Smartwatch Navigation System for Visually Impaired

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Abstract:
Resolving the mobility problem of the visually impaired is a socially challenged task. This paper proposes a method for guiding the visually impaired using the vibration and auxiliary voice guidance of an Android smartwatch that can be worn on the body and introduces the design and implementation of an app that utilizes the method. All input from the user, including receiving the destination input, was processed using voice recognition and TMAP was used for map. In this paper, we developed a safe route-first algorithm that selects the safest route among several routes recommended by the Internet map service. In addition, several vibration patterns to guide the user's movement were designed and implemented in the smartwatch. Also, we developed a monitoring system so that a guardian or administrator could observe the entire route finding and guidance process on the web.

Keywords: Smartwatch, Navigation, Visually Impaired, Vibration, Wearable
DOI Number: 10.14704/NQ.2022.20.15.NQ88422 **NeuroQuantology2022;20(15): 4202-4209**

1. Introduction

Resolving the mobility problem of the visually impaired is a social task to be solved [1].Although dotted blocks are installed on the pedestrian road for the visually impaired to walk, many problems are exposed, such as broken and not being repaired.Fundamentally, the point block is a means of marking a road, not guiding the road to a destination [2].

There have been many social efforts to improve the quality of life of the visually impaired and to help them move.A navigation system for the visually impaired was proposed [1], and a technology to provide various information in a space using RFID location tracking technology for the visually impaired was also proposed [2], and a smart phone navigation system for the visually impaired was also proposed [3].In addition, the Korea Railroad Research Institute has developed a voice guidance device that helps visually impaired people move through a mobile app so that they can use the railroad easily within railway stations, and this guide is currently being used [4].As another example, G-eye [5,6] is a location-based information retrieval platform service that helps the visually impaired search for information about buildings in the front, entrance directions, landmarks in the direction of progress, current location, and nearby facilities.

These existing services that provide information about the movement of the visually impaired or the visually impaired have high value in reducing the information gap between the general public and the disabled, but they are processed with voice, which makes them difficult to use in places with severe ambient noise.

They can receive voice guidance while wearing earphones, but they may be exposed to other difficulties, such as missing other sounds around them or getting lost by concentrating on their voice.

On the other hand, as smartphones become popular, most people find their way through map services such as Naver or TMAP [7] and move while receiving guidance to their destination.

Although these map or navigation services provide tremendous convenience to almost everyone, both drivers and pedestrians, it is difficult for visually impaired people to use a map or navigation service because it is difficult to use a smartphone.This paper introduces the development of GoEasy, an app that allows visually impaired people to easily find a way and guides the way through vibration using a smart watch [8], which has recently been spotlighted as a wearable mobile device.

The reason for using a smart watch in this study is that it is smaller than a smartphone and can be worn on the wrist, and that it can communicate directly with the outside using the Internet.

The GoEasy app processes all inputs through voice recognition to eliminate the inconvenience of using mobile devices for the visually impaired, and unlike existing apps that provide information only with voice, it uses vibration to guide the way, so it can reduce the inconvenience caused by noise.Navigation services usually recommend multiple routes to your destination.

In this study, we developed an algorithm to determine the safest route by analyzing topographical features among several routes to the destination and guide the route accordingly.In addition, a system was developed that monitors the whole process of walking starting from the smart watch in real time so that guardians or supervisors can see it and improve the walking of the visually impaired.

Chapter 2 describes the structure of the entire system including the GoEasy app, and Chapter 3 describes the design and implementation. And a conclusion is drawn in Chapter 4.

2. Architecture of System

The entire system including the GoEasy app designed and implemented in this study is configured as shown in Figure 1.This system targets Android smartwatches that can access the Internet through Wi-Fi or LTE.

Users issue all commands with their voice, and the GoEasy app utilizes the Kakao speech recognition Open API, which all is handled by speech recognition.

GoEasy creates a history of all information about the user or the destination and route searched by the user and stores it in Google's Firebase.

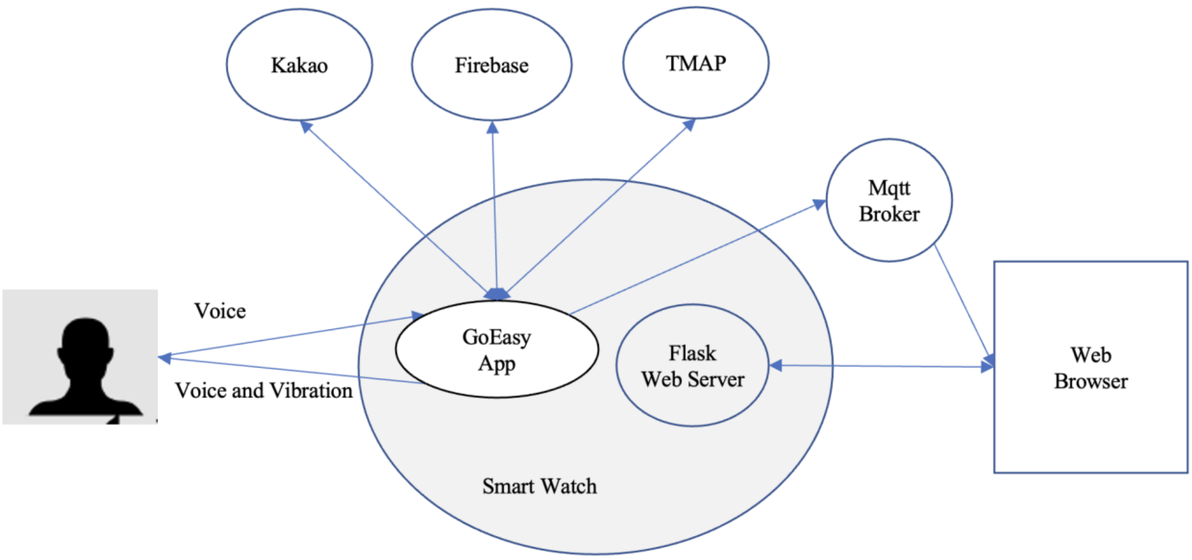

Figure 1. System Architecture

Maps are serviced by TMAP.The current location is determined through the GPS device in the smart watch, and the destination is determined by the user's voice input.If the current location and destination are sent to the TMAP site, TMAP informs the user of four different routes according to the current location and destination.However, depending on the destination, when there are no four different routes, the same route may be duplicated among the four routes.Therefore, depending on the destination, actually 2-4 different routes are valid.The GoEasy app evaluates the features contained in the route sent by the TMAP to determine the safest route and starts a route guidance service.

The navigation service is a service that guides users along the safest route.At the 5m point where the user is from the junction, it notifies the smartwatch of about 9 situations, such as right, left, going straight, and arrival, with different vibrations and voices.

In this study, a system was designed and implemented to monitor all the actions that occurred on the smart watch through a web browser from the outside.For this, Flask, a Python-based web framework, was installed and web pages including HTML, CSS, and JavaScript programs were built.And the web application was written in Python.The GoEasy app notifies the JavaScript code on the web browser using the MQTT protocol for all processes of the user finding directions and navigating to the destination, so the JavaScript code outputs this process to the web browser.We also developed a web page that reproduces the user's movement in the history of a web browser.

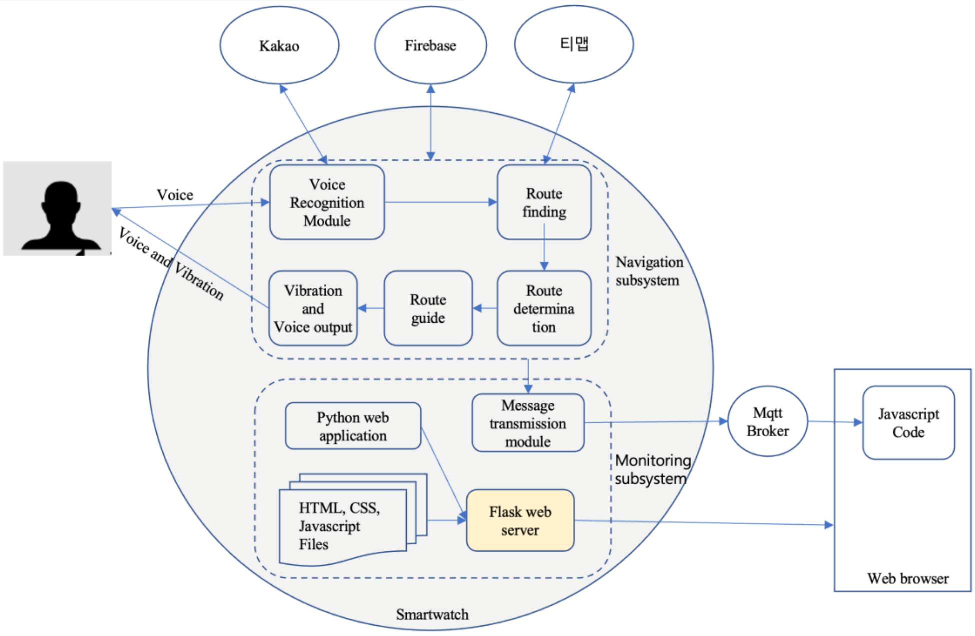

Figure 2. Components of GoEasy App

3. Design and Implementation

3.1 GoEasy App

The software structure of the GoEasy app is shown in Figure 2. It mainly consists of two parts: the navigation subsystem and the monitoring subsystem.Each module of the navigation subsystem is as follows. The voice recognition module receives voice input from the user and converts the voice into text using Kakao's voice recognition open API.The finding route module recognizes the current location using the GPS device in the smart watch, receives the destination from the voice recognition module, and receives several route recommendations from the TMAP site based on them.The path determination module determines the safest path among the paths received from the TMAP.In this paper, an algorithm to evaluate safety was developed to do this.The route guidance module guides the route determined by the algorithm through vibrations of various types of smart watches.For this purpose, in this paper, a vibration pattern was designed.

The monitoring subsystem is a system that outputs the operation process of the GoEasy app through an external web browser, which is described in the monitoring subsystem in Section 4.

3.2 Algorithm to determine route

3.2.1 Concept of Algorithm

The GoEasy app sends the current location and destination location to the TMAP and receives routes from the TMAP.At this time, depending on the destination, 2 to 4 routes are guided. The route decision algorithm calculates the safety level for each route as in Equation (1) and selects the route with the greatest safety level.

$Safety_r = Pos_r + Neg_r$, for route r(1)

where Pos_r is the positive value of the path r, Neg_r is the negative value due to the hazards of the path r, and $Safety_r$is the safety value of the path r.

TMAP provides various information on the route from the current location to the destination in JSON format.In this study, the part related to road safety among this information is classified into 8 types and used to calculate Pos_r and Neg_r.

3.2.2 Algorithm operation process

The path determination algorithm specifically consists of the following three-step operation.

3.2.2.1 Positive evaluation of safety: *Pos*$_r$

In this paper, based on the information received from TMAP, in a positive way, as shown in Table 1, roads were classified into 4 types and scores were assigned.Based on this table, Posr is calculated as Equation (2) for each path r.

$Pos_r = (\sum(PType_{ri} \times Dist_{ri}))/\sum Dist_{ri}$ (2)

where$PType_{ri}$ is the road type score shown in Table 1, $Dist_{ri}$ is the length of the road in meters, and $\sum Dist_{ri}$ is the total length of the route r. Therefore, it is a value of $0< Pos_r \leq 100$.For example, if the total length of route r is 1000 meters, 300 meters is a vehicle control section, 160 meters is a pedestrian separation road, 500 meters is a road divided by a road and a sidewalk, and 340 meters is a comfortable road, Pos_r becomes { (300 * 100) + (160 * 90) + (500 * 70) +(240 * 50) } / 1000 = (30000 + 14400 + 35000 + 12000) / 1000 = 91.4.

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Table 1. Positive Route Types and Scores

Type of Road	Score	Description
PType0	100	Vehicle curfew
PType1	90	Pedestrian separation
PType2	70	Separation of driveway and sidewalk
PType3	50	Good

3.2.2.2 Negative evaluation of safety: *Neg*$_r$

Based on the information received from TMAP, in this paper, four negative information about roads were classified as shown in Table 2 and scores were assigned. Based on this table, Neg_r is calculated as Equation (3) for each path r.

$Neg_r = (\sum(NType_{ri} \times Freq_{ri}))/\sum Freq_{ri}$ (3)

where $NType_{ri}$is a negative score for the road as shown in Table 2, $Freq_{ri}$is the frequency of occurrence of the road type, and $\sum Freq_{ri}$is the sum of the total frequency of occurrence. Therefore, $0 < Neg_r \leq 100$.

Type of Road	Score	Description

Table 2. Route and Negative Types Scores

NType0	10	Bifurcation
NType1	30	Crosswalk
NType2	30	Dangerous facility 1 (elevator, overpass, underpass, stairs)
NType3	50	Dangerous facilities 2 (bridges, tunnels, overpasses, passageways for large facilities)

3.2.2.3 Evaluation of safety : $Safety_r$

For each path r, we compute Safetyr and choose the path *r* with the largest value. Using the previous example, $Safety_r$ of path *r* is 70.03(91.4 – 21.37). $Safety_r$ is determined based on the information given by the TMAP as of the present time.It was because there was an overpass until a few days ago, but now the overpass may have been demolished. $Safety_r$ is a value in the range of $-100 < Safety_r < 100$. If $Safety_r$ is negative, the risk is too high.If $Safety_r$ is negative for all routes provided by TMAP, it is dangerous to users, so it is recommended not to go to the destination.

3.3 Route guidance

Route guidance is achieved through vibration, and voice is used as an auxiliary means.Vibrations are made throughout the route guidance.The vibration pattern is created based on the vibration time and vibration intensity.We gave the most recognizable vibration pattern to the most used guidance.The vibration intensity can be given between 0 and 255, and the vibration unit is designed as shown in Table 3.In this paper, each vibration pattern vibrates for 1.5 seconds.Table 4 shows vibration patterns and voices designed for vibration units.In Table 4, ↓ indicates that the vibration intensity is gradually decreasing, and ~ indicates that the vibration continues to ring until the target is achieved.For example, a right turn vibration means that it will continue to vibrate until the user has finished turning right. Blank means stop vibration for 0.2 seconds.

Table 3. Vibration Unit Design

Vibration Name	Zi	Zing	Zing!!
Vibration intensity	50	150	255

Table 4. Vibration and Voice Design

Guidence type	Vibration pattern	Voice
Start	ZingZi↓	“start guiding”
Start direction guide	Turn right: ZingZingZingZing ZingZingZingZing~ Turn left: ZingZingZingZing~	“Depart at N o'clock”
5m ahead at the junction	Zing	“Turn left/right after N meters”

Direction guidance at the junction	Turn right: ZingZingZingZingZingZingZingZing~ Turn left: ZingZingZingZing~	“Rotate at N o'clock”
After passing the junction	Zing	“Go straight N meters until the next guide (junction)”
Deviation from the route	Zing!!ZiZiZingZing!! ZiZiZing	“Deviate from the route”
Direction guide for deviation from the route	Turn right: ZingZingZingZingZingZingZingZing~ Turn left: ZingZingZingZing~	“N o'clock direction”
Hazardous facility	ZiZing!!	“There is a traffic light/overpass”
Arrive	ZingZi↓	“End of guidence of directions”

The monitoring system that outputs all situations while the user is using the smart watch through a web browser is implemented by dividing it into two modules.First, it is a web service module implemented on the Flask web framework.A web browser connects to the smart watch and forms the basis for outputting monitoring information.

We installed the Flask web framework in the smartwatch and wrote web applications with web pages and Python programs.When the browser connects to the smart watch through TCP port 80, the Python web application receives the connection and sends a web page to the web browser.The web browser downloads and executes the JavaScript code to be used for sending the MQTT message described in the web page.Second, it is a message transmission module using MQTT. The message sending module within the GoEasy app transmits the operation process within the app to the web browser in the form of a message.Message transmission uses an MQTT broker.The GoEasy app's message sending module and the JavaScript code on the web browser exchange messages with each other using the MQTT broker.In this study, the MQTT broker uses a free Mosquitto broker [10] created and distributed by the Eclipse Foundation, and Mosquitto is installed on Amazon Cloud.MQTT is a communication protocol for sending messages in the subscribe-publish format. A client (subscriber) who wants to receive a message first registers a 'topic' with the MQTT broker.After that, when a client (publisher) that wants to send a message sends both a 'topic' and a 'message' to the MQTT broker, the MQTT broker sends the 'message' to all clients that have registered the 'topic'.

The GoEasy app initially sends destination information and 4 route information.And it sends the current location and the user's heart rate every 0.5 second, and when the user passes the bifurcation or hazard while moving, it sends a message that it is passing the bifurcation and hazard.It also sends a message when it deviates from the route or when it arrives at its destination.

4. Demonstration

This section shows the execution process of the implemented GoEasy app.Figure 3 shows the screenshots of the GoEasy app running on the smartwatch, while Figure 4 shows the result of monitoring through a web browser while the user starts navigation by voice and provides directions.

Figure 3. Screen Shots of GoEasy App

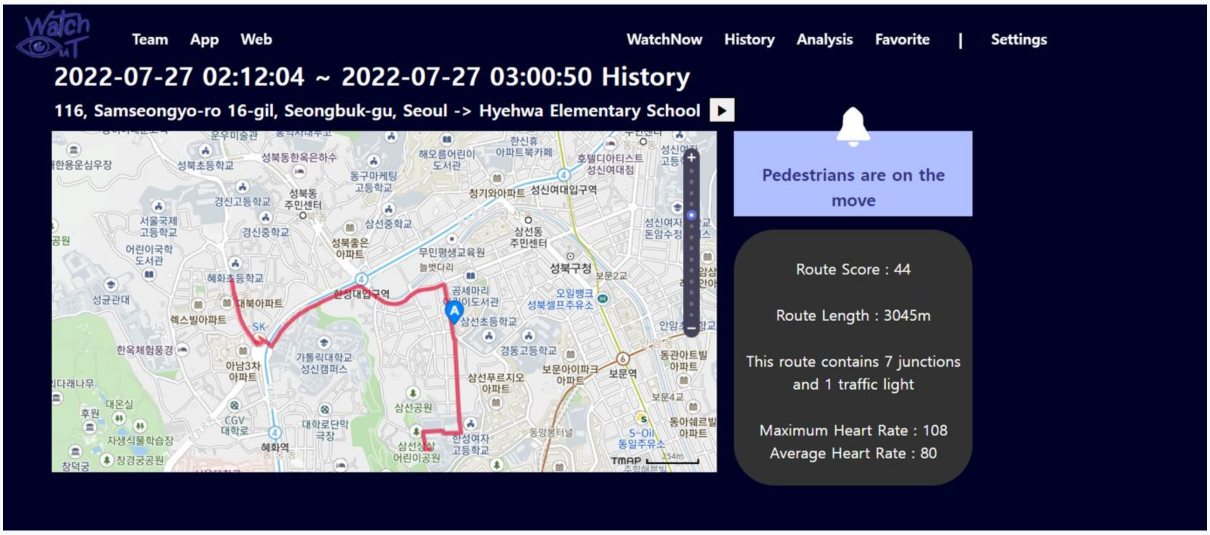

Figure 4. Monitoring Screen of Web Browser

5. Conclusion

This paper proposes and introduces a technique using an Android smart watch to help the visually impaired to navigate and move.The distinction and contribution of the research of this thesis are summarized as follows.First, the smart watch worn by the visually impaired guides the way through vibration.This fundamentally blocks the situation in which voice guidance becomes uncomfortable due to ambient noise.

Second, the safest route is recommended by evaluating several routes provided by the map site with a safety evaluation algorithm.Third, by implementing a monitoring system, all situations of directions and guidance made on the smart watch are monitored on the web and provided to guardians or managers, and the movement history of the visually impaired can be saved and reproduced.

The GoEasy app proposed and implemented in this study can also be usefully used to guide non-blind pedestrians.The evaluation of the suitability and safe way of the GoEasy app should be statistically evaluated through usage data, so it is left for future research.

6. Acknowledgements

This work was financially supported by Hansung University

References

[1] Sumin Jang, et al., Design and Implementation of a Navigation System for Visually Impaired Persons, The Journal of the Korea Contents Association, 2012, vol.12, no.1, pp. 38-47

[2] Choi Hyeong Joon, Moon Seung Jin, Location Information Guide System for the Visually Impaired, Proc. of KICS Summer Conference 2010, pp. 857-858.

[3] Chang Gi Kim, Lee Sang Do, Jeong Min Seo, A Navigation System for Visually Impaired Persons Using Smart Phone, KSCI Summer Conference 2014, Vol 22, No.2, pp. 405-406

[4] https://www.serviceplan.co.kr/kr/our-work/dot-braille-smartwatch.html

[5] https://ko.lbstech.net/service-g-eye-plus

[6] Seonghee Min, Yoosoo Oh, G-eye: Route Guide System Based on Obstacle Map for Blind people, Proc. of The HCI Korea 2017, Vol.2017 No.2, 2017, pp.703-705

[7] https://www.tmap.co.kr/

[8] Reza Rawassizadeh, Wearables: Has the Age of Smartwatches Finally Arrived?, Communications of the ACM, Vol. 58, No. 1, 2015, pp. 45-47

[9] Kitae Hwang, Design and Implementation of Dashboard Author and Viewer for IoT Systems based on MQTT, The Journal of The Institute of Internet, Broadcasting and Communication, Vol. 18, No. 5, pp.31-37, Oct. 31, 2018.

[10] https://mosquitto.org/