Estimation of Road Damage for Earthquake Evacuation Guidance System Linked with SNS

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Abstract. The damage caused by earthquakes is very serious in Japan. One of the most common causes of earthquake damage is delayed escape due to obstructed passage. Rapid evacuation is very important during an earthquake. However, the pathway may be obstructed by obstacles during an earthquake. In this study, we propose an evacuation guidance system to evacuate users from a disaster area by using information from SNS and other sources. In this study, we propose an evacuation guidance system to evacuate users from a disaster area by using information from SNS and other sources. The proposed system enables users to complete their evacuation in the shortest and safest route. However, it is necessary to estimate the damage of the corridor to realize the system. Thesis In order to reduce the computational cost, transfer learning was performed using VGG16. As a result, the classification was achieved with an accuracy of 78%. This method can be used to automatically identify the damage in the corridor and help in determining the evacuation route.

Keywords: Earthquake, Evacuation guidance system, Support Vector Machine.

1 Introduction

1.1 Current Situation of the Earthquake Disaster

Japan suffers from a variety of natural disasters every year. The number of earthquakes that occur in Japan is particularly high, and the human suffering caused by them is enormous. If we take past major earthquakes as an example, the Hanshin-Awaji earthquake and the Great East Japan Earthquake have caused severe damage, claiming tens of thousands of lives [1]. One of the reasons for the deaths of these victims is the delayed escape of secondary disasters such as fires and tsunamis. In addition, according to a survey conducted by the Cabinet Office after the Great East Japan Earthquake and Tsunami, many said that damage to the roads by themselves and debris on the roads were obstacles [2]. These obstacles have hindered evacuation, and the subsequent tsunami has left many people dead or missing. Therefore, measures are needed to prevent the delay in evacuation.

1.2 Measures against Earthquake Damage in Japan

Governments and local governments are working on various arrangements and activities to reduce the victims of these disasters. For example, in Japan, we are focusing on earthquake prediction and strengthening of observation and surveying systems. In addition, we establish various laws for reinforcement, improvement of disaster prevention facility In local government, we send out information about disaster prevention and crisis management in social networks such as websites or Twitter including evacuation information such as evacuation advice at the time of disaster doing [3]. In addition to hazard maps, we also disclose information on shelters, information on soils, and areas such as hazards predicted in the event of an earthquake. Some local governments are using Twitter to train information sharing among users at the time of evacuation [4]. The national and local governments are taking various measures to deal with the damage caused by the disaster. As part of these measures, there have been many attempts to use social networking sites for evacuation.

1.3 Means of obtaining information when the earthquake has occurred

Media and disaster prevention reports can be cited as means of obtaining information in the event of an earthquake. However, in recent years, social network services (SNS) such as Twitter, Facebook, and mixi have attracted attention as a means of obtaining information in the event of an earthquake. They enable get or exchange quickly the information. Also it is excellent in confirming the safety of others. After the Great East Japan Earthquake, many people used SNS to obtain damage information [5]. Further, GPS information can be added to the posting of SNS, and pinpoint information can be transmitted. Research has also been conducted to show the effectiveness of using SNS in disaster evacuation [6]. The results of this study show that the use of social networking sites can be a great way to check on the safety of family and friends in times of disaster. Not only that, it is also an excellent tool for exchanging information, such as sharing information about the situation in the corridor.

1.4 Related study

An example of an evacuation guidance system at the time of a disaster is given [7]. The system uses mobile phones and smart don terminals to guide people along the best route to a predetermined shelter. The system also has a function to report road information with GPS information. The user can evaluate the condition of the passage in three levels: "Passable", "Obstacle", and "Impassable", and then post the information. Then, based on the submissions, the best evacuation route is determined. In this study, we considered that it is necessary to systematically evaluate the passageway situation as a means of understanding the situation of the passageway, considering the possibility of individual differences in the evaluation. In this study, we propose a system that automatically judges the passageway situation and provides evacuation guidance. A method for estimating the damage to the roadway for the necessary treatment portion of the system was also studied.

1.5 Research purpose

From the above background, in order to minimize the number of victims of the earthquake, it was considered necessary to eliminate the delay in evacuation. For that, it is important to choose the shortest route to the shelter. However, in the event of a disaster, there will be various road damages. Therefore, Evacuation guidance system is necessary in consideration of those obstacles. However, to identify a safe passage required information on the road. We paid attention to the case of information provision by SNS and the high real-time performance. Also We proposed a system for providing an optimum evacuation route to a user in linked with SNS In addition, We have studied a systematic method to grasp the damage situation of the passage In addition, a systematic method to grasp the damage situation of the passage will be studied.

2 Overview of the proposed system

In this chapter, the outline of the proposed system in this research and the internal algorithm are described.

2.1 Internal specification

The purpose of this system is to evacuate from a point outdoors to a predetermined evacuation site. The process of evacuation is shown in Figure 1. First, when an earthquake occurs, the system obtains information on the earthquake and the necessity of evacuation from the meteorological agency and local government. If there is no need to evacuate in spite of an earthquake, a warning message is displayed. If it is necessary to evacuate, the shortest route to an evacuation site will be shown to the user. The system will then search for posts on social networking sites. If there is information about damage to a pathway in an evacuation route, the system avoids the pathway and suggests the safest and shortest route to the evacuation site. However, it may not always be possible to complete the evacuation by the safe route alone. For example, there are two shortest routes to the evacuation site, both of which are affected by the earthquake. In this case, you can use the safest route. However, in the case of a high emergency, such as during a tsunami, the choice of a detour route may delay the escape. Therefore, using the safe evacuation distance as a threshold, if the route is within the evacuation range, the safe detour is selected, and if it exceeds the evacuation distance, the damage content of the corridor is estimated based on the posted images. This method is discussed in the next section. Then, a relatively safe corridor is determined and selected as the evacuation route. These actions are shown in Figure 2. Here, the evacuation possible distance is the evacuation possible distance from the start of evacuation. Based on the arrival time of the tsunami and the general walking speed at the time of evacuation, the starting evacuation distance to the arrival time of the tsunami is calculated. If the evacuation route is chosen, it is determined if it is possible to evacuate based on this distance. If it is not possible to evacuate, the damaged corridor should be determined as the evacuation route, even if it is a little dangerous. The equation is based on the following definition [8], and these contents have been discussed in previous papers [9]

$$\text{Evacuable distance}(L) = V \times (T1 - T2 - T3) \quad (1)$$

Where

V : Walking speed

T1 : Tsunami arrival time

T2 : Evacuation start time,

T3 : Time from evacuation start to current location

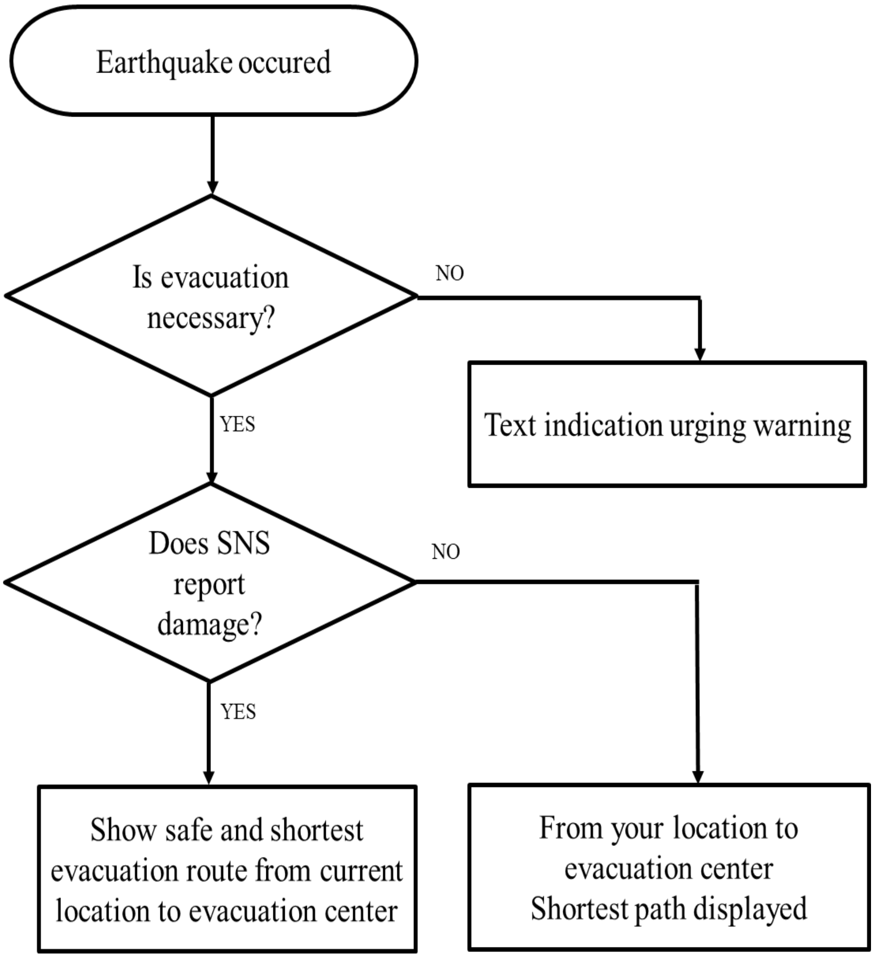

Fig. 1. Route Decision Flow Considering Passage Damage

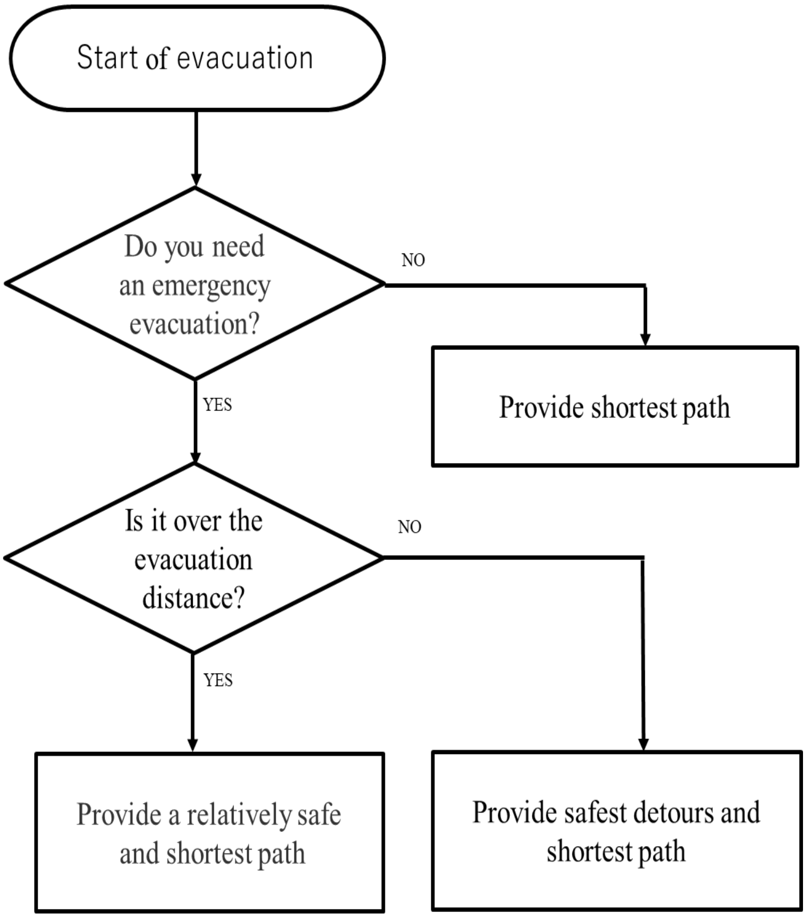

Fig. 2. Route Decision Flow Considering Evacuation Distance

3 Estimation of Damage to Passage

In this chapter, we examine a method to estimate the damage caused by the disaster based on the corridor images acquired from SNS. They are used to determine whether a passage is appropriate as an escape route. First, the machine learning method and other technologies are described, and the details of the experiments are described.

3.1 Support Vector Machine (SVM)

Support Vector Machine (SVM) is a supervised learning method for two-class pattern identification. When a plurality of classes exist in the classification of SVM, the classification of the plurality of classes is made possible by using a method of "one-against-all" or "one-against-one". "one-against-all" performs identification in pairs. So you create as many SVM models as there are classes. On the other hand, "one-against-one" identifies each class one-to-one. Therefore, all classes must be combined [10]. In this study, images were classified by "one-against-one". In this study, the linear function "Liner" was used.

3.2 Transfer learning by VGG 16

The VGG 16 is a CNN model consisting of 16 layers learned in a large-scale image data set "ImageNet". Each parameter used for learning is shown in Table 1 [10]. In this study, we used a learned model of VGG 16 to extract features of training images. The outputs of the convolution layer and the pooling layer of the VGG 16 were used as the input of the classifier by the SVM as feature values..

4 Experiment

The purpose of this research system is to estimate the damage content of the passageway based on SNS posts. The images used for learning were collected from damage reports (picture) posted on Twitter at the time of the actual disaster. It was defined on the basis of those images. Images labeled to those items were learned. Images with multiple defects were excluded. These images were used as training images and verification images, and 10 separate images for each item were prepared, classified as test images, and evaluated.

Table 1. Hyperparameters of VGG16

Parameter	Value
Butch size	256
Momentum	0.9
Weight decay	5e-04
Learning rate	1e-05
Epoch	74

Table 2. Categories and number of images

Categories	Number of images
Collapse of a house	104
Road crack	46
Collapse of a utility pole	43
Road depression	38
The inclination of a utility pole	56
Shredding of the road	41
Collapse of the concrete block	40
No damage	40

For learning, K-fold cross validation (K = 5) was performed, and learning was performed while replacing training data with validation data, and the average value was calculated.

4.1 Evaluation method

As a measure of the recognition system, the evaluation was carried out by fitting rate, reproduction rate, F-measure. Each is defined as follows (Formula 2-4)

$$Precision = \frac{N1}{N2} \tag{2}$$

$$Recall = \frac{N1}{N3} \tag{3}$$

$$F-measure = 2 \times \frac{Recall \times Precision}{Recall + Precision} \tag{4}$$

Where

N1 : $Number\ of\ images\ correctly\ identified$

N2 : Number of images identified as correct

N3 : Number of images in the correct class

5 Result

The classification results of each item are shown in Fig. 3. The vertical axis indicates the correct label of the test image, and the horizontal axis in the figure indicates the prediction of the classification. As shown in Fig. 3 and Table 2, some categories can be classified with high accuracy. Overall classification accuracy averages around 78%. Here, if attention is paid to a misclassified item, for example, an item of "Road crack" is identified as "Road Depression". In addition, some of the items in "The inclination of a utility pole" are identified as "The inclination of a utility pole". Although these are classified incorrectly, they can be identified as roughly similar categories, and it is inferred that these features can be accurately extracted in the process of learning the passage image. The problem here, however, is the "No damage" item. It is possible that the proposed system in this study will post a passageway image with no damage to estimate the damage of the passageway. In this case, it is suggested that a detour route, which is a detour in spite of a safe passage, may be presented. In the implementation of this system, it will be important to extract the passage of "No damage" with high accuracy. Since there is a small number of data in the current learning, it is necessary to examine the method of Data Augmentation. In addition, it is necessary to consider methods for appropriately processing "No damage" images, such as adding classes to improve versatility and capturing damaged images of passages as above.

Predict class

True class	Collapse of a house	Road crack	Collapse of a utility pole	Road depression	The inclination of a utility pole	Shredding of the road	Collapse of the concrete block	No damage
Collapse of a house	10	0	0	0	0	0	0	0
Road crack	0	7	0	0	0	0	0	3
Collapse of a utility pole	1	0	8	0	0	0	1	0
Road depression	0	7	0	3	0	0	0	0
The inclination of a utility pole	0	1	0	0	8	0	1	0
Shredding of the road	0	0	0	0	0	10	0	0
Collapse of the concrete block	0	0	0	0	0	1	8	1
No damage	0	0	0	0	1	1	1	7

Fig. 3. Classification results for each class

6 Conclusion

In this study, we propose an evacuation guidance system based on the route information and evacuation distance in order to reduce the human damage caused by the earthquake. After that, it was thought that it was necessary to determine a safe evacuation route by systematically discriminating the information of the passage, not by the eyes of the user. The damage of the passage was classified into eight categories and estimated by the transfer learning of SVM. As a result, it became possible to identify with 78% accuracy as a whole. In the future, it is necessary to enhance the accuracy by expanding the training data, and to enhance the versatility by adding classes.

Table 2. Evaluation result.

Categories	Precision	Recall	F-measure	Accuracy
Collapse of a house	1.00	0.91	0.95	
Road crack	0.60	0.60	0.60	
Collapse of a utility pole	0,70	1.00	0.82	
Road depression	0.80	0.67	0.73	
The inclination of a utility pole	0.60	0.86	0.71	
Shredding of the road	1.00	0.83	0.91	
Collapse of the concrete block	0.90	0.82	0.86	
No damage	0.60	0.60	0.60	
				0.78

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