Crowd Evacuation

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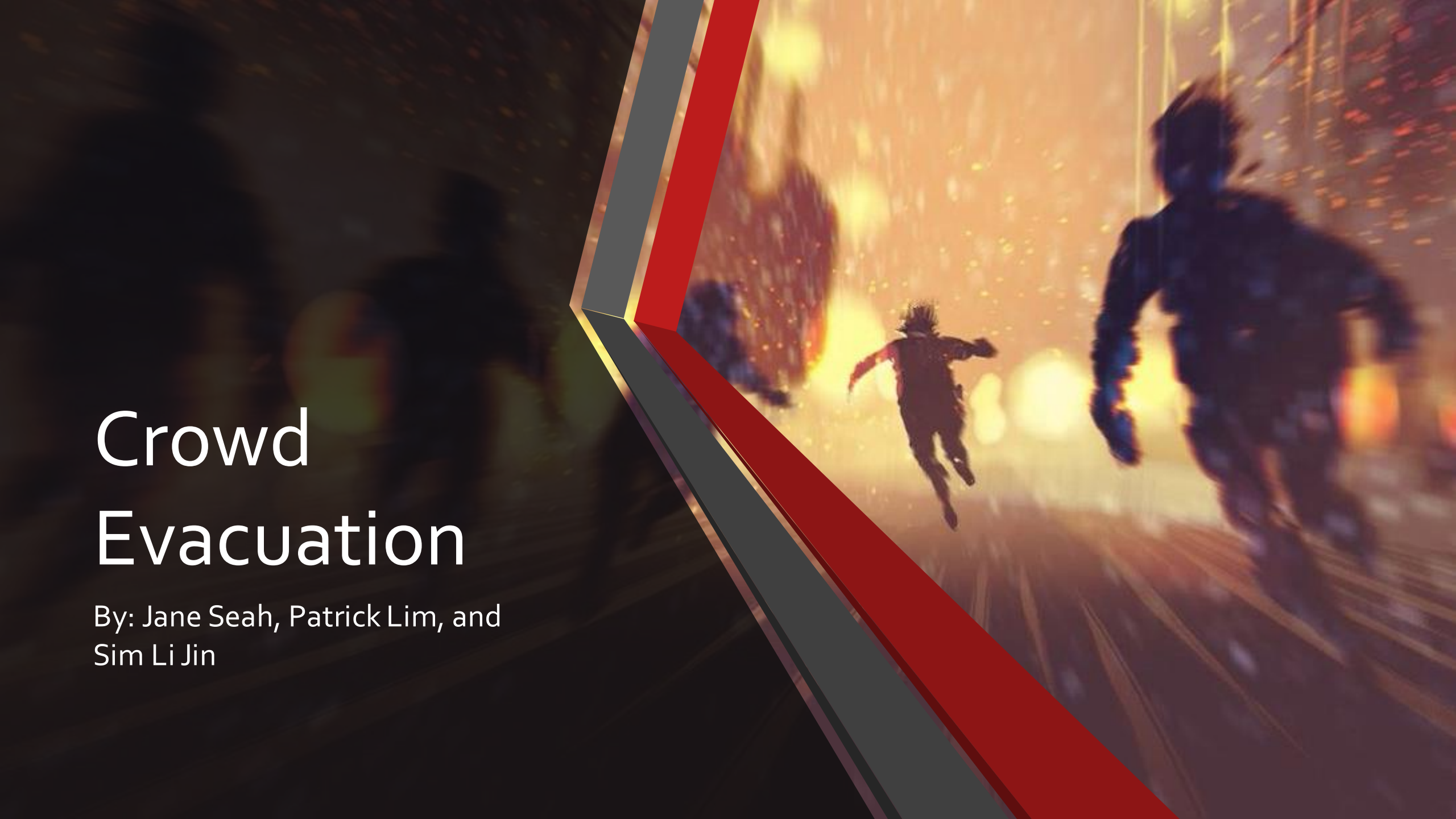


Agenda

- Problem Statement
- Literature Review
- Hypotheses
- Model
- Parameters
- Results
- Evaluation
- Conclusion

Problem Statement

- Crowd behavior in emergency situations difficult to simulate
- Fire drills don't really consider panic conditions
- Impossible to get real people to simulate such events
- Able to model each human individual as an agent with varying characteristics

Relevance of this Problem (News Article)

Rap Concert Stampede in Italy Leaves 6 Dead, Over 50 Hurt

12/8/2018 by Associated Press

AP Photo/Bobo Antic

Two girls comfort each others outside disco Lanterna Azzura in Corinaldo, on Dec. 8, 2018.

At least 717 dead, 863 hurt in stampede at haj near Saudi Arabia's holy city of Mecca

PUBLISHED SEP 24, 2015, 4:30 PM SGT | UPDATED JAN 19, 2016, 2:09 PM

MINA, Saudi Arabia (AFP) - A stampede killed at least 717 people and injured hundreds more at the haj in Saudi Arabia on Thursday, in one of the worst-ever tragedies at the annual Muslim pilgrimage.

The stampede, the second deadly accident to hit the pilgrims this month following a crane collapse in Mecca, broke out in Mina during the symbolic stoning of the devil ritual, the Saudi

2 women die in KL market stampede for free food coupons

PUBLISHED JAN 30, 2019, 5:00 AM SGT

KUALA LUMPUR • A stampede in a Malaysian market that killed two elderly women as people rushed to collect free food coupons will be investigated by police, an official said yesterday.

Almost 1,000 people descended on the indoor market in Kuala Lumpur on Monday to get their hands on 200 vouchers for a buffet meal during next month's Lunar New Year festivities.

Two women aged 85 and 78 collapsed in the crush.

Attempts by paramedics to resuscitate them failed and they died at the scene, police said.

Two other women who fainted during the rush to collect the vouchers, which were being given away by those running the market, were revived.

Such stampedes are uncommon in Malaysia, which is relatively affluent in comparison to other parts of South-east Asia.

A security guard described chaotic scenes, telling The Star newspaper people were "pushing each other" to collect the coupons, and some were screaming.

36 killed, 47 injured in New Year stampede in Shanghai

(chinadaily.com.cn)

Updated: 2015-01-01 03:00

Relatives of a victim hug as they wait at a hospital where injured people of a stampede incident are treated in Shanghai, Jan 1, 2015. [Photo/Agencies]

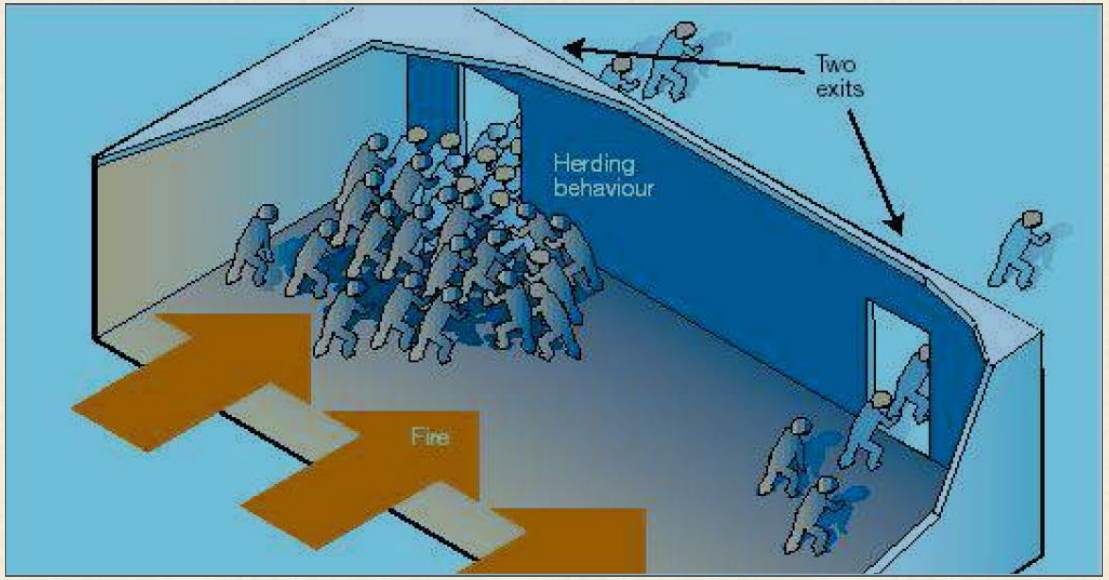
VIDEO (How serious is this Problem)

Literature Review

Abu Bakar, Noor Akma & Adam, Khalid & Majid, Mazlina & Allegra, Mario. (2017). ***A simulation model for Crowd Evacuation of Fire Emergency Scenario.*** *10.1109/ICITECH.2017.8080027.*

- **Panic**
  - Irrational behavior (i.e. pushing)
  - Inability to think logically

- **Herding behavior**
  - Tend to follow others, assuming others could lead them to safety

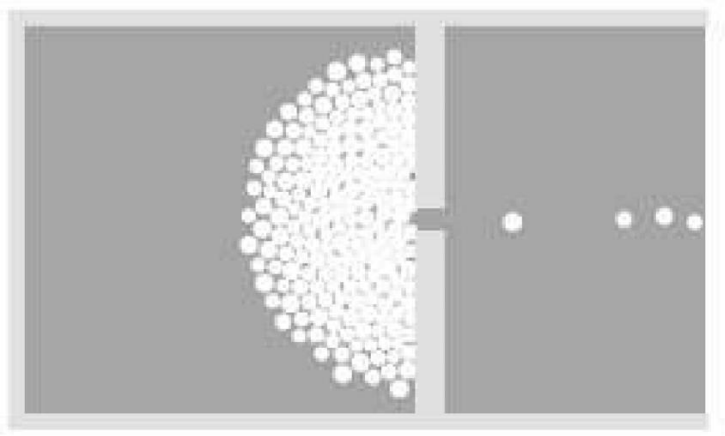


Literature Review

Almeida, J., Rosseti, R., & Coelho, A. (2013). ***Crowd Simulation Modeling Applied to Emergency and Evacuation Simulations using Multi-Agent Systems****.*

Arching

- Happens when big crowd with high velocity tried passing through an exit
- Exit gets clogged and crowd gets arch-shaped
- Ends up taking much longer to exit



Literature Review

Dykiert, D., Der, G., Starr, J. & Deary, J. (2012). ***Sex Differences in Reaction Time Mean and. Intraindividual Variability Across the Life Span****.*

Results

- Male has a faster reaction time as compared to female
- During childhood, there is an increase in speed while a decrease in variability in reaction time

Literature Review

Ngai, K.,Burkle, F., Hsu, A. & Hsu, E. (2009). ***Human Stampedes: A Systematic Review of Historical and Peer-Reviewed Sources****.*

Findings

- Physical interactions in jammed crowd can add up to pressures up to 4450 N/m^2, which can bend steel barriers or push down brick walls
- People show tendency mimicking what other people do

Hypotheses

- The floating platform is not safe enough to allow all the spectators to escape during emergency.
- Lack of knowledge of the floating platform layout is the greatest causes of casualties.
- Young children and the elderly are less likely to survive such emergencies.

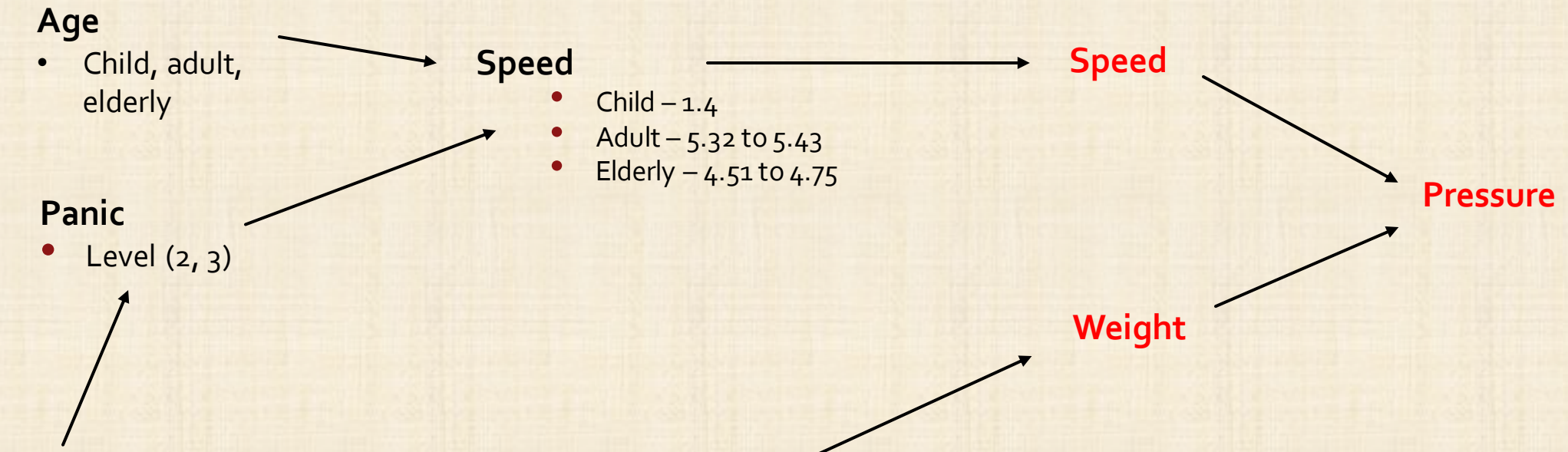
Justification for Multi Agent System

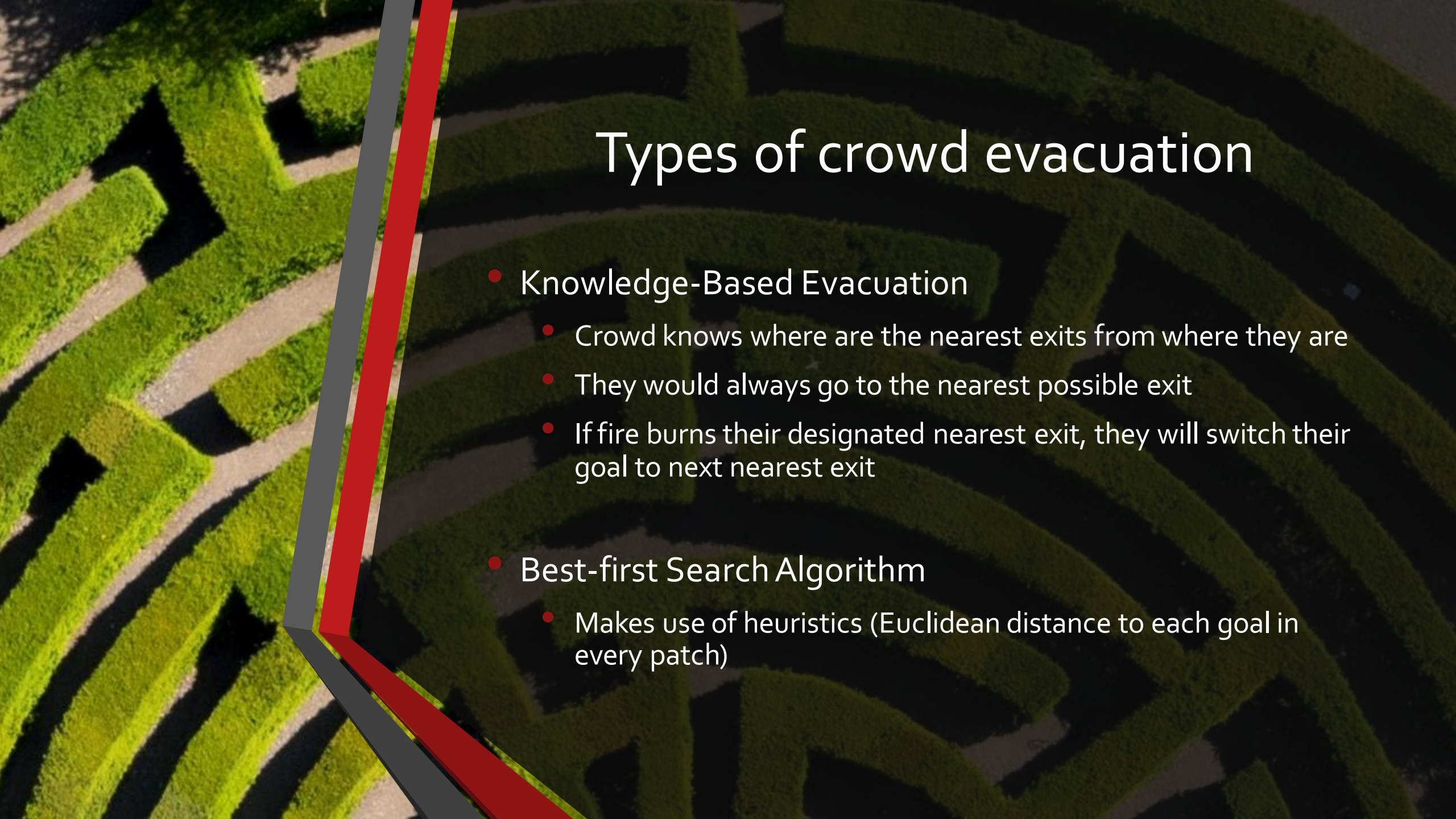
- Model each human individual as an agent with its own varying characteristics and interactions with a virtual environment and with other agents.
- Each agent has a limited **vision** of the world
- Simulate how the human agents continuously sense the surrounding environment to make decisions based on their own rules.
- The crowd social behaviour can then be collectively observed as the emergent phenomena.
- Need to analyse impact of behavioural factors such as panic
- Using MAS will help to more accurately model the decision-making processes present in real-world crowd behaviour in emergency situations.

Model

- Modeled using the floating platform @ Marina Bay
- Resized from 30k capacity to 14,178 capacity
- Simulated bottom of staircases as exit points
- Survivors would try to escape from the fire that has been started at random positions

Survivor Parameters





Types of crowd evacuation

- Knowledge-Based Evacuation
  - Crowd knows where are the nearest exits from where they are
  - They would always go to the nearest possible exit
  - If fire burns their designated nearest exit, they will switch their goal to next nearest exit
- Best-first Search Algorithm
  - Makes use of heuristics (Euclidean distance to each goal in every patch)

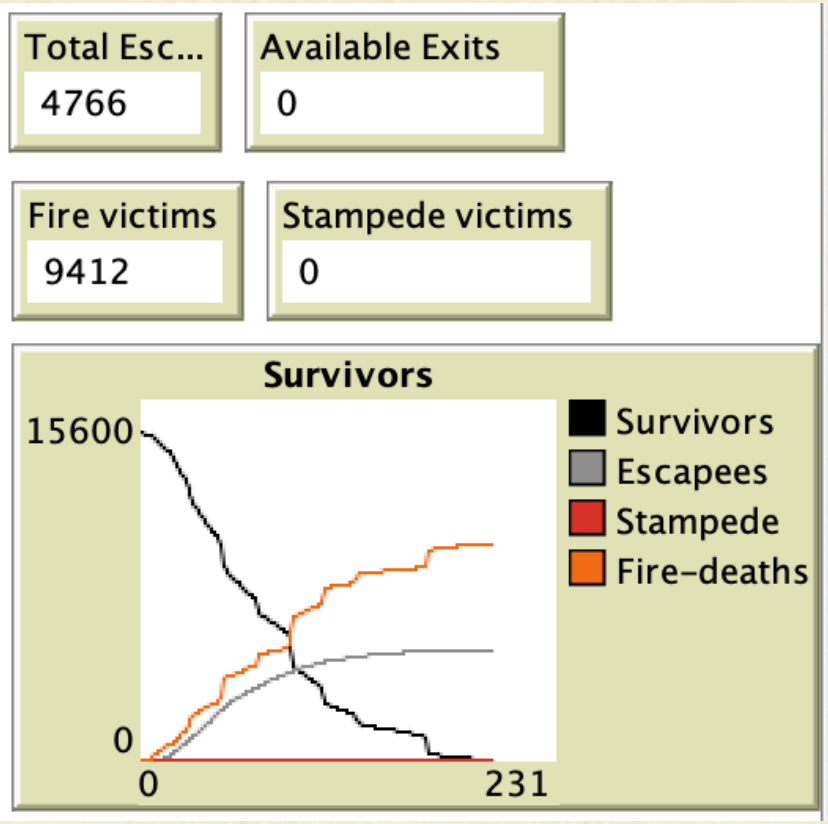
Types of crowd evacuation

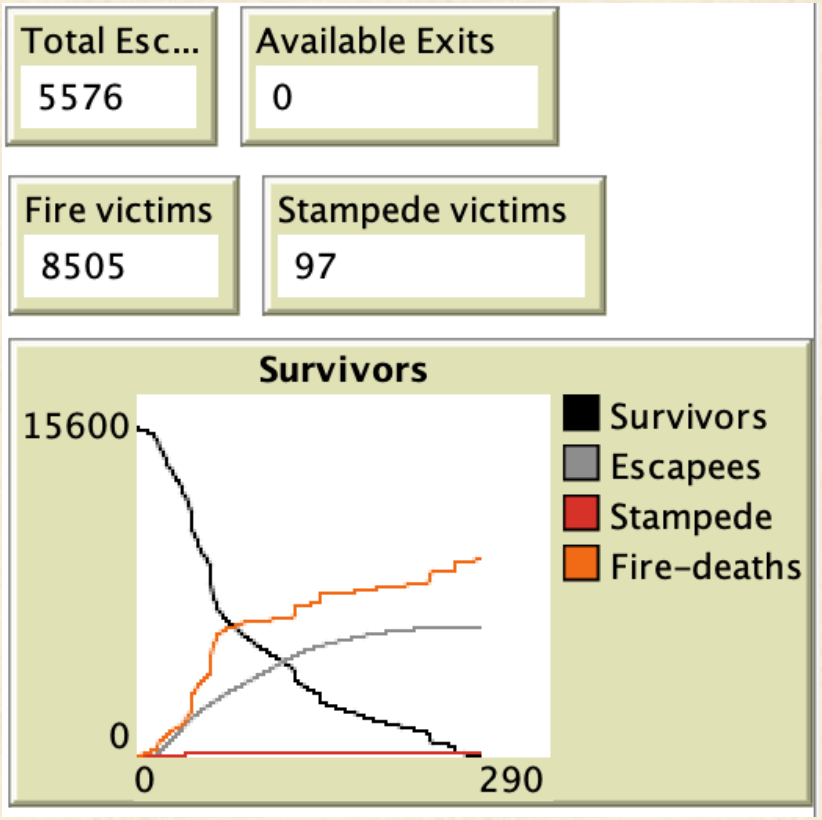
- **Normal Evacuation (Guided by Vision)**
  - Vision (checking patches in-radius)
    - People who see fire will run in opposite direction
    - People who see people running will run in same direction
    - People who see exit will go for exit

Demonstration

Results

Pure Knowledge without Panic **VS** **Knowledge with Panic**

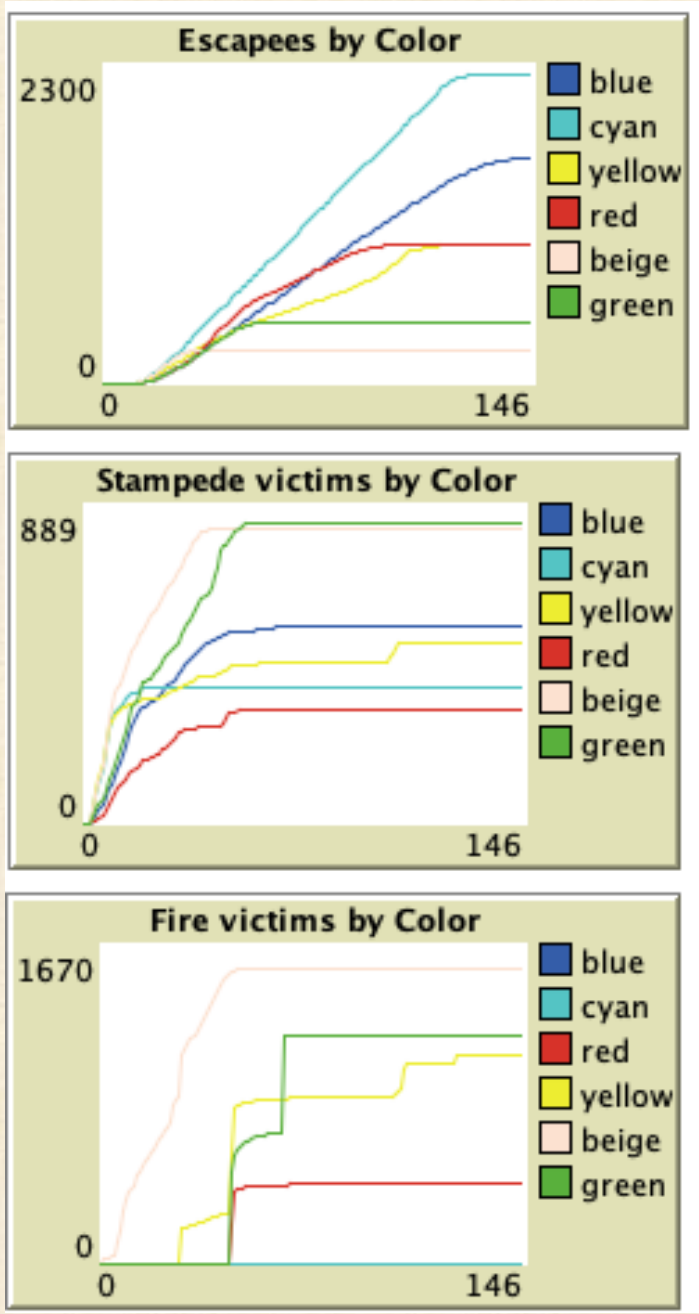




Results

Which Area Is More Prone to Casualties

- Plot Number of each people from each seating zones
- Identify if there is correlation between seating zones and various causes of casualty



Conclusion

- Panic is the key factor that causes deaths from stampedes.
- Different strategies are employed by survivors depending on the knowledge they have of the exit locations.
- Explore more ways of how human movement can be modelled
  - Groups of people who may move together
  - Panic can result in irrationality – random walking
- Running simulations before accidents happen
- Explore on how the environment would affect the people from leaving the place (choke points)

The End

Any questions?