Transportation and Geographic Information Science
Kuwahara Lab.

Normative behaviour based first-best analysis for disaster evacuation

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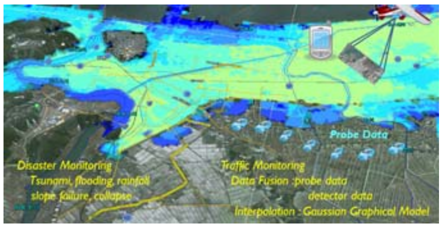
http://www.plan.civil.tohoku.ac.jp/kuwahara/index.php

Research Outline

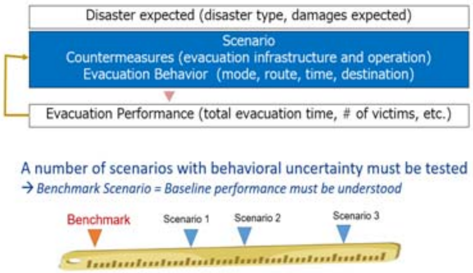
The most uncertain aspect in designing an evacuation plan is the evacuation behaviours of individuals in the immediate aftermath of a natural disaster. Hence, this study attempts to reduce behavioural uncertainty and proposes a first-best analysis assuming that all evacuees perfectly follow the best evacuation strategy that is termed as normative behaviour. Although the first-best performance may not be practical or feasible, it clearly shows the benchmark performance of evacuation planning. This type of a benchmark is quite useful to understand the relative performances of several more practical scenarios. The results indicate that the first-best strategy is obtained by solving a Linear Programming in a time-dependent manner.



Tsunami just after Great East Japan Earthquake
March 11, 2011

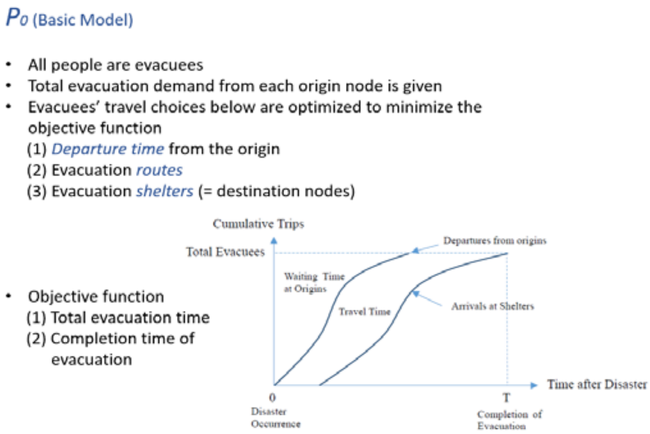
Definition of the First-Best Strategy

In a time-dependent fashion, this study defines the first-best condition as a condition without any queues on a network. This is due to the following reasons: (1) queues backing up on a network always block movement of other individuals, leading to an inefficient evacuation, and (2) even in the absence of queues, the network capacity can be fully utilised if bottlenecks on the network are maintained as busy. As shown below, without queues, the dynamic optimisation problem with many-to-many OD can be reduced to the LP formulation, which outputs the best departure time from an origin and the best routes to destinations for every evacuee to optimise the evacuation performance defined as the objective function of the LP.



Formulation of Linear Programming

Basic Model was first formulated in which the objective function involves the minimisation of total evacuation time subject to flow conservation under FIFO and non-negativity constraints. Both the objective function and all constraints are linear with respect to their unknowns (i.e. time-dependent link flows), and thus the dynamic problem becomes LP.



Extensions

- P_0 Shelter choice (Basic Model)
- P_1 No shelter choice
- P_2 Shelter choice + No shelter choice
- P_3 Trip chain (pick-up behavior)

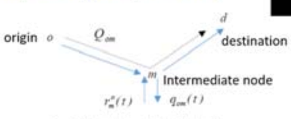


Fig. 2 Illustration of Trip-Chain Trip

- P_4 Risk on a way to a shelter
- P_5 Vehicle conflict with pedestrians
- P_6 Optimum share of vehicle and pedestrian trips

Extension: The basic model was extended to various situations such as considering link risks/damage, including trip-chains, considering conflicts between pedestrians and vehicles.

Application: The model was applied to Ishinomaki City, which was extensively damaged by the Great East Japan Earthquake to examine the model's computational feasibility and confirm the usefulness of the first-best analysis based on the normative behaviour.