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Optimal shelter operation with sequential return of evacuees

Rapid disaster recovery through efficient shelter management

Abstract

Shelters are provided to evacuees whose homes have been destroyed in a disaster. In a recovery phase, efficient operation of the shelters is necessary to restore the facilities to their original use. In this study, we proposed a method to minimize the total cost of operating shelters and the burden of relocating evacuees between shelters by utilizing the return home time of evacuees. Our method allows the shelters to be used for their intended purpose as soon as possible after a disaster, thus enabling rapid recovery. Even when the number of evacuees is large, we introduced a variable that represents the number of evacuees grouped by the return home time so that the calculation can be performed efficiently. We also proposed a method to estimate the burden of relocating evacuees between evacuation shelters, thus achieving a balance between the operation costs of shelters and the relocation costs of evacuees. When disaster simulations are used to select response measures, it is not efficient to run through all the patterns of response measures exhaustively. By developing our method further, we aim to establish a simulation infrastructure that solves not only disasters but also various social issues through simulation.

Motivation

Evacuation Shelters are often set up in Schools, so they must be closed before schooling resumes

Shelters can be closed early if evacuees decreasing are relocated into shelters remaining

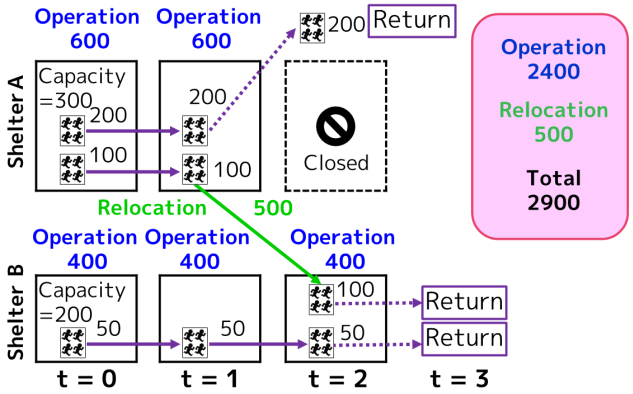
Evacuees' relocation cost "Want to continue to stay in neighbor shelter"

Shelters' operation cost "Want to close shelters and recover early"

We developed a method to minimize total costs

Key Point 1

The amount of calculation does not depend on # evacuees by grouping them with the same return time



Key Point 2

Relocation cost is estimated with historical disaster data (Kobe Earthquake) and the following assumptions

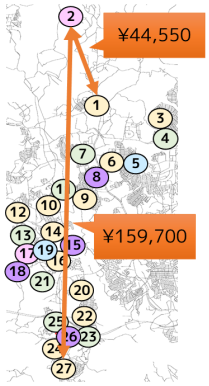
Assumptions

1. No relocation across the district
2. Proportional costs to the distance
3. Best operations at each time

Historical data
- # evacuees
- # shelter operated

→ Estimate

Relocation Cost (Burden): **10,000 yen/km** per capita

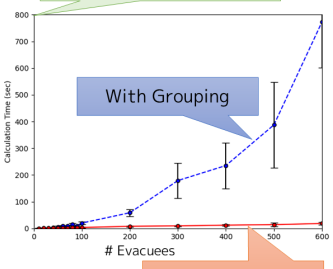


Experiments

Simulation Experiment of earthquake in Ikoma City

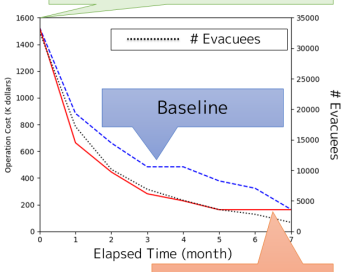
Proposed method reduced Calc. Time & Objective Cost

Calculation Time (sec)



Without Grouping

Operation Cost (x10^5 yen)



Proposed Method

Methods	Baseline	**Proposed**	
Operation Cost	¥4.9 x10^8	**¥3.5** x10^8	29% Cost cut in Operation
# Relocations	8259	3611	Reduced Relocation
Relocation Cost	¥8707 x10^4	¥5383 x10^4	

References

[1] H. Shimizu, H. Suwa, T. Iwata, A. Fujino, H. Sawada, K. Yasumoto, "Evacuation shelter scheduling problem," in *Proc. the 55th Hawaii International Conference on System Sciences (HICSS 2022)*, pp. 5705–5714, 2022.

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