CETCS 2024

Non-linguistic Evacuation-route Navigation System in Flood Disaster Areas

Shinya ABE [1]*   *Kayoko YAMAMOTO* [2]

[1] Tokyo Metropolitan Industrial Technology Research Institute, Japan
[2] The University of Electro-Communications, Japan

ABSTRACT

Japan is a country prone to natural disasters such as earthquakes and typhoons. Japan has also seen a recent increase in the number of inbound foreign tourists, so it is increasingly important to communicate information to foreigners in the event of a disaster. However, language barriers remain an issue in disaster-time communications. Although there are existing multilingual systems for disaster-time communications, it is difficult to accommodate a large number of languages. Therefore, we developed a system that communicates evacuation routes and provides evacuation guidance without the use of language. The system is characterized by its ability to communicate evacuation routes through the use of only non-linguistic information, including geographic information, pictograms, and Arabic numerals. In this study, we conducted demonstration tests in flood disaster areas and demonstrated that the system can provide prompt evacuation guidance.

INTRODUCTION

Japan is a country prone to natural disasters such as earthquakes and typhoons. Japan has also seen a recent increase in the number of inbound foreign tourists, so it is increasingly important to communicate information to foreigners in the event of a disaster (Aibiki et al., 2016; Hada, 2020).

However, language barriers remain an issue in disaster-time communications. Although there are existing multilingual systems for disaster-time communications, it is difficult to accommodate a large number of languages. Multilingualization cannot be comprehensive and is therefore inherently insufficient, so the use of pictorial information such as pictograms has been suggested. (Sato et al., 2020). In a survey of foreigners living in Japan and tourists from abroad, significantly more respondents answered that visual methods of communication such as gestures and pictures are more effective in communicating information during a disaster compared with language (Hasegawa & Mukai, 2022).

Therefore, we developed a navigation system that communicates evacuation routes and provides evacuation guidance without the use of language (Abe & Yamamoto, 2022). The system is characterized by its ability to communicate evacuation routes through the use of only non-linguistic information, including geographic information, pictograms, and Arabic numerals. The base system was developed to provide information for foreign tourists (Abe et al., 2019; Abe et al., 2021).

In this study, we evaluated the evacuation-route navigation system in flood disaster areas. As a result, we found that the system could quickly guide evacuees to shelters.

NON-LINGUISTIC EVACUATION-ROUTE NAVIGATION SYSTEM

This section describes the developed non-linguistic evacuation-route navigation system. The user interface for this system consists only of non-linguistic information such as pictograms, Arabic numerals, and images. Figure 1 shows the developed system, in which pictograms and images indicate evacuation sites and landmarks. Arabic numerals indicate travel times and distances. These are superimposed over geographic information to indicate evacuation routes.

The search Interface for evacuation sites is similarly non-linguistic. The search interface comprises buttons for selecting the means of transportation as a pictogram, and travel times can be selected as Arabic numerals from a drop-down menu. Figure 2 shows the prototypes non-linguistic navigation system for evacuation routes. This prototype is implemented for the Android operating system.

However, we cannot recommend using the search interface in situations where the user's safety is not ensured, such as immediately after a disaster. In such situations, it is important that the user move quickly to a nearby evacuation site. The system thus also has functions for leading users to evacuation sites near their current location immediately after a disaster.

An algorithm based on a slime mold algorithm developed by the authors can be applied as the search method for evacuation routes. The authors have furthermore developed a method for conducting more precise searches by adding the disaster risk level as a new indicator (Yoshitsugu et al., 2019; Yoshitsugu et al., 2020).
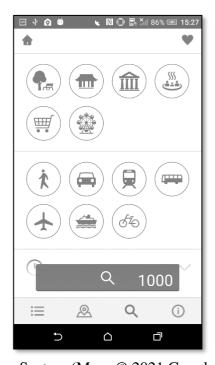

Figure 1: Non-linguistic Evacuation-route Navigation System (Maps © 2021 Google LLC)

Figure 2: Prototypes (Maps©2021 Google LLC)

EVALUATION OF RESPONSE PERFORMANCE

The navigation system overlays non-linguistic information such as pictograms and image onto a map, updating it as necessary to provide users with routes to nearby evacuation sites. Information acquisition time thus relies on response performance. In addition, non-linguistic information generally involves larger data sizes compared with linguistic information. Accordingly, non-linguistic evacuation-route navigation systems can thus be expected to have poorer response performance compared with linguistic systems.

Therefore, in this study, we evaluated the response performance of the developed navigation system, using the prototype shown in Figure 2. We conducted those experiments along railroad lines in flood disaster areas that affected by the Typhoon Hagibis (called "Reiwa 1 East Japan Typhoon" in Japanese). At each station, we measured the acquisition times for three- dimensional location (latitude, longitude, and elevation) of nearby evacuation sites and three-dimensional routes (paths and slopes) from the station to the evacuation site. We took 10 measurements at each location and used the slowest time as the measured value. These experimental conditions are the same as those we used in previous demonstrations (Abe & Yamamoto, 2023).

Table 1 shows the results of experiments at stations on the JR Tohoku Main Line, which was damaged in the Typhoon Hagibis. We performed the experiments on 13-14 December 2021. The longest acquisition time for three-dimensional location information was 2.13 s, and the longest acquisition time of three-dimensional route information was 3.12 s.

Table 2 shows the results of experiments at stations on the Abukuma Express Line, which was also damaged in the Typhoon Hagibis. We performed the experiments on 18 January 2022. The longest acquisition time for three-dimensional location information was 2.10 s, and the longest acquisition time of three-dimensional route information was 3.44 s.

These results are equivalent to those in demonstration experiments of navigation systems we previously conducted. We thus find that the non-linguistic evacuation-route navigation system can quickly communicate evacuation routes and can be applied to evacuation guidance. Note that we measured no suspected outliers in the experiments whose results are shown in Tables 1 and 2.

Table 1: *Loading Time for Location Information and Route Information on the JR Tohoku Main Line*

Stations	Location information (s)	Route information (s)
Shin-Shirakawa	1.48	2.77
Shirakawa	1.63	2.83
Kutano	1.45	2.61
Izumizaki	1.71	2.92
Yabuki	1.72	2.67
Kagamiishi	1.67	2.85
Sukagawa	1.50	2.97
Asaka-Nagamori	1.63	2.50
Koriyama	1.65	2.59
Hiwada	1.75	2.75
Gohyakugawa	1.74	2.84
Motomiya	1.76	3.04
Sugita	1.64	2.49
Nihonmatsu	1.82	3.08
Adachi	1.77	2.68
Matsukawa	1.97	2.90
Kanayagawa	2.13	2.82
Minami-Fukushima	1.73	2.41
Fukushima	1.44	2.27
Higashi-Fukushima	1.69	2.49
Date	1.93	3.01
Koori	1.82	2.73
Fujita	2.01	3.12
Kaida	1.98	3.00
Kosugo	1.42	2.84
Shiroishi	1.46	2.40

Table 2: *Loading Time for Location Information and Route Information on the Abukuma Express Line*

Stations	Location information (s)	Route information (s)
Fukushima	1.56	2.61
Oroshi-Machi	1.42	2.56
Fukushima-Gakuin-mae	1.66	2.70
Senoue	1.85	2.87
Mukaisenoue	1.91	2.85
Takako	2.00	2.89
Kamihobara	1.69	2.93
Hobara	1.72	3.02
Oizumi	1.73	3.08
Niida	1.97	3.21
Nitta	1.73	3.07
Yanagawa	1.84	2.91
Yanagawa-Kibonomori-Koenmae	1.92	3.11
Tomino	1.66	3.36
Kabuto	2.10	3.44
Abukuma	1.48	2.91
Marumori	1.87	3.02
Kita-Marumori	1.65	2.67
Minami-Kakuda	1.63	2.64
Kakuda	1.66	2.48
Yokokura	2.00	2.59
Oka	1.76	2.69
Higashi-Funaoka	1.84	2.76
Tsukinoki	1.72	2.64

CONCLUSION

In this study, we described the evaluation of a non-linguistic navigation system for evacuation-route guidance. The system is characterized by its ability to communicate evacuation routes through the use of only non- linguistic information, including geographic information, pictograms, and Arabic numerals. We conducted demonstration tests in flood disaster areas that affected by the Typhoon Hagibis, and the results demonstrated that the proposed system provides rapid evacuation guidance. We will continue to perform demonstration experiments urban areas.

ACKNOWLEDGMENT

REFERENCES

Abe, S., Yoshitsugu, N., Miki, D., & Yamamoto, K. (2019). An Information Retrieval System with Language- Barrier-Free Interfaces. *Journal of the Information Systems Society of Japan*, 14(2), 57-64.

Abe, S., Sasaki, R., & Yamamoto, K. (2021). Sightseeing Support System with Augmented Reality and No Language Barriers. In: Geertman, S.C.M., Pettit, C., Goodspeed, R., Staffans, A. (eds), *Urban Informatics and Future Cities*. *The Urban Book Series*, 591-611. Springer.

Abe, S., & Yamamoto, K. (2022). Evacuation-route Navigation System with Non-linguistic Interfaces. *Proceedings of the International Conference on Emerging Trends in Academic Research*, 8, 14-19.

Abe, S. & Yamamoto, K. (2023). Non-linguistic Evacuation-route Navigation System in Tsunami Disaster Areas. *Proceedings of the International Conference on Global Issues in Multidisciplinary Academic Research*, 8, 1-7.

Aibiki, R., Yoshizawa, N., Yamaguchi, K., Shimomura, T., Hikawa, T., Taki, Y., Yamazoe, M., & Kuriyama, A. (2016). Method of Providing Disaster Information to Foreign Tourists Visiting Japan. *Journal of Japan Society for Safety Engineering*, 55(3), 182-188.

Hada, Y. (2020). Current Situation and Issues in Providing Disaster Information to International Visitors in Japan. *IATSS Review*, 45(1), 28-35.

Hasegawa, Y., & Mukai, K. (2022). Report on Questionnaire Survey on Evacuation in Case of Disaster -Disaster Countermeasures in Company with Residents' Disaster Prevention Associations-. *Memoirs of the Faculty of Biology-Oriented Science and Technology of Kindai University*, (47), 19-33.

Sato, K., Nangong, Z., & Okamoto, K. (2020). A Study on the Dissemination Way of Disaster Information to Foreign Tourists to Japan. *Treatises and Studies by the Faculty of Kinjo Gakuin University. Studies in Social Sciences*, 16(2), 112-122.

Yoshitsugu, N., Abe, S., & Yamamoto, K. (2019). Derivation Method of Evacuation Routes Using Physarum Solver. *IPSJ Journal*, 60(12), 2325-2329.

Yoshitsugu, N., Abe, S., & Yamamoto, K. (2020). Method for Deriving Evacuation Routes Considering Disaster Risk. *Journal of Information Processing*, 28, 1065-1072.