視障者語音售票系統之研究

A Study of Ticket Seller System for the Visually Disabled People

陳昱丞
Yu-Cheng Chen

環球技術學院商品設計系

摘　要

眼睛為靈魂之窗，盲人沒有視覺的資訊來源，因此其行動能力遠不如明眼人。而根據調查，台灣視覺障礙者中約有 39.2%的人極度希望重新回歸到社會，而行動能力的不足正是造成視覺障礙者無法獨立生活的重要因素。有鑑於此，如何提供視覺障礙者一套理想的交通工具售票系統，將是協助盲人得以儘快投入社會行列的重要課題之一。

根據通用設計的原則，本研究以視障者的感覺特性為基礎，開發出一套火車電腦語音自動售票系統，主要是利用視障者的聽覺與口語能力來與售票系統進行互動，而電腦語音辨識技術的日益純熟，也是本系統得以開發的重要因素。

正因為視障者的感覺特性，對於利用語音辨識來做為電腦設備的輸入單元可說是最便利的輸入方式，因此本研究便以開發出更人性化的語音操控人機介面為主要工作，希望提供視障者一個、簡單便利又準確的火車語音自動售票系統，協助其得以獨立自主的行動，更進而使其早日回到社會的行列！

關鍵詞：視覺障礙、電腦語音辨識、人機介面

Abstract

The eye is the window of the soul. Without the input of visual information, the mobility for those with visual disability is much limited compared with people with healthy eyes. Surveys have revealed the visually disabled people in Taiwan desperately wish to return to the society and that the lack of mobility is one the major causes leading to their inability to live an independent life. Therefore, the provision of an ideal ticketing system for public transportation catered to the needs of the visually disabled has become one of the most important issues surrounding the discussion about how to help the blind to start participating in the various societal activities as early as possible.

According to the principle of the Universal Design. This study has developed a train ticketing system applying computer interactive voice response technology according to the sense characteristics of the visually disabled.

The main idea is to allow the blind to interact with the ticketing system through hearing sense and verbal ability. The increasingly sophisticated computer speech recognition technology also played a pivotal role in the development of the system.

Using speech recognition as the input unit of the computer equipment is probably one of the easiest and most convenient methods for the blind. Hence, this study set out to develop a more user-friendly voice-controlled man-machine interface, with an aim to provide a simple, convenient, and accurate automatic train ticketing system for the visually disabled, making it possible for the blind to move more freely and independently, thereby facilitating their needs to return to the society as early as possible.

Keywords: Visual Disability, Computer Voice Recognition, Man-Machine Interface

1. Introduction

As countries around the world are actively making legislations to protect the rights to living, personality, work, and education of the disabled, Taiwan is gradually feeling this heat of social welfare and has come to realize the importance of providing an obstacle-free environment for the disabled. Ordinary people have a typical impression about the disabled being inferior to normal people in all aspects, and thus tend to either discriminate against or patronize those with a disability. In fact, despite the disability, there is not much difference between the disabled and those considered normal. Contrary to the conventional impression, when specially trained, the disabled may even perform better than the ordinary people. However, to enable the disabled to learn and grow like normal people, it requires an obstacle-free living environment so that the disabled will not be prevented from going out for education.

According to the World Health Organization's estimation: the number of blind people will reach at least 70 million by the year 2020(WHO Press,1997).If government institutions can care more about the visually disabled and give extra consideration to the use characteristics of those with a visual disability in the planning of public construction projects and provide the disabled a living environment free of obstacle, the visually challenged will be able to lead a life as independent and autonomous as that enjoyed by ordinary people.

Thanks to modern technologies, various electronic guiding devices have been developed and made available for the blind including, among others, audible road signs, electronic guide dogs, and supersonic walking sticks, which provide more effective mobility guide for the blind. Nevertheless, many seemingly easy tasks for the ordinary such as ticket purchasing at the train station can still present an enormous problem to the blind. Not to mention the various ticketing information signboards provided at the train station, which are completely useless to the blind.

In light of this, this study aims to investigate the man-machine interface between the blind and the automated computer voice ticketing system. In the human society, man, equipment, and environment together form an interactive system, in which the humanity should be in the center and in control of the system. This principle should also apply to the visually disabled. In other words, all product design should first and foremost analyze user characteristics and needs in order to make sure that it complies with the basic principles of humanization design. The so-called “user” refers either to HO (human operator) or HU (human user). This study intends to unveil the black-box operations in human perception during ticket purchasing of the blind in order to develop a computer voice ticket selling system tailored to the specific operation characteristics of those with a visual disability. The American human-factor scholar John H. Burgess (1989) developed a flowchart of HO operation behavior as illustrated in Figure 1, in which the black-box operations are divided into four sub-systems in order to help explain the intermediate process between information input and response output.

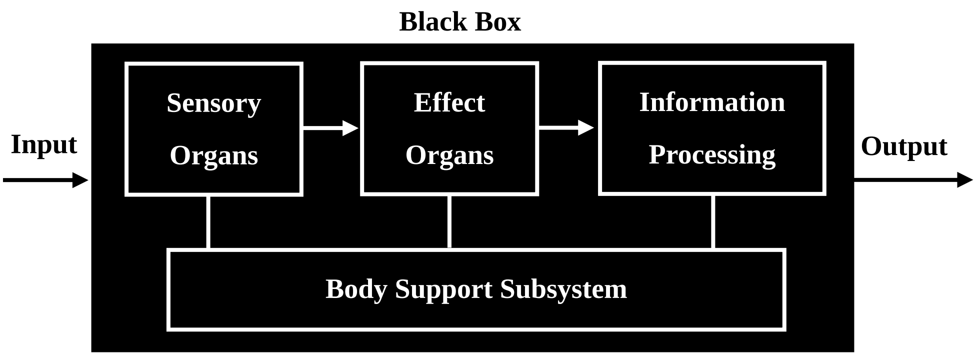

Figure 1. The flow chart of human operating behavior

In terms of the sensory characteristics, the visually disabled cannot use visual ability to analyze or make decisions about the various processes involved in the ticket purchasing activity. Therefore, they have to utilize their remaining sensory abilities (hearing, touching, and speaking) to resolve various related problems. Currently, research on HCI (human-computer interfaces) mainly deals with traditional input interfaces such as mouse and keyboard, and rarely touches upon voice recognition operation and control interfaces. However, since these voice recognition operation and control interfaces allow “free hands for jobs and flexibility”, they are in effect a more convenient mode of operation than Braille input. Jenny Preece (1998) pointed out the following advantages of voice input: 1. Voice input is a natural communication tool, hence the training is easy. 2. Voice input requires no hand control, hence leaving the hands free for other operations. 3. Voice input provides the visually or physically disabled persons an opportunity to use modern technology. However, voice input also has its own disadvantages: 1. It is difficult to distinguish the difference between words that have the same pronunciation but different meanings. 2. Speech recognition accuracy is susceptible to background noises. 3. Computers have problem comprehending the true meaning of the language in its natural form. Currently, these problems have to some extent limited the development of voice recognition applications.

In order to help make contributions to the improvement of life of the blind, the study has developed an automated computer voice ticketing system, which is expected to effectively resolve inconveniences in train ticket purchasing for the blind, and through reasonable and efficient interface design, it is hoped that the blind too can go about their life as independently and autonomously as normal people.

2. Speech recognition in barrier-free design

The main purpose of voice recognition is to make computers understand human speeches and further command computers to execute corresponding tasks. When a voice is input to computer via an input device, the voice recognition program will start to match the input voice with pre-saved voice samples. After the matching process is completed, the number of the voice sample most “similar” to the input voice will be selected, and the computer will be able to know what the voice pronounced by the user means and issues corresponding commands. The voice recognition procedure is illustrated in Figure 2. As visually-disabled people lack the visual senses and can only use other senses to communicate and interact with the outside world. For instance, they can use Braille to recognize the functions of the command units and the hearing to judge the variation of sounds or voice time announcement to know the present time. These are examples of the visually disabled using senses other than visual senses to communicate with the outside world. Besides, they can also use natural languages to orally communicate with mechanical equipment to reduce the inconvenience caused by their visual disabilities and obstacles in their lives

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Figure 2. The flow chart of voice recognition

With the development of voice recognition technologies, the interactions between human and computer facilities are not subject to the use of keyboard or mouse. Interactions with voice input also allow people to communicate with computer facilities in natural languages. Without visual attention, users can use traditional input devices to interact with computers and easily control various kinds of facilities or acquire related information. Especially in Asia, among numerous user interfaces, voice input is mostly paid attention to (Ameersing Luximon et al., 2001). This new technology will help the visually disabled return to the life as normal people in the most convenient and safest way. Even without any aid to visual abilities, they can still easily operate all kinds of life-essential devices, such as ticketing machine, registration at hospital, purchasing products, and dialing on cell phones. The voice recognition and synthesis technology not only benefits blind users but also provides a man-machine interaction model for the physically impaired, visually-weak elderly, and children. Users can easily communicate with mechanical facilities via oral conversations. “They can do most of the things with only their mouths,” and there is no obstruction in the communications between human and machines. In the future, with the mature voice recognition and synthesis technology, the convenience and safety for the visually disabled can be significantly improved.

3. Design Methodology

The voice ticketing system is designed according to the specific physiological and psychological characteristics of the blind. In interface design, the system stresses simplicity and humanization and avoids operations that require visual judgment and decision-making. After comparing various existing computer command input methods, the researcher considers voice input as the most appropriate interface. Through the design of a computer voice controller, the system allows ticket purchasing through the natural way of talking and without any pushbutton operations, so as to provide the most convenient ticket purchasing services for the visually challenged. Wei Zhang et al (1999) found in their survey that the overall satisfaction of the respondents was higher with voice data input than with traditional keyboard entry, however the former also required a longer time than the latter to complete the task. According to the same study, over 80% of the users were satisfied about the interactive effects of voice systems and considered voice recognition convenient as opposed to the interactive functions achieved by pushbuttons.

As of the present day, research and development on voice recognition technology has yet to achieve maturity. Many academic and industrial institutions in Taiwan are actively engaging in the research and development of relevant technologies. Take the research results of the Institute of Telecommunications as an example, the accuracy rate of non-specific speaker continuous voice number input verification has reached 95%. Regarding speech synthesis technologies, since the system of this study produces only speeches made up of a fixed group of vocabulary, it adopts "digital speech synthesis technology”. The basic principle for such systems is to first record human speeches including sentences, phrases, and words and then store and string the voice data together.

(1) Basic Framework

Current computer speech recognition technologies can be divided into three categories of “specific speaker”, “adapted speaker”, and “non-specific speaker” technologies. The system in this study plans to adopt the non-specific speaker technology because a train station ticket selling system is provided mainly for visually disabled users of different genders, age groups, and accents. Since the users have different characteristics, the system adopts the non-specific speaker system in order to perform its functions without having to go through a learning process for speech recognition. In addition, considering that this ticketing system provides ticketing services for stations of which the names are mostly already known, for reduced recognition complexity, the system simply adopts the small-vocabulary recognition technology. Based on the discussion of relevant speech recognition technologies, this study has developed the basic framework for speech recognition of the computer voice ticket selling system. Figure 3 illustrates the operation flow of the voice recognition system of this study.

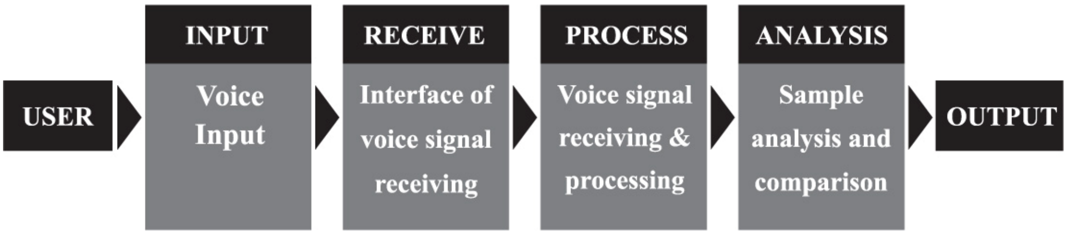

Figure 3. The Basic Framework of Speech Recognition

(2) Interface and Interactions

Under the development of ergonomic technology, the man-machine interface has been considerably improved. The ergonomic specialist design a user/tool/task model to solve the problem of completing a task with a tool, focusing on the manipulation interface between the user and the tool, and then on the engagement interface between the tool and the task. (Rungtai Lin & John G. Kreifeldt, 2001) By using natural conversations, this ticketing system is expected to make the interface between blind people and ticketing systems more compliant to the design principle of the man-machine interface, so as to reduce blind traveler's difficulty in purchasing tickets and further encourage them to get more involved in the outside world. In this system, blind people do not need to manually operate on any function keys and only need to converse with the ticketing system in a colloquial way. It is expected to achieve two-way communications between human and machine with the voice recognition technology.

Despite the fact that most of the current ticketing systems at public transportation stations have been computerized, the provided operational interfaces are not ideal. Thus, even for normal people, it still takes a lot of time to visually recognize the interface and purchase tickets, and operational mistakes may frequently occur (as shown in Figure 4). Let alone the visually disabled people who need to operate the ticketing machine with their sense of touch. As a result, this study expects to use natural conversations and mature voice recognition and synthesis technology to help the visually disabled interact with ticketing machines on a simplified operational interface. Besides, a stereotypical model of voice communication is designed based on the ticketing procedure as a reference for the future development of similar systems.

Figure 4. The Ticketing System in Japan

However, the voice ticketing system is still not enough to create a good barrier-free facility. This study also includes the factor of the interface between the blind and guide bricks. The interface between human and guide bricks at the entrance of stations, the interface between human and ticketing machines, and the interface at the waiting area are issued comprehensively considered in this study. The relationship of interfaces between human and facilities is shown in Figure 5. This study places the emphasis on how to improve interfaces, make them more human-centered, and also protect the right to mobility for the blind.

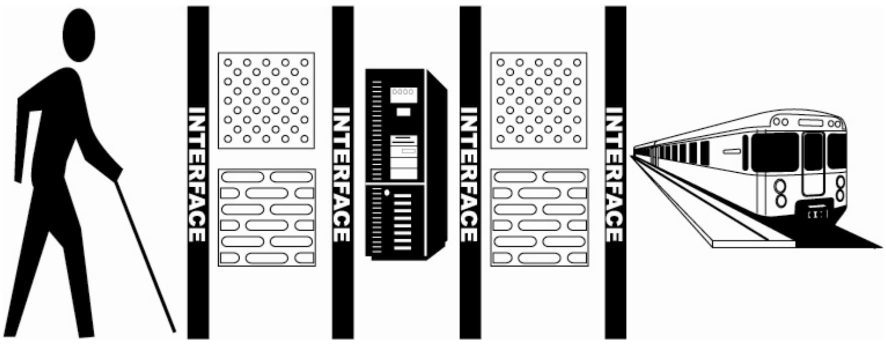

Figure 5. Interfaces between the Blind User and the Objects

4. Implementation

Judging from the above data and analysis, verbal communication systems can indeed be of assistance for the blind with many household appliance operations. Voice-aided devices have been applied in “talking” computers several years ago. Other similar voice function products include audible road signs, voice watches, and talking microwave ovens. However, most of the existing products with a voice function provide only one-way voice prompts. No sophisticated talking system based upon speech recognition technology is available for the blind as yet. Therefore, when operating these types of voice-function products, the blind still need to rely on their Braille reading skills or other sensory abilities for recognition. However, not every visually disabled person is equipped with Braille reading ability, particularly those who are not born blind. Besides, even with Braille training the learning result is not always evident because of the differences in sensory abilities and habits between those who are naturally blind and those who are not. Therefore, the development of a product that replaces the conventional pushbutton operations and Braille touching with verbal communication will a help make a major improvement to the interfaces between the blind and the product.

In order to verify the feasibility and adequacy of this system for future implementation, the experimenter has, after the completion of the preliminary architecture of the ticketing system, utilized the Macromedia Director software to produce a set of simulated digital files (see Figure 6) to conduct a simulation test on the eight fully-blind massagists at You-ming Massage Center in Tainan and then revised the system based on the data obtained from the simulation test, and finally completed the development of a typical man-machine verbal communication model (see Figure 7) that meets the perception characteristics and operability requirements of the blind. The basic information of the respondents participating in the simulation test is as follows:

a. Average age: 46.

b. Gender distribution: 5 males; 3 females.

c. Education background: Most of the respondents only has elementary school education (3 persons), followed by junior high school education (3 persons), vocational high school education (1 person), and two-year junior college education (1 person).

Figure 6. Ticket Seller Simulated System

(1) Case simulation

Picture a situation where a blind person who plans to travel from Taichung to Taipei by train walks into the Taichung train station and towards the voice ticket seller with the help of the guide bricks. As he reaches within

70cm of the ticket selling machine and stays within the sensory zone for three seconds, the infrared sensors will immediately wake up the auto voice ticket selling system which has until then stood dormant. (After ten seconds of completion of ticket purchase or when the user has left the sensory zone of the equipment for more than ten seconds during operation, the system will automatically enter into a dormant or standby mode.) Below is a typical conversation between the blind user and the voice ticketing system:

Seller System: Hello! Welcome! This is Taiwan Train Station computer voice ticket selling service. Chinese or English, (Beep…)

User: English.

Seller System: Please tell me your destination. (Beep…)

User: Taipei.

Seller System: Destination-Taipei. Answer yes or no. (Beep…)

User: Yes.

Seller System: Do you wish to take the train nearest to the current time? Answer yes or no. (Beep…)

User: Yes.

Seller System: How many tickets do you purchase? (Beep…)

User: one.

Seller System: The nearest train leaves at 9:40. It is a Chu-kuang mountain line train to Sungshan. The ticket is five hundred seventy-one NT dollars in total. The train will be arriving in Taipei at 15:04. Do you wish to take this train? Answer yes or no. (Beep…)

User: Yes.

Seller System: Insert your IC card, Insert your IC card, Insert your IC card……. (Keep on produce the sound to instruct the user inserting the IC card.)

User: (The user inserts the IC card for ticket purchasing; the computer processes the purchase.)

Seller System: Please retrieve you IC card and collect the ticket. Please turn left and follow the guide bricks through the underground passageway to the second platform for the train. Thank you for traveling with us and we wish you a pleasant journey. (The insert slot ejects the IC card and the ticket and makes a beep sound. If the IC card or the ticket is not completed pulled out, the beep sound will continue until both are completed removed from the slot.)

(2) Space and Route Planning

To satisfy related specifications of a barrier-free environment, in addition to building a voice communication model for man and machine, this study also pays attention to the route convenient for the blind to purchase tickets and embark on vehicles. Thus, according to the international standards for blind guiding facilities, a proper blind guiding route is designed to effectively guide blind people to enter the station → purchase tickets → enter the platform → wait for the vehicle and embark on the vehicle safely and quickly without any guidance of other people.

Guide bricks can be divided into two main types. As shown in Figure 8, they respectively have the alert function and the inductive function. The alert-type guide bricks will prompt blind people that they are approaching the destination, while the inductive-type will guide them to select a proper route. In a public space, blind people need to rely on their soles and walking sticks to feel the rising shape of a guide brick and judge if it is a route or the destination. Thus, a good blind guiding facility will correctly guide the blind's actions and avoid inconvenience or dangers caused by their unfamiliarity with the road conditions.

This study will simulate the situation in which blind passengers purchase tickets and take a train in Taichung Train Station as an example. Based on the features of blind people's senses (Lai & Chen, 2006) and field observation and simulation, an optimal route for blind passengers to purchase tickets and take a train is planned (as shown in Figure 9). With the aid of the computer voice ticketing system, it is expected that blind passengers can still purchase tickets and take a train without the assistance of other people, so that the goal of creating a barrier-free environment can be achieved. This study plans to set up guide bricks starting from the entrance of the station and guide blind passengers to the ticketing system. After they retrieve the tickets, they will be guided to the waiting area. And the guide bricks are arranged according to the alert and inductive functions so as to help blind passengers enter the station, purchase tickets, and embark on the train successfully.

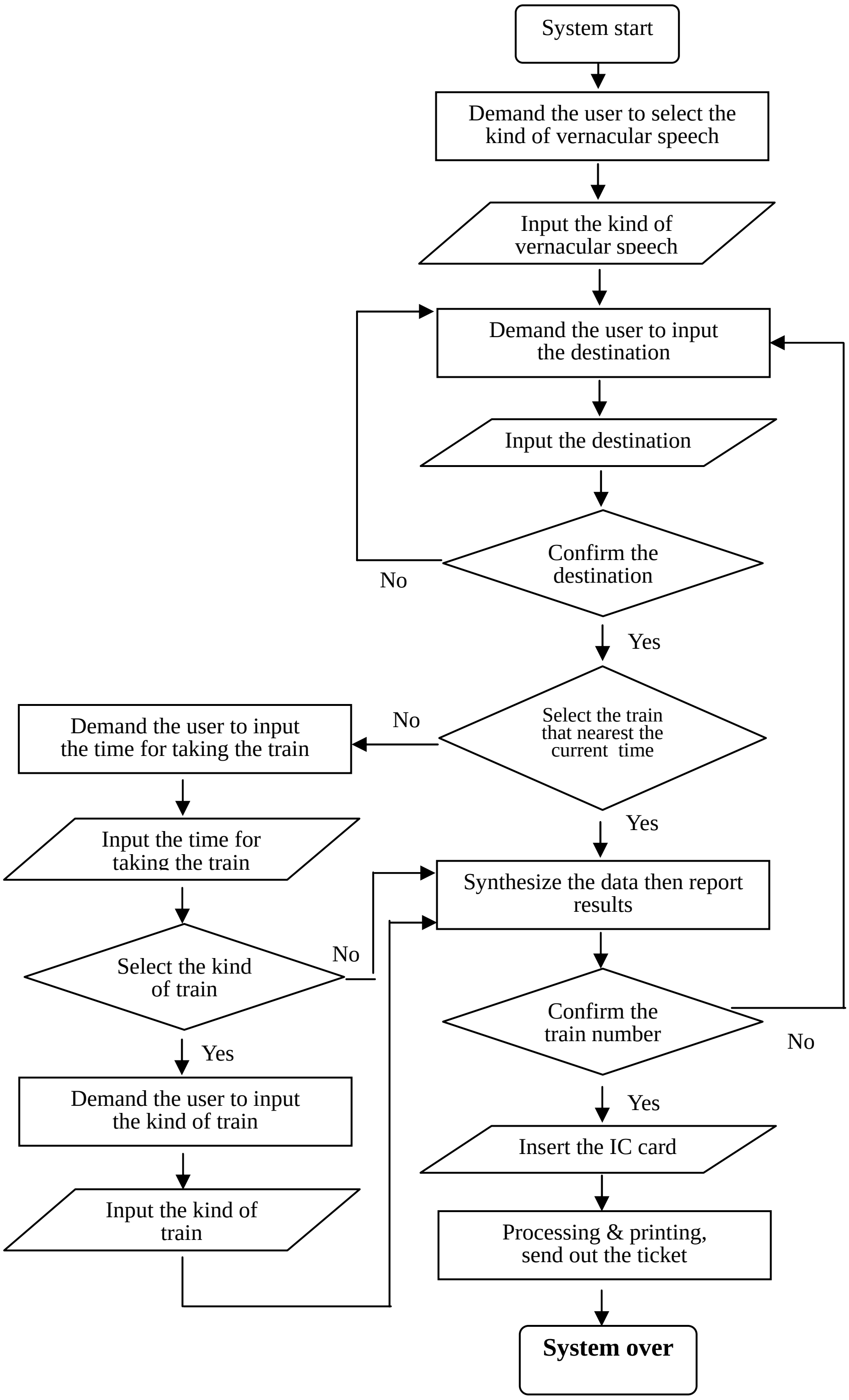

Figure 7. Typical Model for Man-machine Verbal Communication

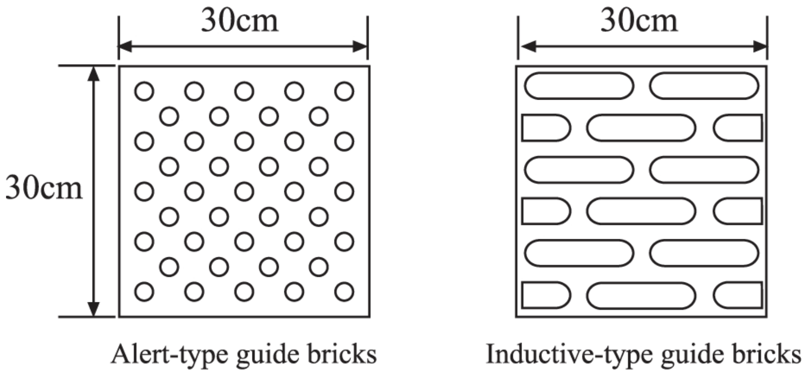

Figure 8. Two Types of the Guide Bricks

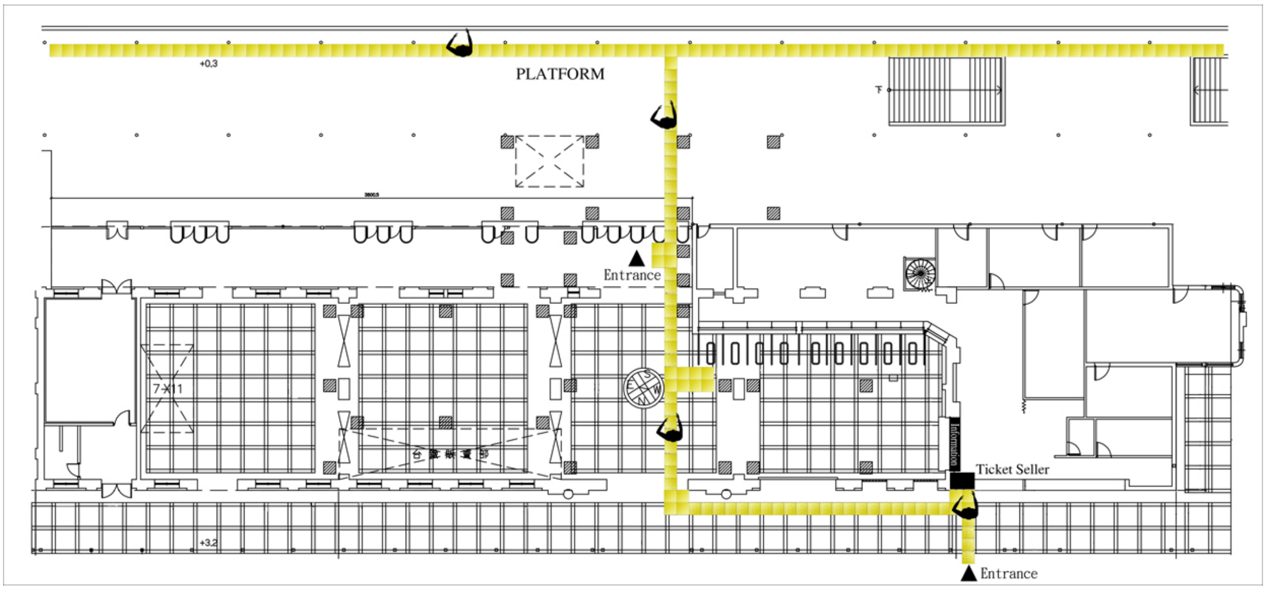

Figure 9. The Route of the Blind Passenger Purchasing Ticket and Take a Train

5. Conclusions

80% of human's information comes from visual senses, so blind people can only rely on the hearing and touching senses to acquire information from the outside world. The proposed computer voice ticketing system compliant with the sense properties of blind people is able to let them "be transported" with more independence and dignity. They don't need others' assistance at all times, so that they can get more involved in the society with more confidence and contribute themselves. Besides, a proper blind-guiding route is incorporated in this study. As a result, the blind guiding plans are reciprocal to one another, and a barrier-free environment can really be created.

With the objective to provide the most convenient and safe ticketing system for the blind, this study has concluded the following for future reference with the design of similar computer voice ticket auto-selling systems:

(1) This system provides 24-hour non-stop service thus is not affected by employee strike, indolence, or bad

attitude. In the meantime, since computers are one hundred percent obedient, they can effectively resolve the various problems that the blind often encounter when purchasing a train ticket.

(2) The overall planning of guiding systems can lead the blind to walk from outside of the train station to the station concourse where the system is located and finally to the correct platform after completion of ticket purchase.

(3) The system applies the verbal communication interface, which allows the most natural and convenient way of ticket purchasing for the blind.

(4) Even those blind people without Braille reading skills can use voice input to purchase a train ticket.

(5) This ticketing system has a built-in computer artificial intelligence function which can learn to recognize the environmental noise such as the running air-conditioner and the noise of the crowd. Through training, the computer system can effectively reduce the level of environmental interference.

(6) The system adopts environment-friendly, energy-saving design. It uses infrared for auto-sensing to break the dormant or standby mode of the system and to avoid unnecessary energy consumption when the system is not in use.

(7) The ticket sold by the system not only provides relevant instructions in print but also has Braille instructions for user verification.

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