Routing Diverse Crowds in Emergency with Dynamic Grouping

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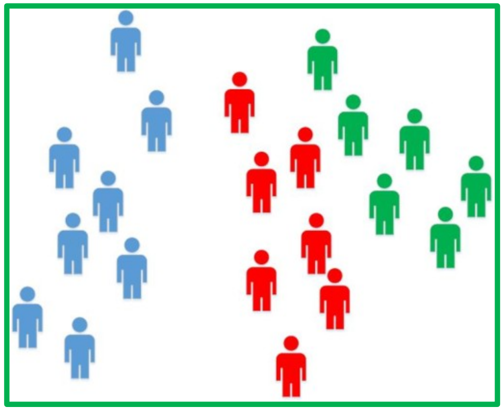
Routing Diverse Crowds in Emergency with Dynamic Grouping

Outlines

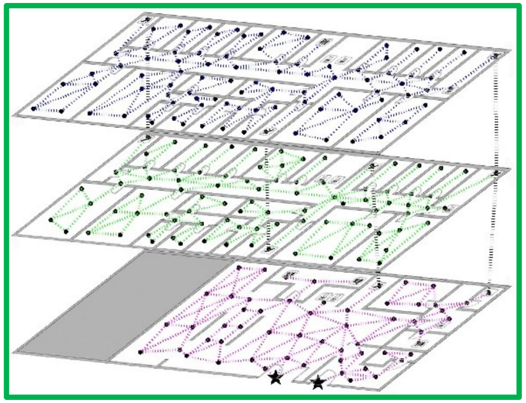
- Overview
- Related Work
- Cognitive Packet Network
- Routing Metrics
- Dynamic Grouping Mechanisms
- Simulation Model
- Experimental Results
- Conclusions

Overview

Objective



Graph model



Evacuee routing algorithms typically adopt one single criterion to compute desired paths and ignore the specific requirements of users caused by different physical strength, mobility and level of resistance to hazard

Our research aims to guide different classes of evacuees with respect to their specific requirements and dynamically switch their classes when certain conditions are fulfilled.

As an example of our approach, consider:

- A Graph: Representing three lower floors of Imperial College's EEE building
- Vertices: Significant locations, also called Points of Interest (PoI) such as doorways and corridors
- Sensors & Communication Units are placed at PoI
- Edges: Physical paths between PoI.

Related work

- Most emergency navigation algorithms focus on "normal" evacuees.

- Most emergency navigation algorithms concentrate on searching paths with one criterion, such as shortest paths or safest paths.

- Most emergency navigation algorithms persist on a single decision algorithm during the whole evacuation process.

Cognitive Packet Network

Cognitive Packet Network (CPN)

CPN node can adaptively collect information with "interested" counterparts.

CPN can rapidly solve optimal solution for any user-defined goal function

- Components
  - Smart Packets (SPs)
  - Acknowledgements (ACKs)
  - Dumb Packets (DPs)

Variations for evacuee routing problem

Unlike DPs, evacuees cannot be source-routed as they need path updates in case the initial path becomes dangerous or congested.

A movement depth value is used to ensure that every evacuee can receive a new route after traversing a given number of nodes.

Evacuee categories

Class one evacuees	Class two evacuees
 Includes evacuees within the age range 12 – 50 years with health level above 50.	 Includes evacuees with age < 12, >50 and class one agents whose health level falls below 50

- Two classes have different speed and resistance to fatigue and to the hazard
- The health level of every evacuee is always initialized to 100.

Routing Metrics

The routing metrics are the QoS goals that are pursued by SPs and optimised by the RNN algorithm.

Time metric

- The primary goal of this metric is to choose egress paths that minimise the evacuation times of the evacuees.
- Used for Class one evacuees (prime-aged adults)

$$G_t = \sum_{i=1}^{n-1} [\frac{E\big(\pi(i, i+1)\big)}{V} + \frac{q_i + t_i \cdot (a_i - d_i)}{a_i}]$$

Safety metric

- seek paths such that the evacuees are ahead of the spreading hazard
- Used for Class two evacuees (children and the elderly)

$$G_s = \sum_{i=1}^{n-1} [L[t_i - t_{haz}^i] \cdot c_i + s(\pi(i, i+1))]$$

Dynamic Grouping Mechanisms

Previous studies in emergency navigation persist on a single decision algorithm during the whole evacuation process and do not adjust in accordance with individuals' physical conditions and their immediate environments.

Health-aware grouping

- Any Class one evacuee whose estimated health level has dropped below 50% of its original value will be immediately considered as a class two evacuee

Congestion-aware grouping

- If the queue length at a vertex is larger than or equals to a certain value, the related DN will re-assign the newly arrived evacuee to the congestion-ease group and suggest a less congested path with acceptable main QoS value

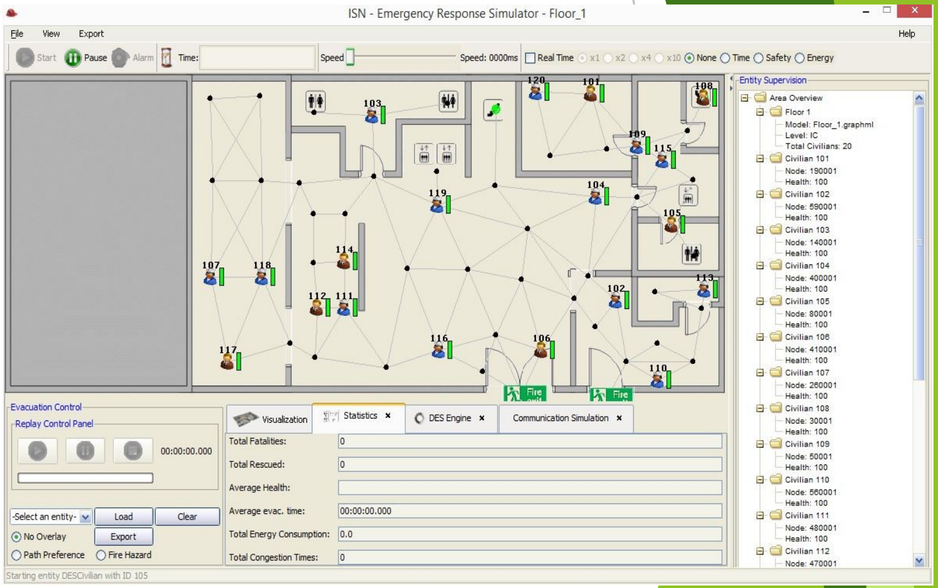
Simulation model

Distributed Building Evacuation Simulator

- Agent based.
- Graph based.

Assumptions

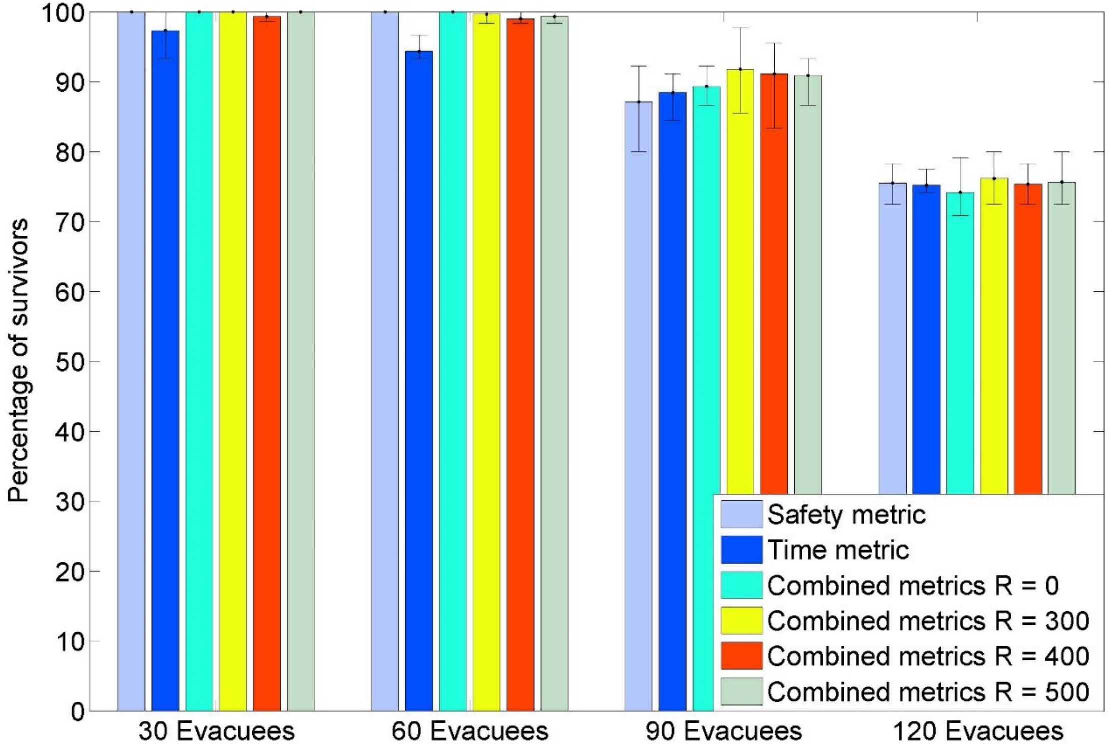
- Sensor nodes and decision nodes deployed at POI
- Suggestion transferred to evacuees through portable devices or visual indicators
- Fire starts near a main channel.
- Evacuees are randomly scattered in the building.
- Civilians alerted of fire outbreak



Experiments

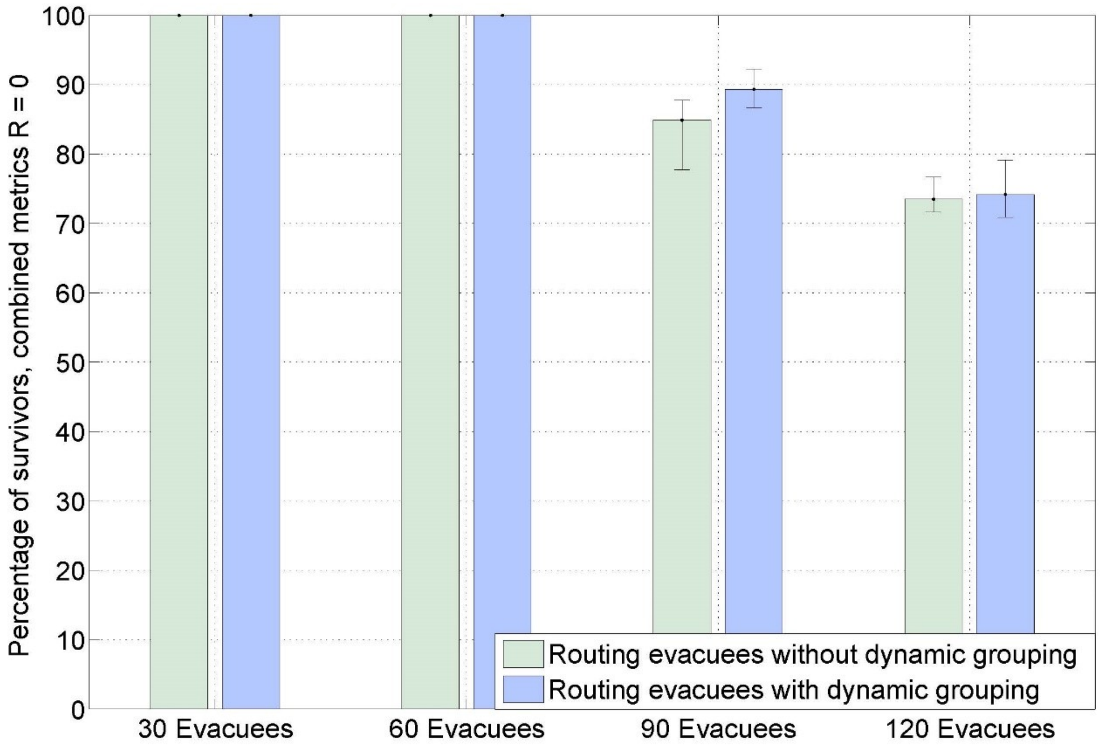
Experiment	Evacuee type	Aim
CPN with safety metric (SM)	Class 1; Class 2	Safest path
CPN with time metric (TM)	Class 1; Class 2	Quickest path
CPN with safety and time metric (CM) without spatial information	Class 1; Class 2	Quickest path; safest path
CPN with safety and time metric (CM) with spatial information (R = 300cm)	Class 1; Class 2	Quickest path; safest path
CPN with safety and time metric (CM) with spatial information (R = 400cm)	Class 1; Class 2	Quickest path; safest path
CPN with safety and time metric (CM) with spatial information (R = 500cm)	Class 1; Class 2	Quickest path; safest path

Results: Average Percentage of Survivors



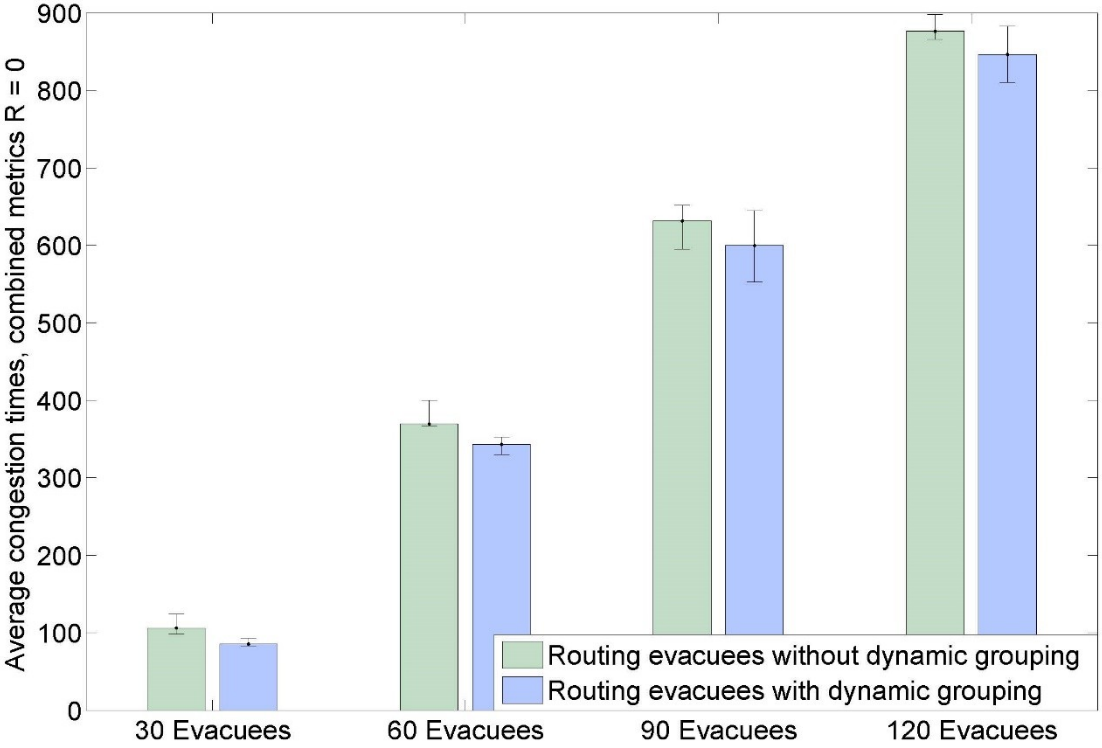
- CPN with combined metric (CM) gains better results than other algorithms and CM with R = 300 achieves the overall best performance. This reflects that the range of spatial hazard information (R) can affect the system performance.

Results: the effect of dynamic grouping



- The figure compares the average percentage of survivors between routing evacuees with and without dynamic grouping
- The results indicate that the use of dynamic grouping can improve survival rate in densely populated environments.

Results: the effect of dynamic grouping



- The figure compares the count of congestion between routing evacuees with and without dynamic grouping
- As expected, the use of dynamic grouping can reduce the congestion level of evacuee flows.

Conclusions

- Routing diverse evacuees with respect to their specific requirements can provide improved survival rates.
- The use of dynamic grouping mechansims can achieve higher survival rates and ease congestion.

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Thank you!