DEVELOPMENT OF SMARTPHONE APPLICATION TO SUPPORT TSUNAMI EVACUATION

Dawn Chenxi Han, Waseda University, dawnhan@akane.waseda.jp
Tomoyuki Takabatake, Kindai University, takabatake@civileng.kindai.ac.jp
Miguel Esteban, Waseda University, esteban.fagan@gmail.com
Tomoya Shibayama, Waseda University, shibayama@waseda.jp

INTRODUCTION

Kamakura is a historical city situated along the Japanese coastline, which is at risk of being devastated by a tsunami due to its relatively flat topography and proximity to the Sagami and Nankai Troughs. Evacuation would play an important role to reduce the potential loss of lives resulting from a tsunami event. While carrying out evacuation drills is helpful to enable participants to take appropriate responses during an actual tsunami event, it is not realistic for all the residents to participate in such drills. Furthermore, as some coastal areas are renowned sightseeing spots, there might be many visitors who do not know the area well and struggle to evacuate in the event of a tsunami (Takabatake et al., 2017; 2020). Thus, the authors developed a smartphone application (App) that supports swift tsunami evacuation, which can be especially helpful for those who do not have sufficient knowledge about evacuation routes and refuge places. The present study aimed to investigate the effectiveness of the developed app, and to clarify its impact on people's decision making with regards to evacuation behavior.

METHODOLOGY

The app was developed utilizing Unity3D, which is a well-known cross-platform game engine. The game engine is able to construct two-dimensional and three-dimensional games. Utilizing a dynamic map software development kit, a location-based application was developed, which enables users to visualize Kamakura City in three dimensions. As the developed app aims to guide people, especially those who do not have sufficient knowledge about the area, to appropriate evacuation routes during a tsunami event, the area of interest was carefully reproduced by including the natural and constructed environment, evacuation signs and designated refuge buildings. A GPS-positioning system was also incorporated to show the current location of the evacuee him/herself. Figure 1 shows the user interface of the developed app.

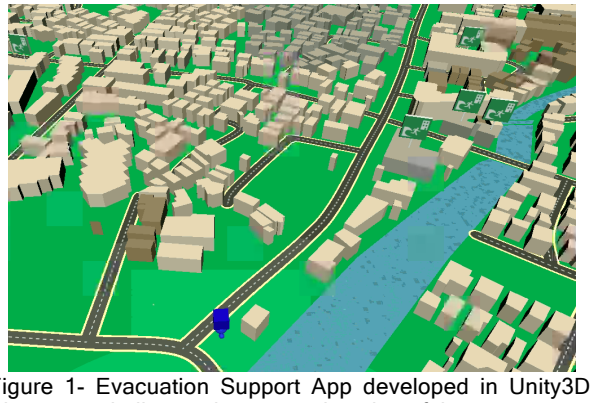

Figure 1- Evacuation Support App developed in Unity3D. Blue avatar indicates the current location of the user.

The effectiveness of the developed app was investigated by conducting tsunami evacuation experiments at Kamakura City. In the experiments, a total of 43 subjects that were not familiar with the area were asked to evacuate from a designated starting point, set close to Yuigahama beach. A GPS logger was used to record the evacuation time and route taken by each subject. The subjects were divided into two groups: The first group had 23 subjects and were asked to evacuate without the app; the second group was composed of 20 subjects who were given the app. They were instructed to evacuate to any location that they perceived as "safe". After the experiments, the subjects were also asked to fill up a questionnaire to further understand their decision-making logic during the experiment.

RESULTS

Figure 2 displays the recorded GPS data from the subjects. 70% of the subjects without the app arrived at designated evacuation places, while 85% of the subjects with the app arrived at evacuation places. Overall, subjects without the app showed a greater spatial distribution of their chosen routes (i.e. more distance travelled) than those subjects with the app.

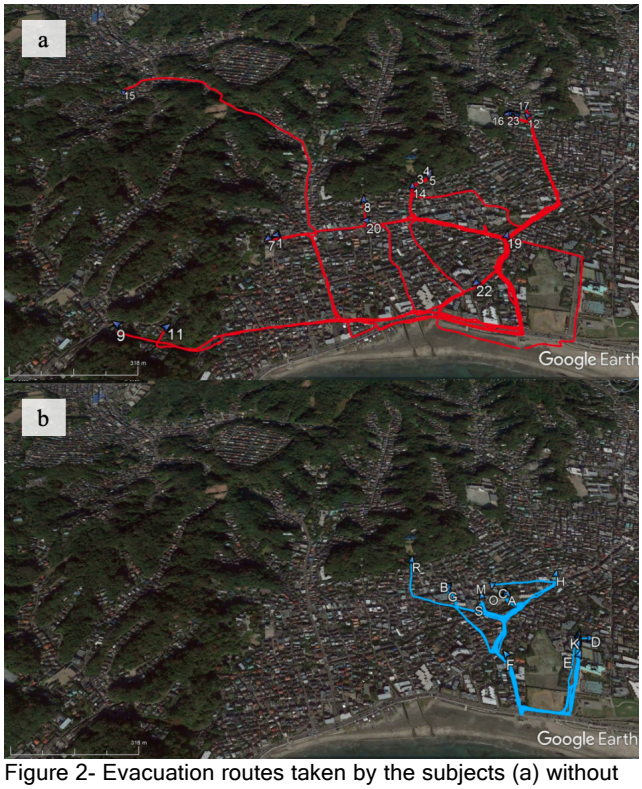

Figure 2- Evacuation routes taken by the subjects (a) without using the app and (b) with the app during experiment.

The averaged evacuation distance, time and speed were calculated based on the results of the 43 participants and shown in Figure 3(a)-(c). The results obtained were separately displayed for subjects with and without the app. Upper and lower bounds show the 95% confidence interval for each of the results. In general, the evacuation distance of the subjects without the app was approximately two times greater than that of the subjects with the app. The time taken to evacuate also shows a similar trend, where those without the app took 1.5 times longer to reach "safety" than those with it. In contrast, subjects with the app travelled slower than subjects without the app, as they took more time to look at the screen.

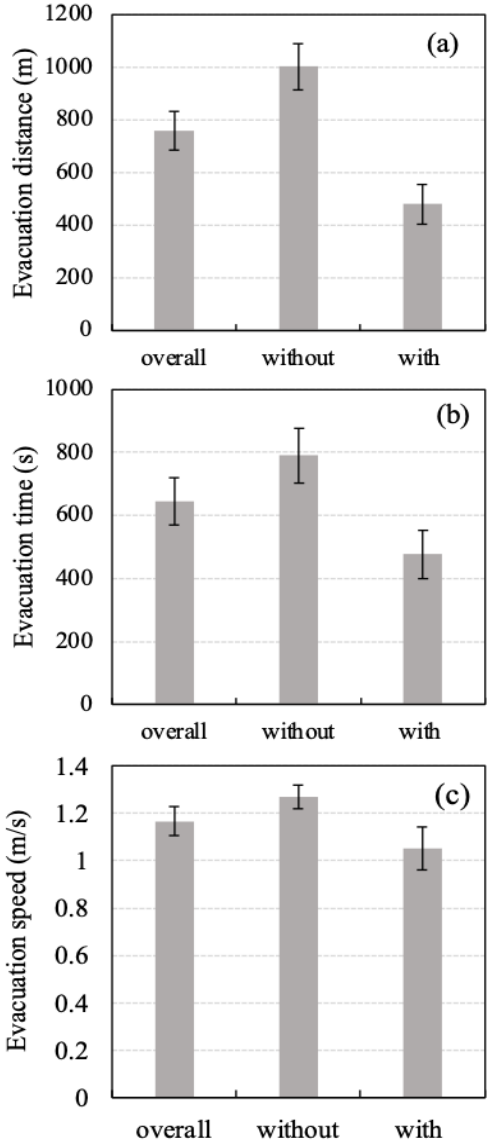

Figure 3- Averaged value of (a) evacuation distance, (b) evacuation time taken and (c) evacuation speed of the subjects who evacuated without the app and with the app. Upper and lower bounds indicate 95% confidence interval.

From the survey conducted post-experiment, subjects evacuating with the app demonstrated a stronger tendency to overlook the evacuation signs placed on the street. While many subjects reflected that they were focusing on the app, several subjects further pointed out that the placings of evacuation signs on the streets was unobtrusive, especially the evacuation signs placed on the ground. Many subjects commented that they choose their final destination as an evacuation building shown on the app, indicating the effectiveness of the app to guide users to the nearest evacuation spots within their proximity.

DISCUSSION

The present study has a number of limitations. All 43 subjects began their evacuation at the same starting point. In a realistic setting, beach users would have been more spread out within the coastal area, which would have led to more variation in the evacuation routes. In addition, the experiments were carried out in different days, which means that participants were subjected to different weather and traffic conditions. It should be noted that experiments were conducted at noon to ensure good visibility of the surroundings (and thus nighttime evacuation might have resulted in different patterns). As the current developed app is unable to display narrow/minor routes, some subjects who used the mobile application needed to make detours to reach their choice of evacuation site.

CONCLUSIONS

A new smartphone application to support tsunami evacuation was developed and confirmed to be effective by conducting tsunami evacuation experiments. As a result, the time taken to reach evacuation sites was reduced, indicating that it resulted in an improved efficiency of evacuation. Nevertheless, further improvement and development of the app is necessary to provide additional information to users about the capacity of refugee buildings, and the estimated inundation depths due to possible tsunamis.

REFERENCES

Takabatake et al. (2017) Simulated Tsunami Evacuation Behavior of Local Residents and Visitors in Kamakura, Japan, Int. J. Disaster Risk Reduct., 23, 1-14.

Takabatake et al. (2020) Effectiveness of Hard and Soft Tsunami Countermeasures on Loss of Life Under Different Population Scenarios, Int. J. Disaster Risk Reduct., 45, 1-16