A Destination Notification System for Disembarking Public Transportation Using Smart Devices and High Frequencies

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Abstract: As a result of the recent rapid increase in smart technologies, many people now enjoy movies and music content through their smart devices while using public transportation. However, because their concentration is aimed at content on their smart devices, passengers sometimes forget to disembark and miss their destination stations. In this paper, we therefore propose a destination notification system for disembarking public transport using high frequencies based on the smart devices themselves. The proposed application could support automatic debarkation notifications when the smart device approaches the destination station. We tested destination notification with the proposed system and ten smart devices to evaluate its performance. According to the test results, the proposed system showed 99.4% accuracy and was therefore confirmed as potentially very useful. As such, the proposed system could be a useful technology for notifying smart device users when to get off public transport, capable of global commercialization.

Key-Words: High frequencies, Inaudible sound, Smart device, Public transportation, Destination notification

1 Introduction

Recently, the development of smart devices and the increase in their accessibility means that many people now enjoy movies, music, and social networking services everywhere via their smart devices. In particular, many can be seen watching movies or listening to music on their devices as they travel by public transportation. However, passengers sometimes miss their destination because they concentrate solely on the movie or music content. Therefore, destination notification services based on the smart devices themselves exist for users of public transport.

Such notification services use various technologies such as GPS information [1], Wi-Fi fingerprinting using access points (APs) [2], and server data about the movement of public transportation [3, 4]. Approaches that only use GPS are useful for urban bus routes because GPS information can be more precise here than on the subway, for example. As such, this type of technology is not suitable for subway destinations because GPS information is weak underground. Wi-Fi fingerprinting stores location data based on the surrounding signal strength of Wi-Fi APs and can support specific information about a user's smart device. As this approach has high user location accuracy indoors, it is suitable for both urban bus and subway routes. Nevertheless, fingerprinting technology has some inconveniences because it relies on communication between a smart device and the public transportation information server and must collect data again whenever equipment or installations are added, moved, or removed at the location. Notification services that use server data about transport movement combine the GPS data of each bus at an integration server which can identify the location of the user's smart device based on that movement information at the integration server. However, because this technology only shows the current location of the transport, continuous communication between the device and the server is required to notify the passenger via their smart device when the destination is approaching.

In this paper, we propose a new destination notification system for disembarking public transportation using smart devices and high frequencies which could be emitted from in-built speakers on buses or subway trains. The microphone of the smart device can detect audible frequencies in the range from 20 Hz to 22 kHz, and specific high frequencies could be detected via an application installed on the device [5]. We use basic in-built speakers on buses or subway trains and two high frequencies between 18 kHz and 22 kHz which have been constantly used in high frequency studies of, for example, smart information service applications and data transmission. Importantly, these frequencies are not audible to people in indoor spaces [6, 7]. Subsequently, the smart devices of public transport passengers collect and analyze all environmental sounds; when the device detects a specific signal that is equal to that of the passenger's destination station, the proposed application displays disembarkation information to the user.

To evaluate the performance of the proposed application and notification service, we developed a high frequency detection application to signal disembarkation to the user based on their smart device and on a system of high frequencies generated according to each subway station. We investigated the disembarkation notification system using ten different smart devices, and the results show that the proposed application is useful technology for subway services with an accuracy of 99.4%. This new smart destination notification service using inaudible high frequencies and smart device microphones could therefore be a highly useful technology for many people who travel by public transportation.

This paper is organized as follows: In Section 2, we describe the proposed application as based on smart devices and a high frequency-generation system; in Section 3, we describe an experiment using the proposed application and the frequency system, and we discuss the results regarding performance; and finally, in Section 4, we present our conclusions and areas for further research.

2 Smart Destination Notification System for Public Transportation

In this section, we explain the proposed application's use of smart devices and high frequencies for notifying users to disembark public transport. The complete flow of the proposed system's processes is shown below in Fig. 1.

In Fig. 1, the passenger sets up their destination within the app either before or after boarding the public transport. As each station is announced via the bus or train's in-built speaker, a specific high frequency for the station is emitted via the same speaker. Smart devices on board the transport collect all environmental sounds via their microphones which are then converted to frequencies by fast Fourier Transform (FFT). The app compares the values of the detected high frequencies and that of the destination station until a pair of high frequencies over 18 kHz is detected. At that point, the application displays a disembarkation notification to the user.

At this time, the specific pair high frequencies which are over 18 kHz is selected two high frequencies as 100 Hz unit between 18 kHz and 22 kHz (Total : 41 kinds). And to avoid interference of high frequencies, the interval between each high frequencies is over 600 Hz. Thus, the pair high frequencies could compose total 595 kinds like as 18.0 kHz-18.7 kHz, 18.0 kHz-18.8 kHz, ……, 21.3 kHz-22.0 kHz. The composed pair high frequencies are generated by speaker of the proposed high frequencies occurring system and it produce during ***k*** seconds and ***n*** times. The ***k*** means the duration of the pair high frequencies and ***n*** means repetition time of the pair high frequencies to improve the accuracy of the proposed system. The produced type of pair high frequencies is shown below in Fig. 2.

In Fig. 2, the pair high frequencies are composed with 19.0 kHz and 20.0 kHz, ***k*** is 5 seconds, and ***n*** is 2 times. Thus, the pair high frequencies are generated by speaker of urban bus or subway and smart device which is located in checks whether the pair high frequencies exist or not consistently. And, if smart device detect the pair high frequencies, it wait during fixed ***m*** seconds and detect the pair high frequencies

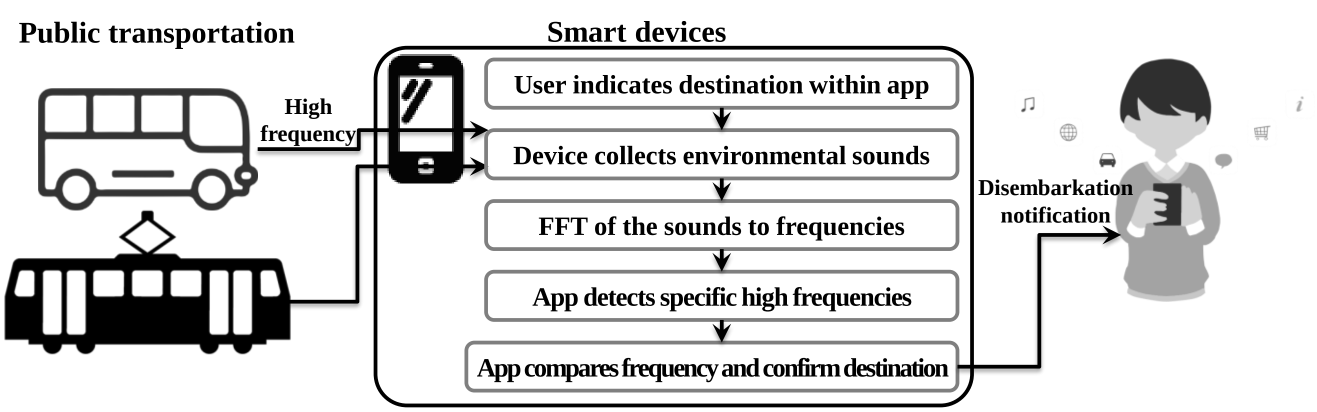

Fig. 1. The complete flow of the proposed application.

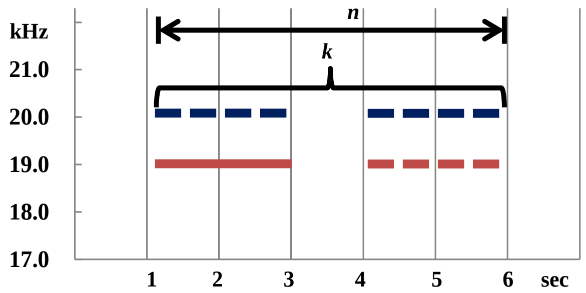

Fig. 2. An example of the proposed a pair high frequencies for disembarkation notification to user.

again to confirm same pair high frequencies. And then, if the first pair high frequencies and the second pair high frequencies are same, smart device compare with the pair high frequencies value and the value of destination station which is setting up by user and it shows the notification for disembarkation to user when the values is same.

Thus, because the proposed application only uses a pair high frequencies via built-in speaker at public transportation, it is more economical than the existing research and application service. Moreover, because the proposed application does not need any data like as GPS of public transportation, Wi-Fi fingerprint from Wi-Fi Aps, and etc., it could work well at public transportation anywhere in the world though smart device could not use Wi-Fi or LTE for receiving information about disembarkation

3 Experiments and Evaluation

This section explains the proposed application based on smart device and analyze the result of the experiment using the proposed application. Most of all, the screen composition of the proposed application based on smart device is like below as Fig. 3. In Fig. 3, the graph located at left of Fig. 3 show the bin value of the high frequencies from collected sound data via microphone of smart device and we confirmed that 18.1 kHz and 19.5 kHz were remarkable among the other high frequencies. And, many text located at right of Fig. 3 are User's destination (City Hall {21}), detected pair high frequencies, and Now station (Gangnam {42}). The numbers in parentheses like as {21} and {42} are high frequency values of each subway station. If the value of high frequencies are 01, it means 18.0 kHz and 18.7 kHz. 18.0 kHz and 22.0 kHz means 34, 18.1 kHz and 18.8 kHz means 35, and 18.1 kHz and 19.5 kHz means 42: Gangnam subway station. Thus, we set high frequencies value of each subway station up from 01 to 51, because the number of subway station of line 2 in Seoul, South Korea is 51 like as Fig. 4.

When the application compare with Destination number and Now station number and if they are same, the application show a disembarkation notification to user smart device like as Fig. 5. Thus, when user want to enjoy the other contents, the proposed application could change to background mode and it shows the local notification as foreground again when subway is approaching the destination station.

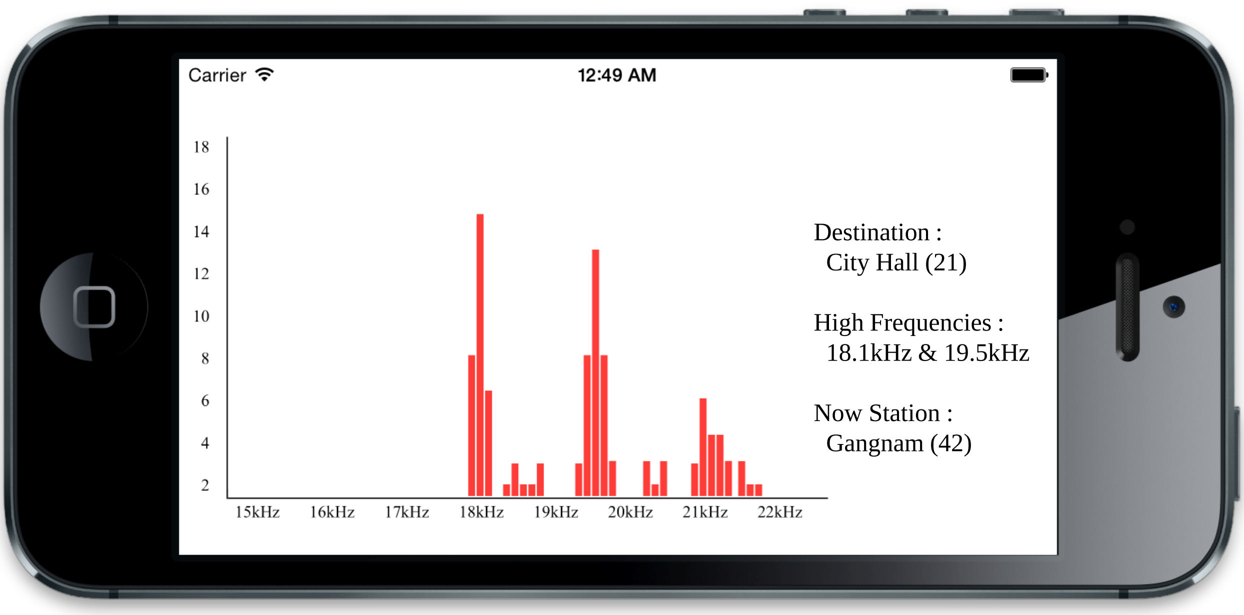

Fig. 3. The screen composition of the proposed application for disembarkation notification to user.

Fig. 4. The screen of the proposed application when subway is approaching the destination station.

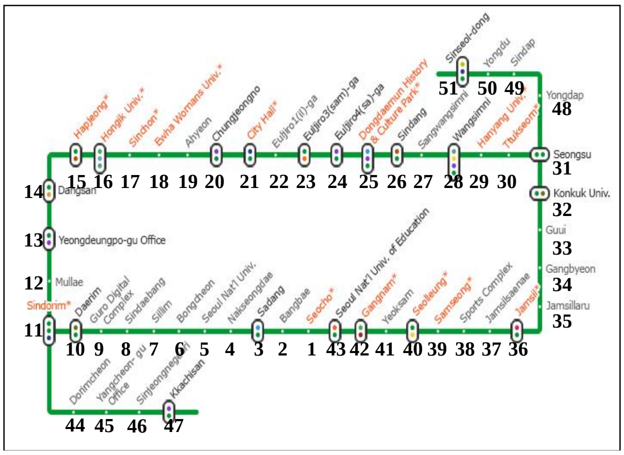

Fig. 5. Subway 2 line map in Seoul and the high frequency value for each subway station

Next, in this paper, we proceeded the experiment for disembarkation notification to user using the proposed application as follows. The subway was line number 2 of Seoul, South Korea and we used ten smart devices which are various kinds like as iPhone 7, iPhone 6, Galaxy s7, and etc. The high frequencies occurring system uses JavaScript and transmits the high frequencies through speakers in the laptop. At the experiment, the ***k*** of pair high frequencies was 3.0 seconds, and m was 1.0 seconds. And then, ten smart devices are located within 5 m from the laptop. Each participant sets up three stops from start station as the destination station and checks the notification for disembarkation to user. We tested 100 times using the laptop and the proposed application and Fig. 6 showed the disembarkation notification result of the pair high frequencies from each smart device.

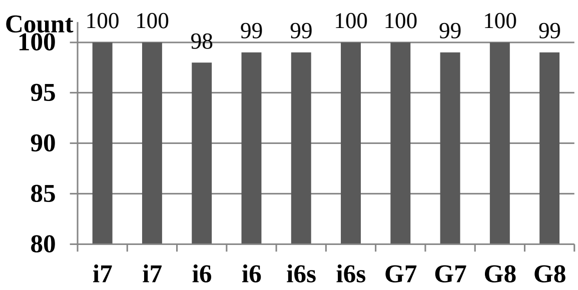

Fig. 6. The disembarkation notification result of the pair high frequencies from each smart device.

In Fig. 6, i7 means iPhone 7, i6 means iPhone 6, i6s means iPhone 6s, G7 means Galaxy s7, and G8 means Galaxy s8. The count does not mean the detection number of the pair high frequencies and it means the disembarkation notification number to user when each smart device detected the pair high frequencies and matched with destination value and now station value. At this time, the most smart devices were detected the pair high frequencies over 98 times. We could see that third i6 showed 98 times and fourth, fifth, eighth and tenth showed 99 times. Because the third i6 was sometimes located over 5m from laptop, we expected that this smart devices could not detect the pair high frequencies. Thus, the proposed application and high frequencies occurring system showed 99.8% accuracy from this experiment and we expected that the proposed system could be useful technology for disembarkation to user at public transportation.

4 Conclusion and Future Work

In this paper, we have proposed a new smart destination notification system for disembarkation at public transportation using smart device and high frequencies which could send out from built-in speaker of urban bus or subway. In the experiment, various smart devices detected the pair high frequencies about each subway station and each smart devices can show the destination notification to user. From this process, the proposed application and high frequencies occurring system could be useful to many smart device user who often enjoy movie, music contents via smart device at public transportation.

In future research, we will study about the advanced destination notification system for disembarkation at public transportation using smart device, high frequencies and the existing GPS, moving information from public transportation. Moreover, we will study how the accuracy of the proposed application and high frequencies occurring system could be upgraded and we will test many experiments using the proposed application and system.

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