

Behavior Analysis of Stranded Person Using Mobile GPS Data

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Abstract: At present, Tokyo metropolitan area has two kinds of natural mega-hazard: M.7 class inner-plate earthquake and Tsunami. Central Disaster Prevention Council which is the supreme organization of disaster affairs in Japan has warned about them in published reports. Right after the 2011 off the Pacific coast of Tohoku earthquake, the railway system in Tokyo metropolitan area completely shut down so that a large number of people had difficulty in moving. So far, many expertise in disaster prevention have proposed that such people should keep staying same place where they encountered big earthquake for their safety. However, it was observed that after the earthquake a lot of people tried to go home on foot even though the trip distance was quite long, and many person who commuters unable to get home go to home through the dangerous zone which are fire dangerous zone and building damage dangerous zone. This paper analyzes the behavior of persons who commuters unable to get home under the 2011 off the Pacific Coast of Tohoku Earthquake using mobile GPS data. Authors proposed and developed smart phone application based on the previous analysis.

Keywords: GPS, behavior analysis, stranded person, earthquake disaster

1. INTRODUCTION

Massive destruction was brought to the north-eastern region of Japan when the 2011 off the Pacific coast of Tohoku Earthquake occurred at 14:46 (JST) on March 11th, 2011. In Tokyo metropolitan area where maximum of 5-upper seismic intensity (JMA) was recorded, the earthquake suspended the transportation system such as bus and train services. As the result, many people tried to return home on foot. However not all succeeded in returning home and many of them ended up going to emergency shelters put into place or waited the recovery of public transportation for a long time.

According to the 10th census on transportation in Tokyo metropolitan area, approximately 9,500,000 commuters use public transportation system per day and the average travel time was 68 minutes long. It is evident that once the public transportation system fails, a great number of people will face difficulty in returning home.

Nakabayashi (1992) researched the relation between the distance to home and the success rate of returning home. He mentioned that all the people could return their home if the distance is less than 10km and the rate decreases by 10% per additional kilometer. Furthermore, people face difficulty in returning home if the distance is more than 20km. However, on March 11th, 2011, there were those who could not return home even though the distance was less than 10km and those who succeeded in returning home even though the distance was more than 20km. Shimohara et al. (2010) and Osaragi (2008) examined disaster

prevention plans by estimating a behavior model of the commuters in case of devastating earthquake. However, these studies may not fully reflect the actual behaviors as mentioned above.

Transportation system will be completely shut down if the Tokyo Metropolitan Inland Earthquake with magnitude-7 level occurs. Tokyo Metropolitan Government has worked on establishing new ordinance which asks companies to stock emergency supply in the office buildings. This countermeasure would contribute to keep employees staying in the building until the transportation system recovers.

In order to study the effective disaster prevention countermeasures regarding the evacuation of affected people after the large scale earthquake, we analyzed the behaviors of the affected commuters by the 2011 off the Pacific coast of Tohoku Earthquake on March 11th, 2011.

Hiroi (2011) conducts similar study and estimated choice behavior model of the affected commuters with using questionnaire survey data. However it is not verify whether they succeeded in returning their home.

In this study, we analyzed the behavioral characteristics of the affected commuters using a GPS data. The respondents of the survey were the affected commuters who faced difficulty in returning home.

2. CHARACTERISTICS OF ACTIONS ON THE DAY OF THE EARTHQUAKE

2.1. FLAG INDICATOR OF TRAVELING

The figure-2 shows the percentage of people's traveling from the affected areas after the earthquake. 29.5% of the people did not move at the time of the earthquake while 70.5% of the people tried to move. It became clear that 89.1% of the people who tried to move were trying to return home (figure 3). Thus we decided to investigate into further details to find out the situation that affected the decision making process and to find out whether those who hoped to return home actually succeeded in returning home. The results will be presented in the next chapter.

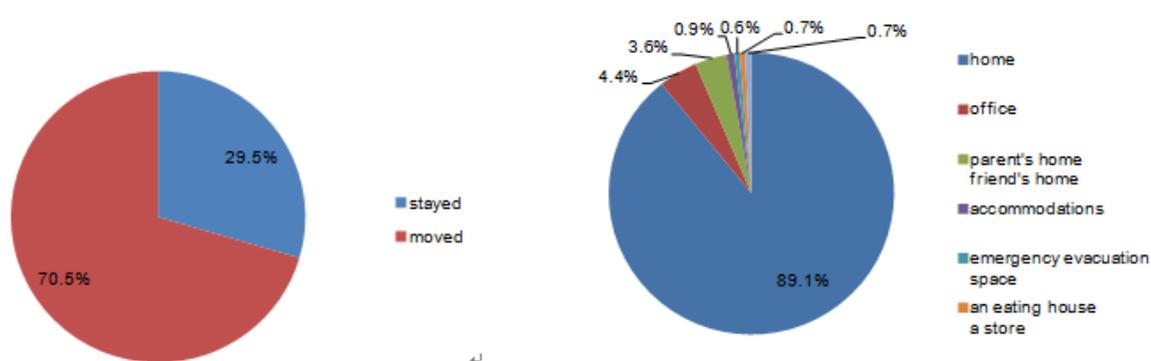


Figure 2. percentage of moved or stayed.

Figure 3. percentage of destination

2.2. SITUATION OF HOME RETURNING ON THE DAY OF THE EARTHQUAKE

The figure-4 indicates the result of the people’s attempt to return home. 92.7% of the people succeeded in returning home. The figure-5 shows the percentage of the final place of stay of those who could not return home. 34.1% of them stayed at their company, 30.5% at family and friends’ house, 13.3 % at hotels, 9.8% at emergency shelters. It became clear that people tried to return home once but chose to stay according to the situation.

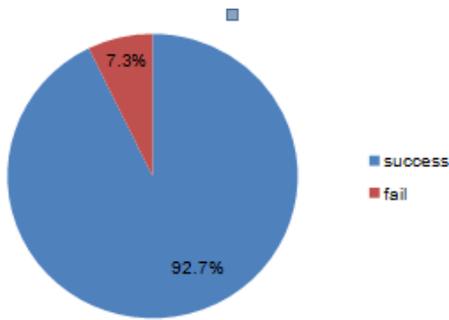


Figure 4. the success or failure of the go home.

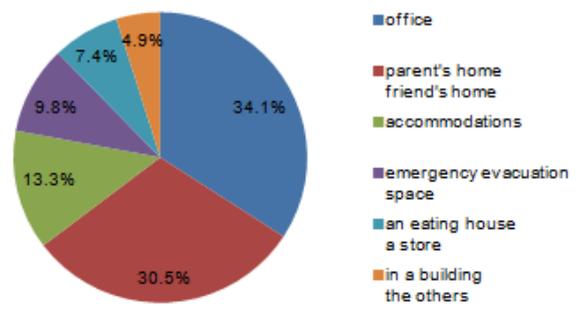


Figure 5. stay place of the return abandonment person.

2.3. RETURNING ACTIVITY ON THE DAY OF THE EARTHQUAKE

The figure-6 indicates the major means of transportation for those who attempted to return home. For those who used multiple means, each individual chose their main means of transportation in the order of car, train, bus, taxi, motorbike, bicycle, and walking. Out of those who attempted to return home, 54.6% tried to return home by walking, 15.5% by car, 14.4% by train, 8.3% by bus, 3.6% by taxi, 3.0% by bicycle, and 0.5% by motorbike. This fact indicates that more than half of the population who use train on a daily basis had attempted to return home by walking. The figure-7 indicates the amount of time spent for returning home. Most people spend about 2-3 hours and 30% of the people spent more than 5 hours.

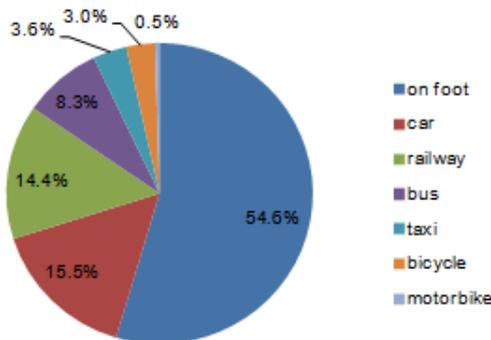


Figure 6. use transportation.

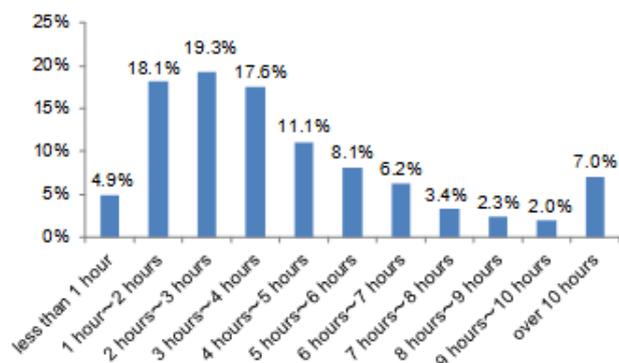


Figure 7. time required of go home.

3. ANALYSIS ON THE BEHAVIOR TO REMAIN

Firstly, we analyzed the final location of stay of those who stayed and those who moved. The figure-8 indicates the final location of stay organized according to the means of transportation. 83.4% of those who responded “attempted to move” indicated their own home as final location of stay while 71.2% who responded “to stay” indicated their companies as final location. From this observation, the affected people can be divided into two major categories. One is a segment for those who wish to return home and the other is a segment for those who stay.

Secondly, we analyzed the characteristics of the desired location of stay. In this study, we have distinguished three types of initially desired location of stay namely “home”, “other than home”, and “remaining”. The figure-9 shows the relationship between the linear distance to home and desired location of stay. The result indicated that less people wished to return home as the distance to home increased and more people wished to remain where they were. The result also showed that 27% of the affected people wished to return home even when their home was more than 40 km away.

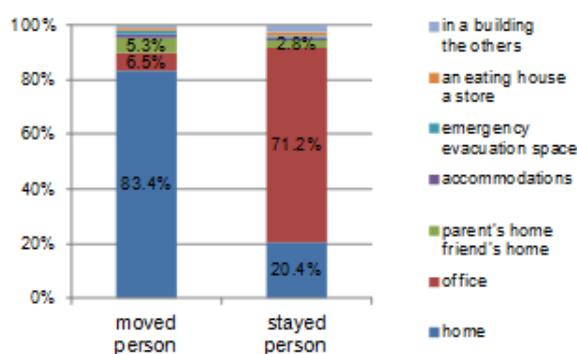


Figure 8. stay place of moved person and stayed person

4. BEHAVIOR ANALYSIS FUSING GPS DATA

We analyse commuters' behaviour under large scale disaster in Tokyo Metropolitan area. It became clear that stranded commuters' pass through the fire dangerous zone and building collapse zone for going his/her home. It is very dangerous for stranded commuters' under large scale disaster in Tokyo Metropolitan area as shown in fig.9 and fig. 10.

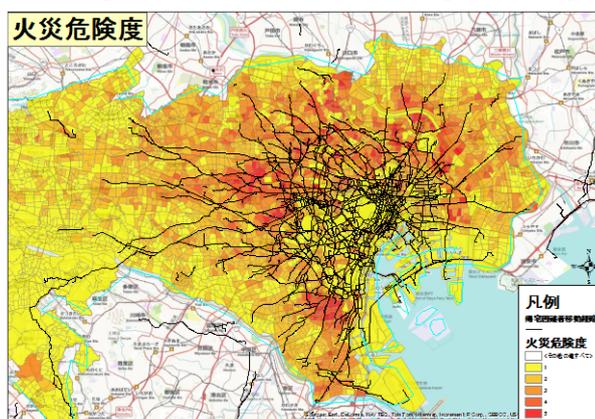


Figure .9 Behaviour route with fire zone

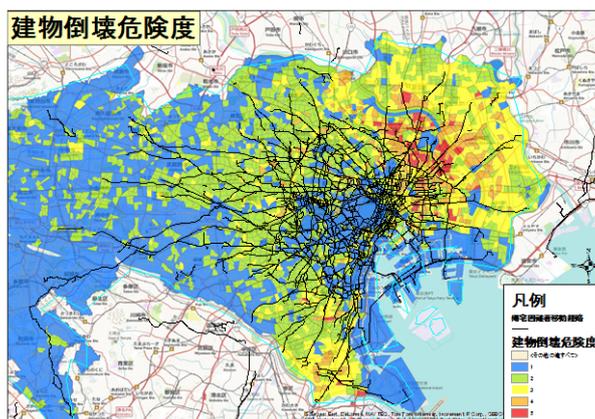


Figure .10 Behaviour route with building collapse zone

5. CONCLUSION AND FUTURE PROSPECTS

This study investigates the behaviour of the people having difficulties in going home after the 2011 off the Pacific coast of Tohoku Earthquake occurred.

As the result of this study, it becomes clear that approximately 70% of the affected people attempted to move and approximately 92% of those who attempted to return home managed to do it.

We clarified that many affected people had attempted to move and many of them succeeded in doing it. However, it is estimated that Tokyo Metropolitan Inland Earthquake would bring more severe condition such as shut down of transportation services, massive fire, building collapse, road congestions and so on.

Thus, in order to be prepared for coming large scale earthquake in Tokyo metropolitan area, it is necessary to develop effective countermeasures such as storing of necessary items and securing of safe places to stay, announcing the employees to remain until the transit system recovers, and establishing a procedure of safety confirmation of family members and friends.

On the other hand, it is desirable to prepare safe environment to return home for those who attempt to return home. In order to accomplish it, development of a method of safe evacuation is required, considering the disaster level, distance to a home, and personal attributes.

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