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Evaluation of Non-linguistic Evacuation-route Navigation System in Urban Areas

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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 urban areas and demonstrated that the system can provide prompt evacuation guidance.

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Keywords: Evacuation-route Navigation System, Non-linguistic Interface, Urban area, Response Performance

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 urban 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. 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 2 shows the prototypes. These prototypes are non-linguistic evacuation-route navigation systems, which are implemented to run on Android smartphones. These prototypes can also be used by foreigners who do not fully understand the local language.

However, we cannot recommend using the systems 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 systems thus also have functions for leading users to evacuation sites near their current location immediately after a disaster.

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

Figure 2: Prototypes (Maps©2021 Google LLC)

EVALUATION

The navigation system overlays non-linguistic information such as pictograms and images onto a map, updating it as necessary, and provides to 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 prototypes shown in Figure 2. We conducted those experiments along railroad lines in urban areas. 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; Abe & Yamamoto, 2024).

Table 1 shows the results of experiments at stations on the JR Yamanote Line. We performed the experiments on 28 January 2022 and 4 February 2022. The longest acquisition time for three-dimensional location information was 1.95 s, and the longest acquisition time of three-dimensional route information was 2.57 s.

Table 2 shows the results of experiments at stations on the Toei Oedo Line. We performed the experiments on 9 February 2022 and 16 February 2022. The longest acquisition time for three-dimensional location information was 1.82 s, and the longest acquisition time of three-dimensional route information was 2.60 s.

Table 3 shows the results of experiments at stations on the Rinkai Line. We performed the experiments on 28 February 2022. The longest acquisition time for three-dimensional location information was 1.93 s, and the longest acquisition time of three-dimensional route information was 2.62 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 Table 1, Table 2, and Table 3.

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

Stations	Location information (s)	Route information (s)
Tokyo	1.43	2.20
Kanda	1.43	2.27
Akihabara	1.49	2.36
Okachimachi	1.51	2.38
Ueno	1.52	2.39
Uguisudani	1.83	2.51
Nippori	1.54	2.48
Nishi-Nippori	1.51	2.52
Tabata	1.79	2.45
Komagome	1.76	2.46
Sugamo	1.47	2.40
Otsuka	1.38	2.32
Ikebukuro	1.26	2.10
Mejiro	1.82	2.38
Takadanobaba	1.60	2.15
Shin-Okubo	1.34	2.11
Shinjuku	1.45	2.09
Yoyogi	1.68	2.23
Harajuku	1.36	2.15
Shibuya	1.42	2.06
Ebisu	1.53	2.14
Meguro	1.66	2.46
Gotanda	1.91	2.57
Osaki	1.95	2.49
Shinagawa	1.69	2.57
Takanawa Gateway	1.76	2.39
Tamachi	1.86	2.52
Hamamatsucho	1.56	2.15
Shimbashi	1.51	2.36
Yūrakucho	1.42	2.23

Table 2: *Loading Time for Location Information and Route Information on the Toei Oedo Line*

Stations	Location information (s)	Route information (s)
Shinjuku-nishiguchi	1.47	2.09
Higashi-shinjuku	1.44	2.07
Wakamatsu-kawada	1.52	2.30
Ushigome-yanagicho	1.60	2.21
Ushigome-kagurazaka	1.61	2.22
Iidabashi	1.48	2.28
Kasuga	1.56	2.35
Hongo-sanchome	1.62	2.40
Ueno-okachimachi	1.65	2.34
Shin-okachimachi	1.72	2.29
Kuramae	1.75	2.48
Ryogoku	1.80	2.51
Morishita	1.78	2.36
Kiyosumi-shirakawa	1.74	2.39
Monzen-nakacho	1.66	2.42
Tsukishima	1.58	2.34
Kachidoki	1.68	2.26
Tsukijishijo	1.53	2.36
Shiodome	1.57	2.31
Daimon	1.41	2.22
Akabanebashi	1.52	2.37
Azabu-juban	1.64	2.44
Roppongi	1.48	2.13
Aoyama-itchome	1.40	2.08
Kokuritsu-kyogijo	1.63	2.41
Yoyogi	1.40	2.06
Shinjuku	1.41	2.18
Tochomae	1.42	2.11
Nishi-shinjuku-gochome	1.45	2.19
Nakano-sakaue	1.59	2.33
Higashi-Nakano	1.67	2.42
Nakai	1.47	2.40
Ochiai-minami-nagasaki	1.63	2.44
Shin-egota	1.78	2.60
Nerima	1.71	2.58
Toshimaen	1.81	2.27
Nerima-kasugacho	1.82	2.50
Hikarigaoka	1.80	2.42

Table 3: *Loading Time for Location Information and Route Information on the Rinkai Line*

Stations	Location information (s)	Route information (s)
Shin-Kiba	1.74	2.57
Shinonome	1.88	2.55
Kokusai-Tenjijo	1.93	2.59
Tokyo Teleport	1.68	2.41
Tennozu Isle	1.63	2.37
Shinagawa Seaside	1.70	2.62
Oimachi	1.56	2.39
Osaki	1.48	2.29

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 urban areas, and the results demonstrated that the proposed system provides rapid evacuation guidance. We will continue to perform demonstration experiments in other areas.

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