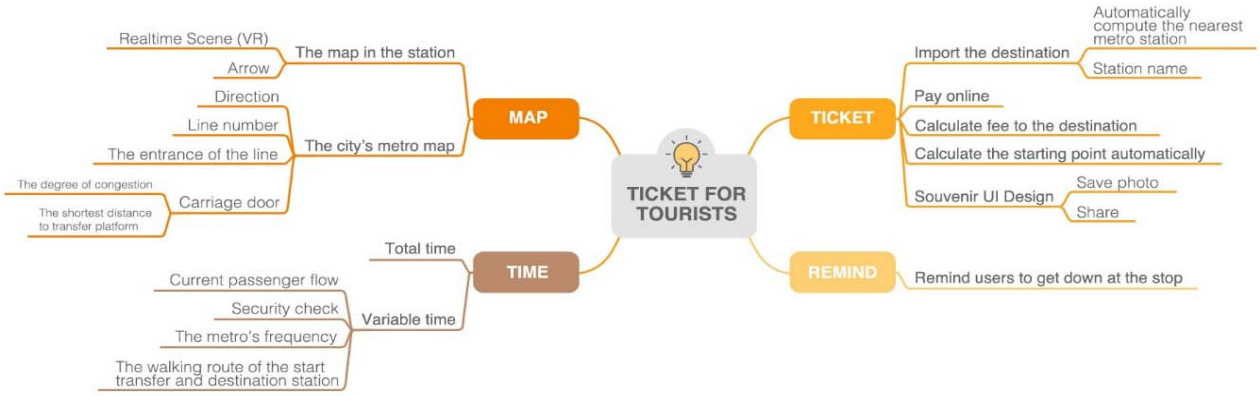

Fig. 14 Mind map (the app's four functions)

Let the QR code close to the scanning position of the gate, and users can enter the station after the code is identified. Below the QR code, there is a ticket folder and history icon. Click the history icon to view the history itinerary. Click the icon of ticket folder to browse every commemorative ticket of cities and it allows sharing. In the Drawer section, the users can

turn on or off the Reminder of debus, set the language of the app in Setting, and enter the ticket folder. Fig. 15 shows the function flow of this application.

The logo design based on the special functions of the app, including convenient payment, location feature and special AR guidance. It combines those functions directly and show them clearly. The mobile app employs a yellow background to give users cheerful mood. Icons are clean designed to be line illustration and big size, has a clear, straightforward feel to it. Meanwhile, the application is equipped with nine kinds of languages. Figs. 16 and 17 show the logo design, color board, icon design and UI design of the app.

VII. Conclusion

This study establishes an application to improve the tourists' experience of utilizing the metro and aims to optimize the process of passengers taking metros in new cities. This study collects and discovers the problems encountered by tourists when they take the metro through two different ways: user observation and survey. Based on the research, the prototype of the App is preliminarily designed. After that, the app is tested by user test to find the problems in the actual application and the parts that can be improved. Based on the shortcomings of the current metro, the App of this study proposes a solution to help tourists solve the riding problem, which helps to reduce the learning cost of taking the metro in nonlocal places, improve the passenger experience, slow down their anxiety, help visitors plan their travel time better, commemorate and collect. But, this research is only the first step. In the future, we will continue to conduct in-depth research on how to improve the entire process while taking the metro and provide more comprehensive assistance to tourists. Even though the results obtained so far are only preliminary findings, there is potential for success in the future. The questions and data collected by the study can be referenced by other research institutes in this field. The idea of improving the metro ride experience can be borrowed by other cities' metro stations and other types of transportation stations, which hopes to promote the popularity of public transportation.

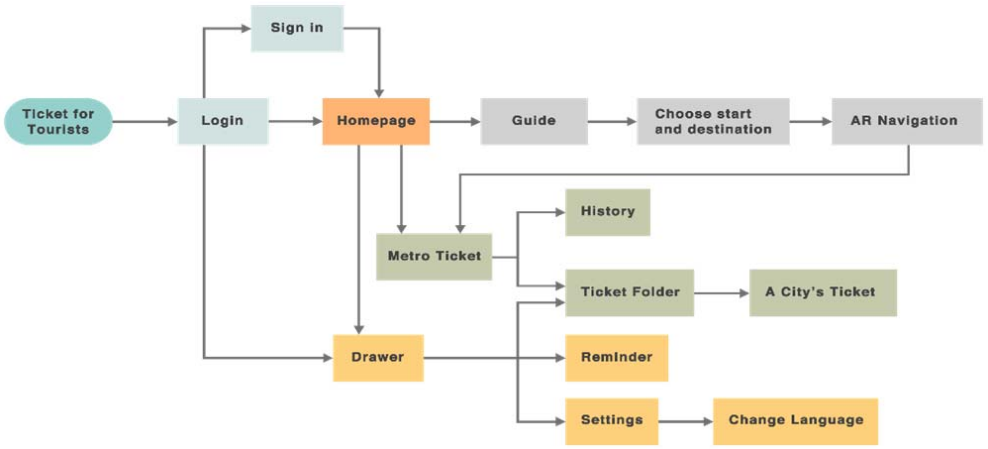

Fig. 15 Function flow

Fig. 16 Icon design, color board and logo design

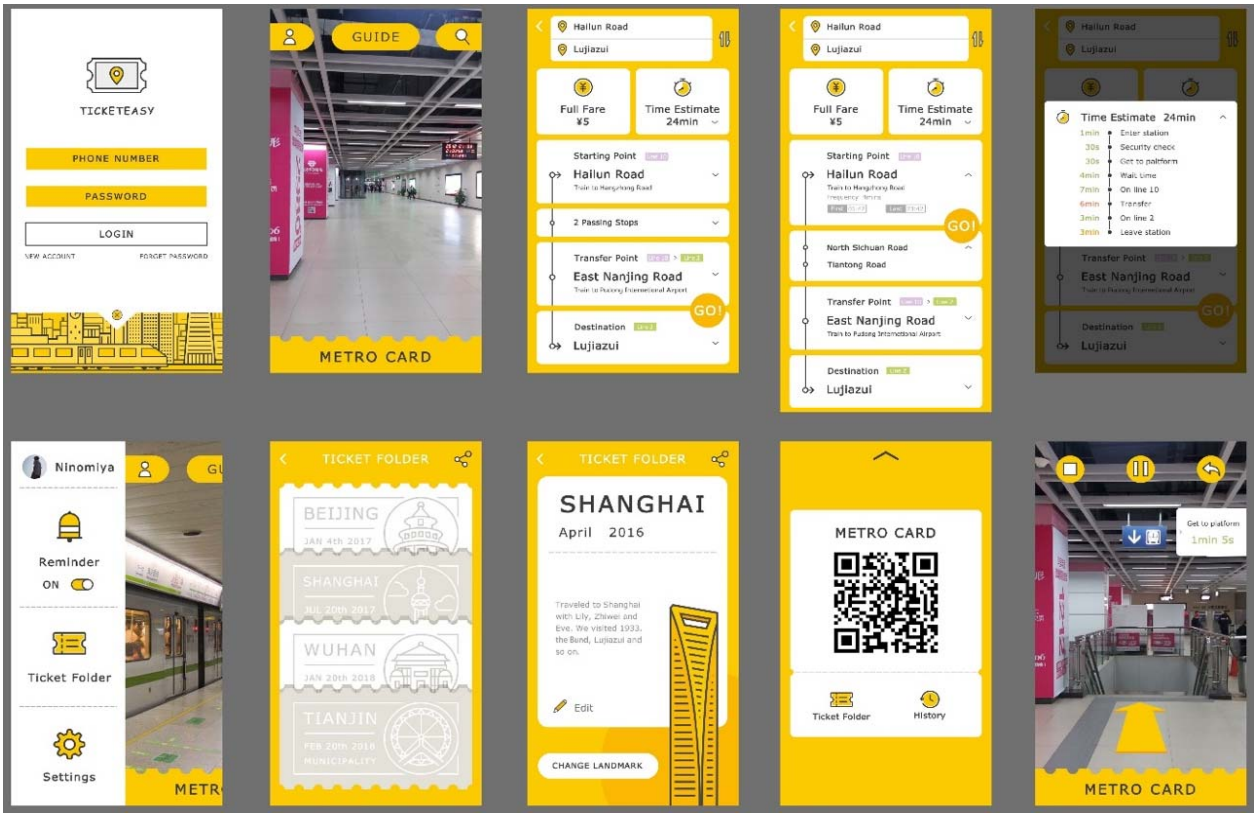

Fig. 17 UI design

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