# A Dynamic Indoor Field Model for Emergency Evacuation Simulation

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# Content

# Background

The research has been conducted by Xiong,Zhu, DU, Zhu, Zhang, Niu, Li, and Zhou, and they collected the data from the Yujiabao train station in China.

According to a statistical analysis of fire accidents in high-rise buildings in China in 2013:

1. 388,000 buildings fires caused 1637 causalities and
2. a total loss of 0.71 billion dollars in property damage

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1. The complexity of the indoor scene
2. The diversity and dynamics of human behavior, and
3. Highly effective evacuation analysis

# Basic indoor spatial model

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1. Interior structure and dynamic emergency
2. Dynamic changes among indoor objects, and
3. Congestion and stagnation prediction

# Elements Required for Indoor Emergency Evacuation

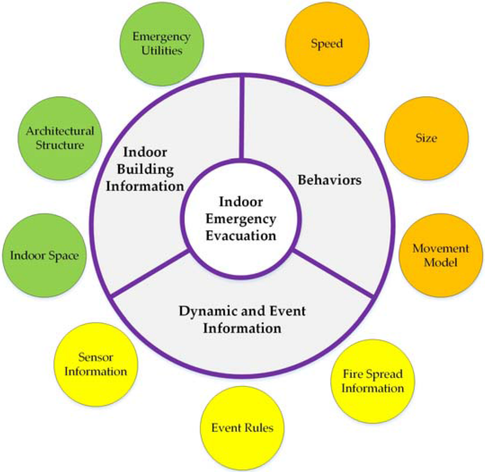


Figure: Fig 1.Dimensions of indoor emergency evacuation

# Findings

Based on the dynamic indoor field model (DIFM),the researchers found that a 3D network can reduce the evacuation time up to **33 percent**.

# Mathematical Approach

$$\mu_i = \begin{cases} 1.4 & \rho \leq 0.75 \\ 0.0412\rho^2 - 0.50\rho + 1.867 & 0.75 < \rho \leq 4.2 \\ 0.1 & \rho > 4.2 \end{cases}$$

$\rho = \frac{n}{Area}$

Where $\mu_i$ is the speed of an evacuee in m/s, and

$\rho$ is the referencing crowd density in persons/m$^2$, *and*

n represents number of people

$$\omega_{utility} = \begin{cases} 0.0 & \text{grid is not covered by utilities} \\ 1.0 & \text{utility is a water resource} \\ \frac{s}{dis(u)} & \text{grid is cover by fire utility} \end{cases}$$

Where $\omega_{utility}$ is the utility weight of grids, $dis(u)$ represents the distance to the fire utilities, and $s$ is the grid's geometric size

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Where $\omega_{utility}$ is the utility weight of grids, *dis(u)* represents the distance to the fire utilities, and $s$ is the grid's geometric size

$$\omega_{detector} = \begin{cases} 0.0 & \text{grid is not covered by detectors} \\ -\frac{s}{dis(d)} & \text{grid is cover by detectors} \end{cases}$$

Where $\omega_{detector}$ is the detectors weight of grids,and *dis(d)* represents the distance to the detectors,

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$$\omega_{fire} = \begin{cases} 0.0 & \text{grid is not in fire field} \\ -\frac{s}{dis(f)} & \text{grid is in fire field} \end{cases}$$

Where *dis(f)* is the distance to the fire

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## Final weight of a grid

$$\omega_{grid} = \omega_{utility} + \omega_{detector} + \omega_{individual} + \omega_{fire}$$

The two ways that grid weight can be 0.0

1. The grid is not occupied by utilities.
2. The grid is covered by fire utilities and water resources

# Building potential evacuation route

Optimized route from individual's location to a building exit can be calculated by A* search algorithm

A* is a search algorithm that is widely used in path finding and graph traversal, the process of plotting an efficiently traversable path between points, called nodes.

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$$Route(i,j) = f(Grid, L_{(i,j)}, E_{(i,j)})$$

$$Route_{individual} = \sum Route(i,j)$$

# How A* search algorithm works?

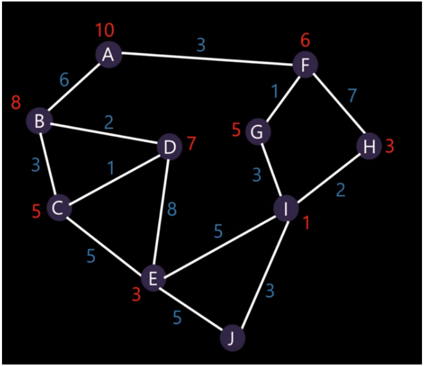


Fig 2.A* search algorithm

Find the shortest path between A and J.

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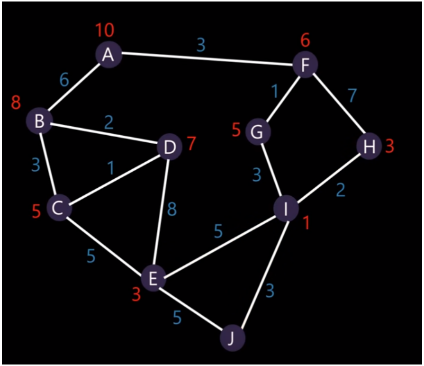


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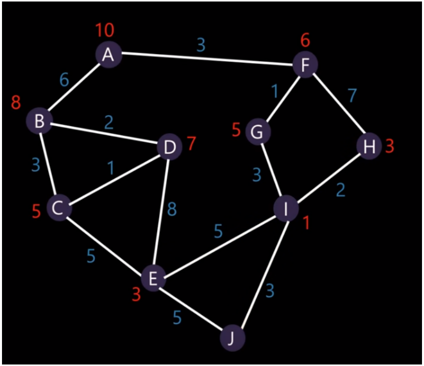


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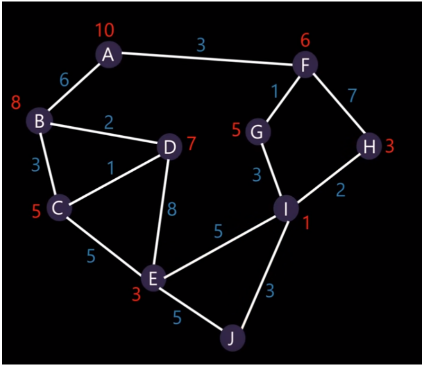


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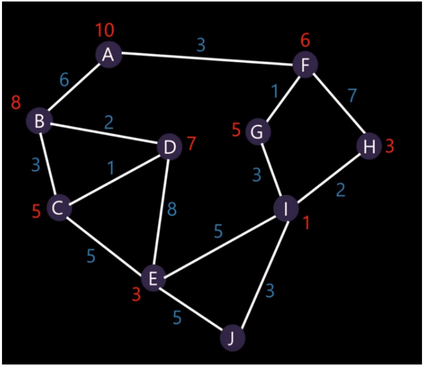


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f(F)= 3+1+5=9 or 3+7+3=13

f(G)= 3+1+3+1=8

f(I)= 3+1+3+2+3=12 or 3+1+3+5+3=15 or 3+1+3+3=10

# Identifying potential congestion and stagnation

$\rho = \frac{n}{Area}$

$$Situation = \begin{cases} Congestion & \rho \in [1.5, 2] \\ Stagnation & \rho > 2.0 \end{cases}$$

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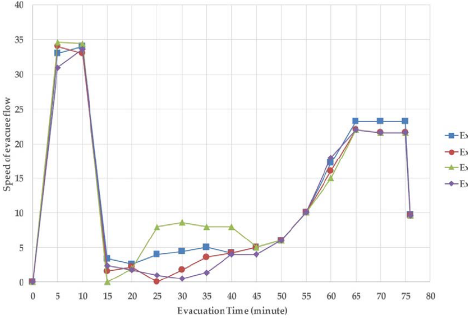
**Re-calculate evacuation route**

When congestion and stagnation occur around exits, the evacuation route must be re-calculated.

# The new method Vs the previous method



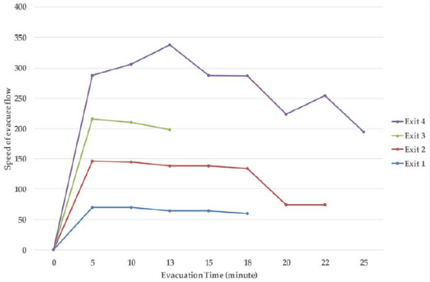




Fig 3. Speed of evacuee passing through each exist in the station with a previous model

Fig 4. Speed of evacuee passing through each exist in the station with the new 3D model

# Future Studies

1. The proposed model can be easily applied to outdoor environments.
2. Apply a detailed fire dynamic model (FDS).
3. Further study on crowd flow

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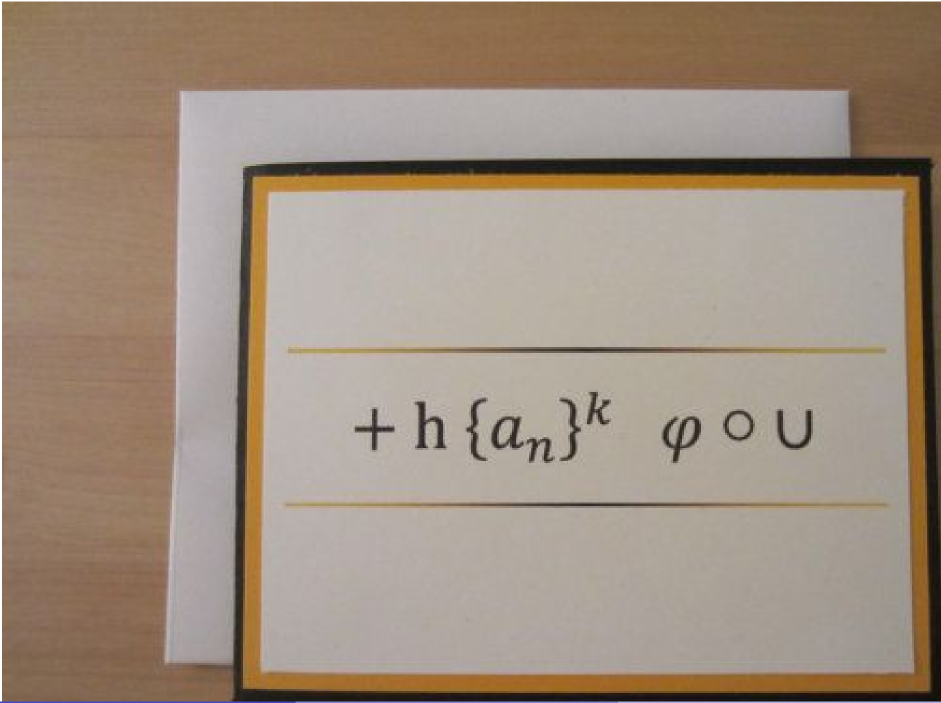
# Reference


- Xiong, Qing and Zhu, Qing and Du, Zhiqiang and Zhu, Xinyan and Zhang, Yeting and Niu, Lei and Li, Yun and Zhou , Yan (2017), *A dynamic indoor field model for emergency evacuation simulation*, ISPRS International Journal of Geo-Information,
- Nosrati, Masoud and Karimi, Ronak and Hasanvand, Hojat Allah (2012), *Investigation of the*(star) search algorithms: Characteristics, methods and approaches*, World Applied Programming, pp. 251–256.


Q&A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