An Activity-Based Multimodal Model Structure to assess Transportation Management Strategies for Urban Emergencies

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Introduction

Urban emergencies

Urban emergencies

Flooding, hurricanes, wildfires, tsunamis, large-scale traffic accidents, airplane crashes, industrial accidents, nuclear disasters, terrorist attacks, etc.

• Observed characteristics (one or more):
  • Substantial delays for everyday traffic
  • Presence of evacuation traffic
  • Emergency services trying to reach the disaster site

• Urban transportation system is easily overloaded
Introduction
How to control

- Transportation authorities need a strategy
- Candidate strategies need assessment
- Assessment requires a simulation model
- Assessment allows for optimisation

Three issues regarding assessment:
- Interface with transportation management problem
- Travel choices of affected population
- Network performance and travel times
The management problem

Overview

Decision variables

Objective

Constraints
The management problem

Decision variables 1/2

- Decision variables
  - Operational
    - Traffic light and ramp metering settings, dynamic speed limits, peak-hour and contraflow lanes, dynamic route information, public transport announcements, traffic regulators, emergency services, ...
  - Tactical and strategic
    - Departure advice, mode advice, destination advice, route advice, roadblocks, contraflow roads, temporary road construction, public transport, public shelters, ...

Challenge the future
The management problem

Decision variables 2/2

- Adaptiveness: take uncertainty into account
  - Operational variables: frequent real-time changes
  - Tactical variables: infrequent changes
  - Strategic variables: no changes

- However, the disaster plan must be unambiguous
  - Since assessment must be possible
  - For changable variables, the decision process must be codified
    - E.g. simple decision rules, model-predictive control, ...
The management problem

Objective and constraints

• Objective
  • Two main categories:
    • Non-evacuations: minimise delays
    • Evacuations: maximise evacuation effectiveness
  • Robustness: evaluate goal function for multiple scenarios to account for uncertainty
    • Prevents creation of overly optimistic disaster plans

• Constraints
  • Limitations of traffic management options
  • Quality/safety of rescue operations
  • Ethics
The management problem

Simulation model components

Evaluate the goal function

- Model travel choices
- Simulate network performance
Travel choice modelling

Why and how

- Used to determine expected loads on transportation system
- Used to see how authorities can influence these

- Activity-based
  - Generates a synthetic population with activity-travel schedules
  - Considers intra-household relationships
    - Important for evacuations
  - Continuously tracks location of individuals and vehicles
  - Can explicitly include relation between normal day and emergency situation

- Dynamic
  - Can study dynamic development of emergency situation
  - Can consider information availability
Travel choice modelling

Escalation model for household

**Normal**
- Follow activity-travel pattern from equilibrium situation
- Initial state of all households

**Adaptation**
- Adapt to experienced or anticipated delays
- Ranges from switching routes to rescheduling everything

**Evacuation**
- Danger is perceived and acted upon
- Household members gather and evacuate or seek shelter
Travel choice modelling

Example implementation

1. Perform everyday activities
   - Household in danger?
     - No: Adjust activity-travel schedules if necessary
     - Yes: Home still safest option?
       - Yes: Travel home
       - No: Evacuate to friend/hotel/shelter

2. Home is safe?
   - No: Evacuation
   - Yes: Normal Adaptation
Simulating network performance

Why and how

• Used to determine congestion levels and travel times

• Dynamic
  • Can study dynamic development of emergency situation

• Multimodal
  • Should be as multimodal as urban regions
    • Public transport could be effective means of evacuation

• Macroscopic (rather than microscopic)
  • Can be more parsimonious
  • Can be calibrated on macroscopic level
  • Is computationally more efficient
Simulating network performance
Choice component interaction

Serial execution
Normal day
Method of successive averages

- Choice (fraction of households)
- No choice (other households)
- Network loading

Modelled time

Parallel execution
Disaster scenario

- Choice
- Network loading

Modelled time

Normal day
Conclusion

Assess effectiveness of emergency transportation management strategy, by using a simulation model

- Allows robust testing of adaptive disaster plan
- Activity-based and dynamic choice model
- Dynamic, multimodal and macroscopic network performance model

What’s next?
- Model implementation (already started)
- Model calibration
  - Stated preference survey for choice model
- Coupling with optimisation module