Pedestrian Evacuation Dynamics in Public Spaces

Understanding the Impact of Environmental Familiarity and Intervention Strategies

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(Group 13)

01

Introduction

Problem description and
importance of the research

Escalating Challenges in Public Space Evacuations

- Rising Attendance
- Crowded Environments *(Lui, 2018)*
- High density risks
- Catastrophic incidents may occur *(Yuan and Tan, 2009)*

Figure 1. *Freepik. (n.d.). A large crowd of people inside a mall. Freepik. https://www.freepik.com/premium-photo/large-crowd-people-inside-mall_2386643861.htm*

Research question:

How do varying levels of environmental familiarity and the implementation of intervention strategies influence the speed of crowd evacuations in public spaces under an emergency situation?

Emerging behaviour

- Activation and movement
  - Attraction towards exits
- Social force *(Helbing and Molnar, 1995)*
  - Repulsion
- Novelty of our model:
  - Environmental familiarity → Knowledge spread

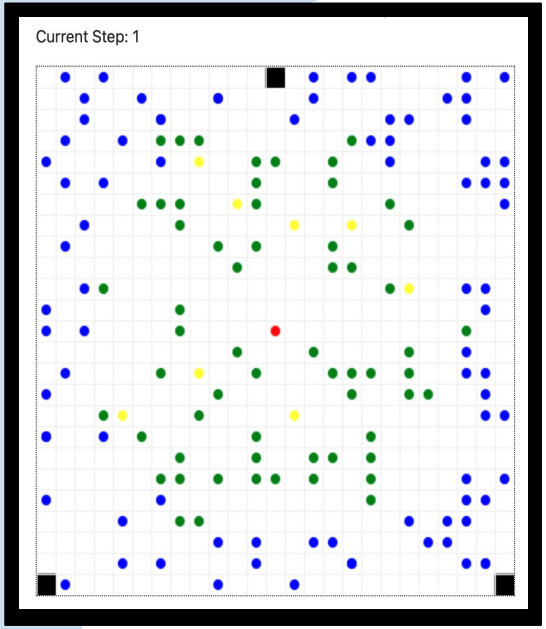
Importance of an agent-based modelling approach

- Complexity and heterogeneity of Pedestrian Behavior
  - Knowledge variance
  - Social preferences
- Interaction between individuals
- Influencing external factors/ environment
- Spatial localization

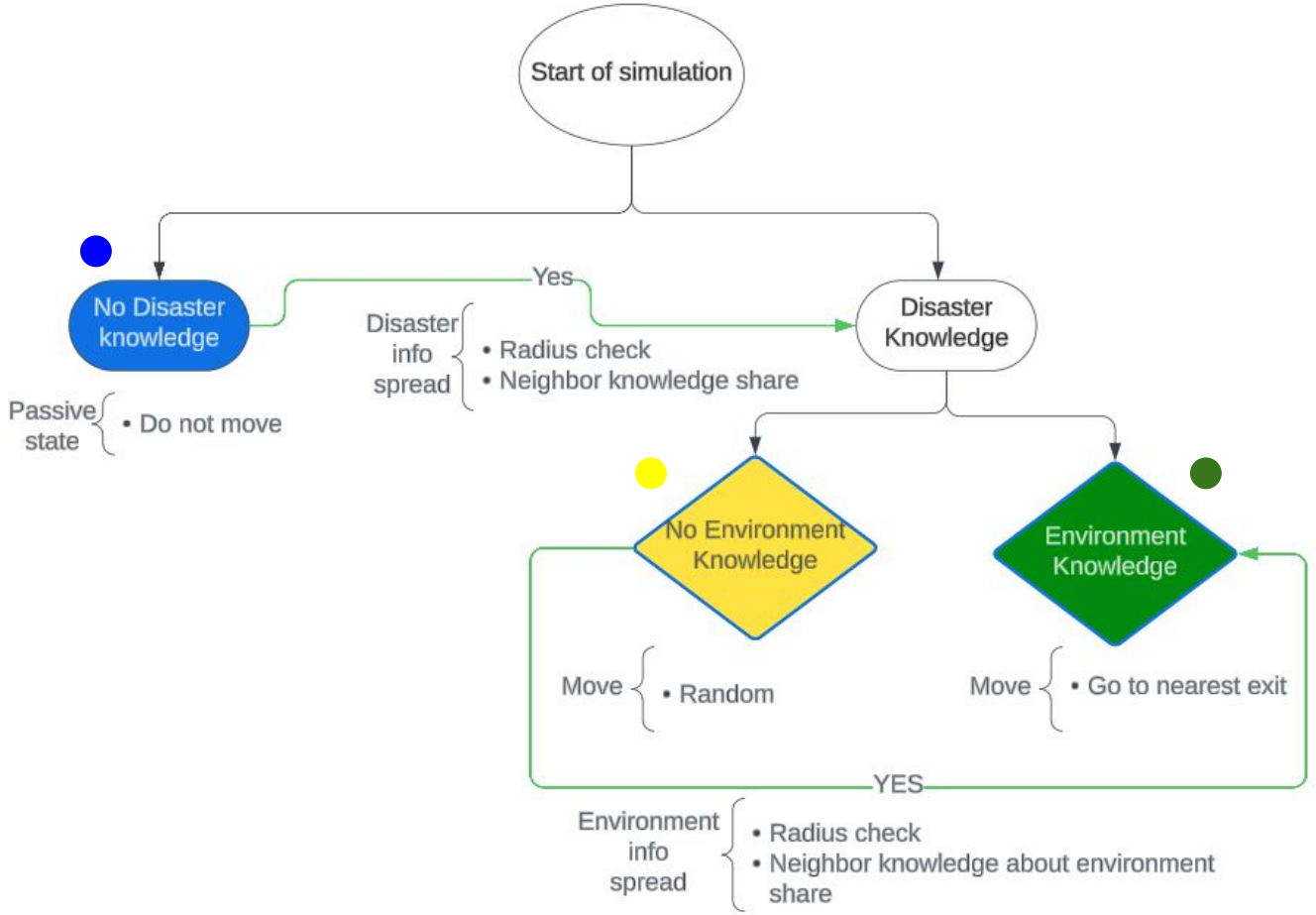
(Bonabeau, 2002; Zia and Ferscha, 2020)

02

Model implementation



Model description



Disaster

Exit

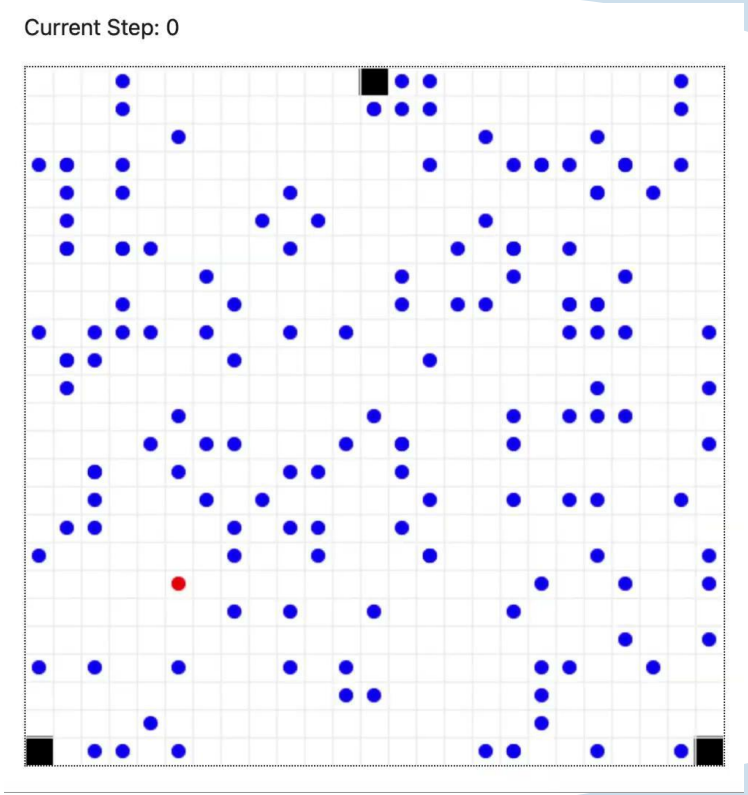
Movement of agents

- Attraction to one exit
- Social repulsion force

$$\begin{cases} \frac{dx}{dt} &= v \\ \frac{dv}{dt} &= F_{goal} + F_{social} \end{cases}$$

$$F_{goal} = (\vec{v}^0(t)\vec{e}^0(t) - \vec{v}(t))/\tau$$
$$F_{social} = -\nabla_{\vec{r}_{\alpha\beta}} \exp(-b(\vec{r}_{\alpha\beta}))$$

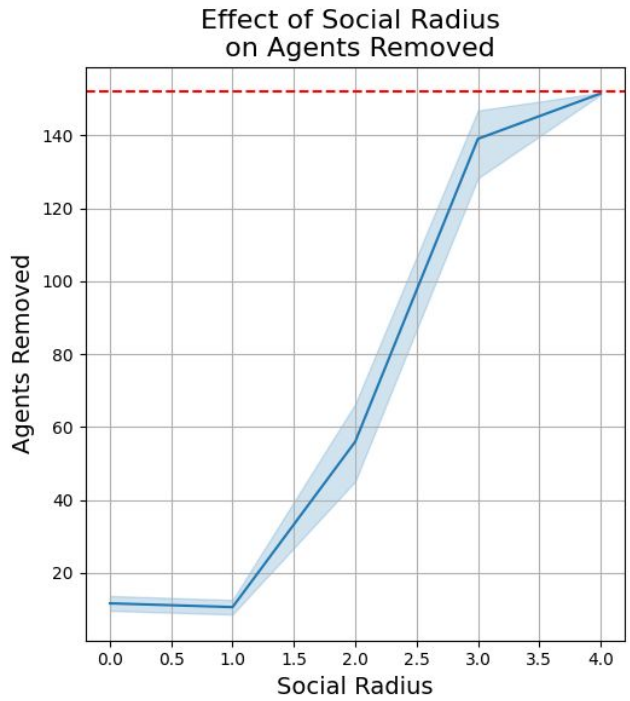
$$2b := \sqrt{(||\vec{r}_{\alpha\beta}|| + ||\vec{r}_{\alpha\beta} - v_\beta \Delta t \vec{e}_\beta||)^2 - (v_\beta \Delta t)^2}$$

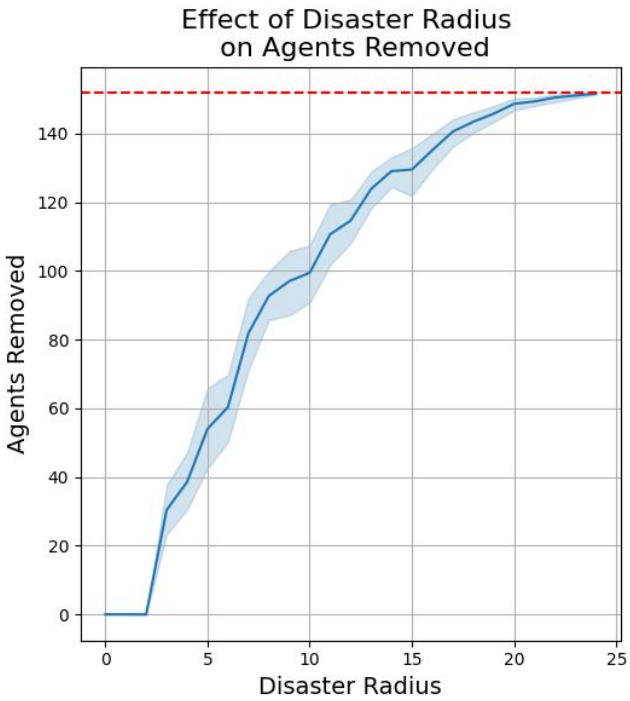


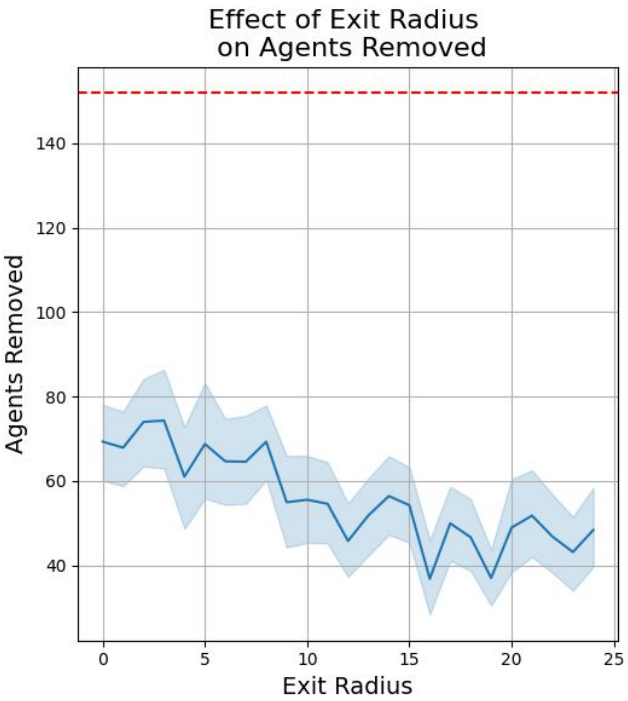
03

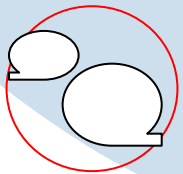
Experimental setup and Results

Local sensitivity analysis

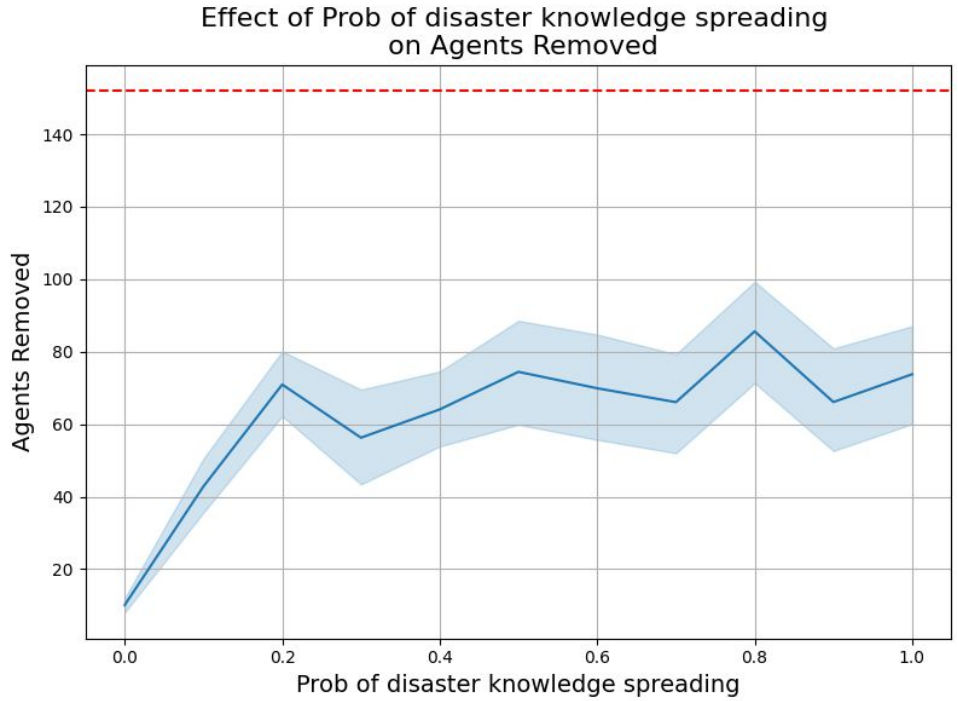


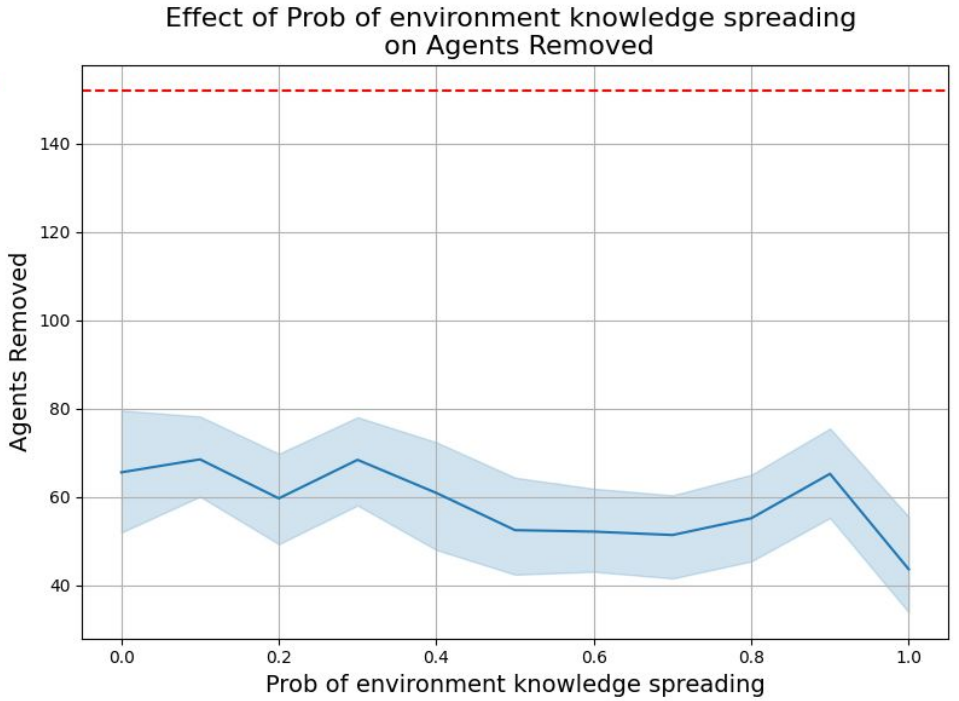






Local sensitivity analysis





Total Agents

Experiments

Environmental Familiarity

- No prior knowledge of environment
- Empirically skewed thresholds for prior knowledge

Testing parameters

Number of agents :
- Evacuated
- Knowledge of exits
- Knowledge of disaster
- Speading knowledge
- Changing exit choice

Intervention Strategies

- Signage
- Disaster Announcement
- Evacuator

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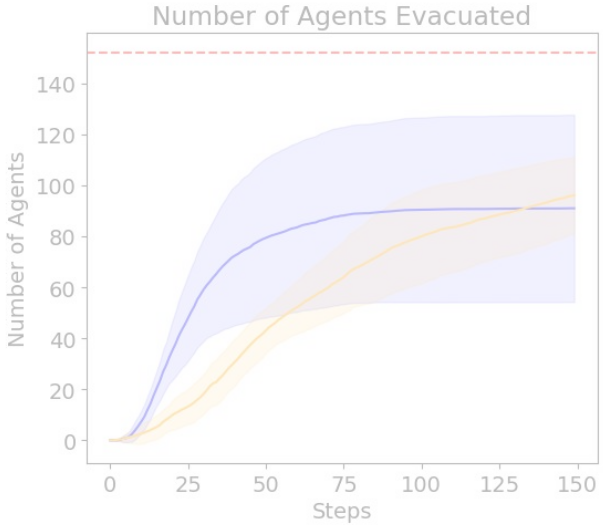
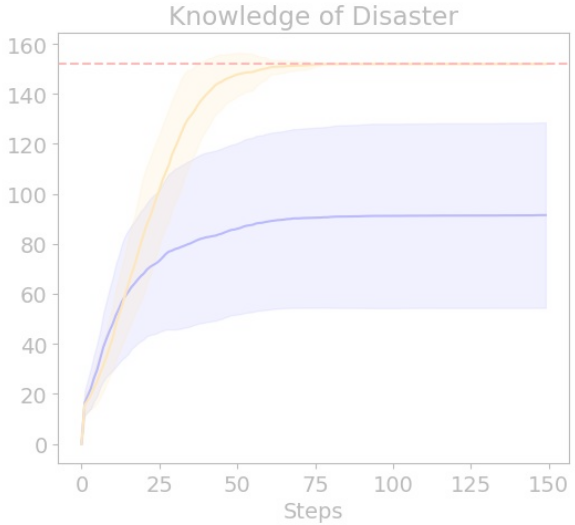
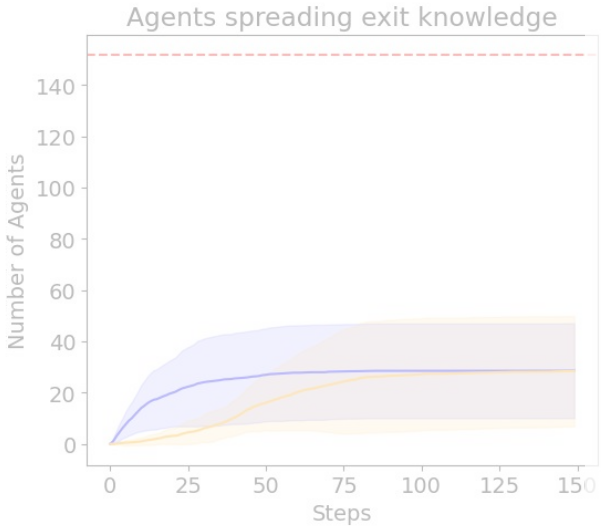
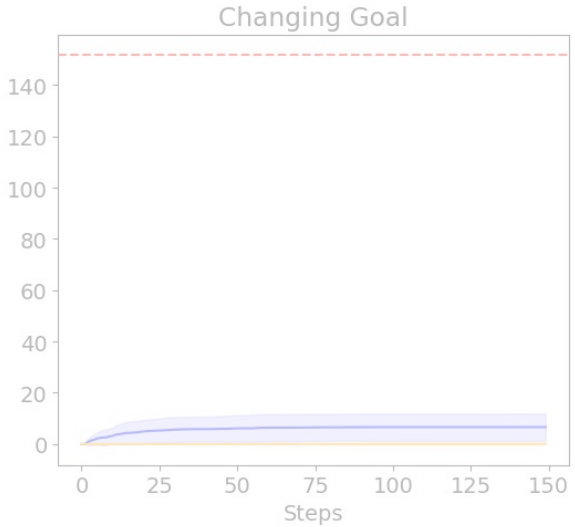
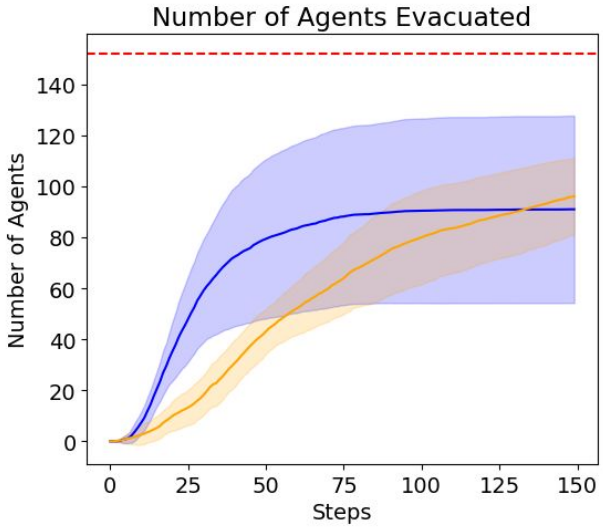


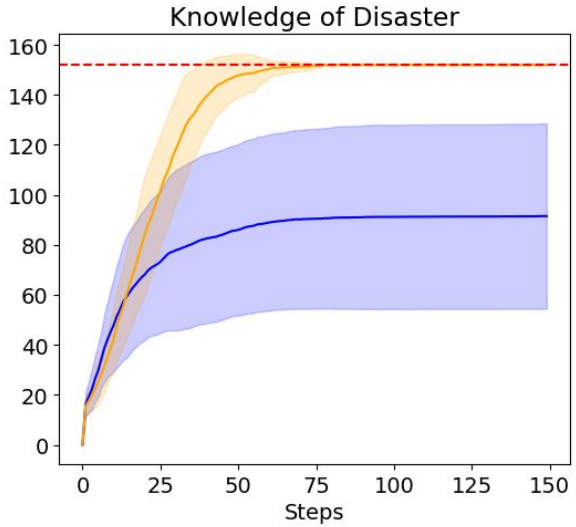


Environmental Familiarity









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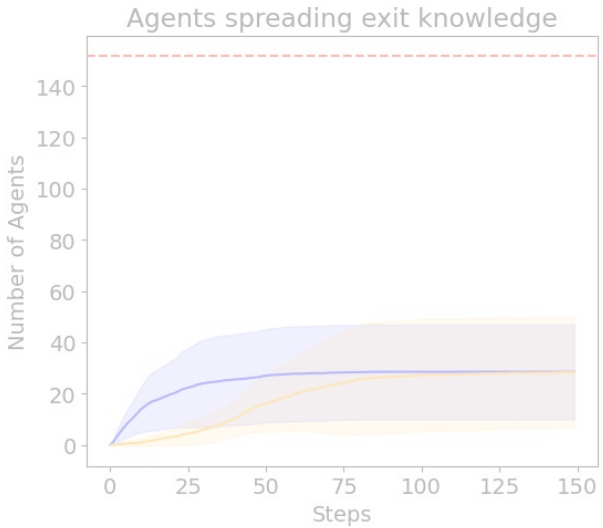

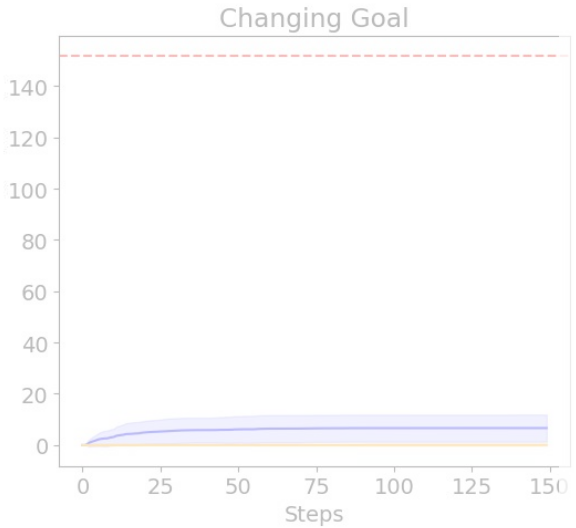

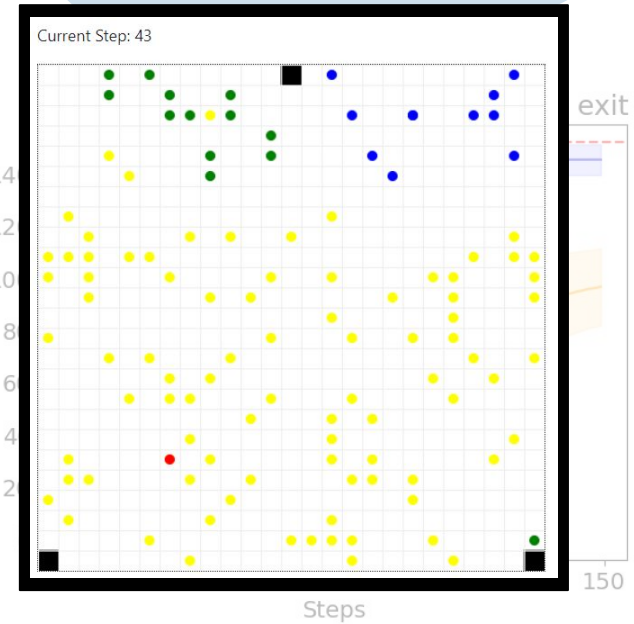

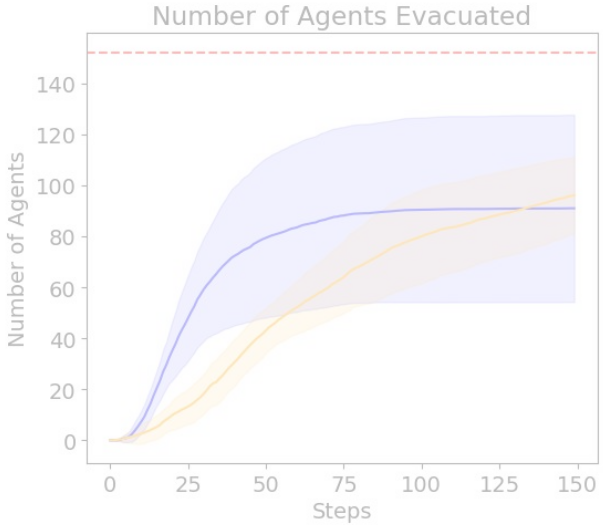

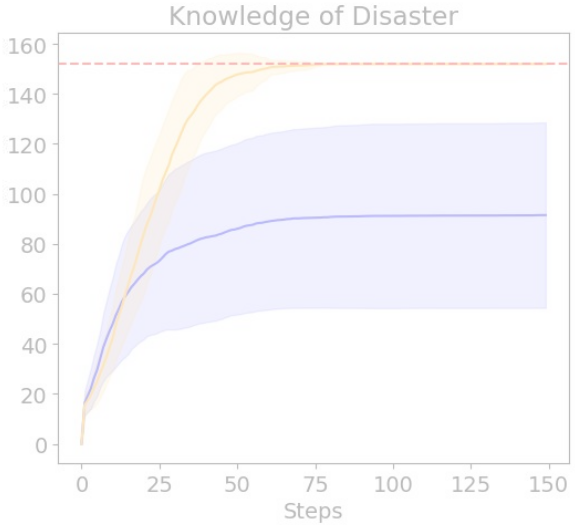

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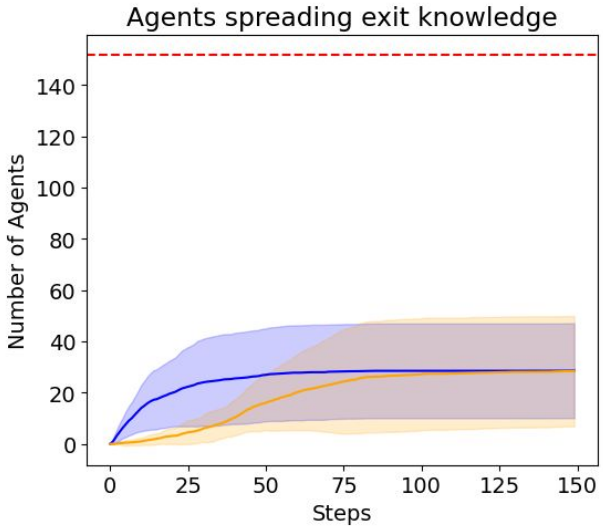

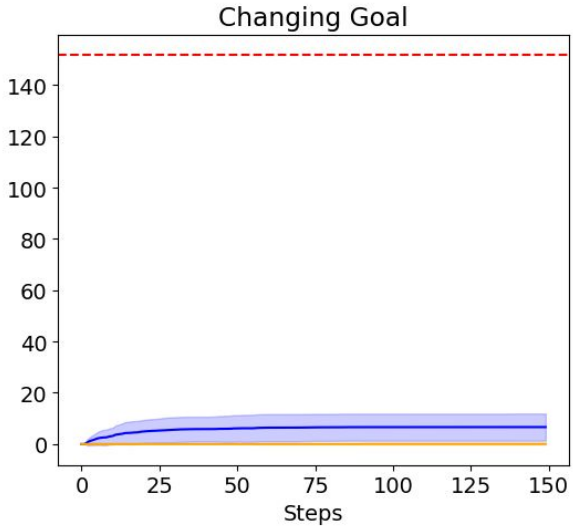

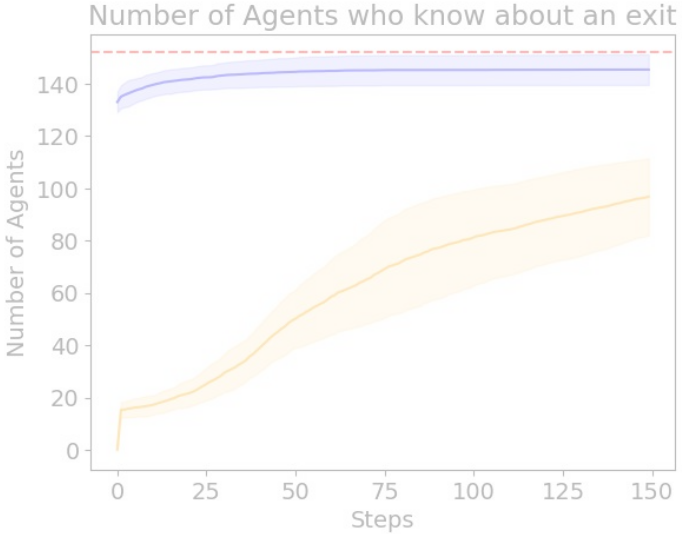

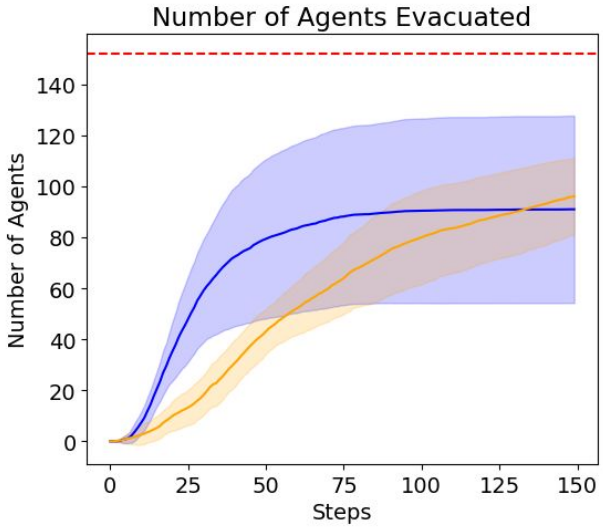

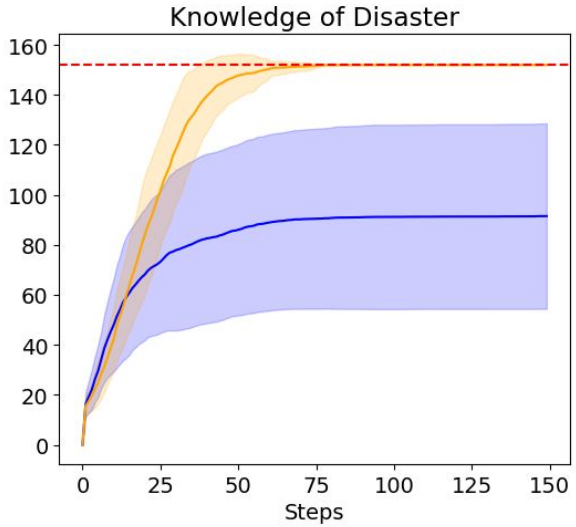

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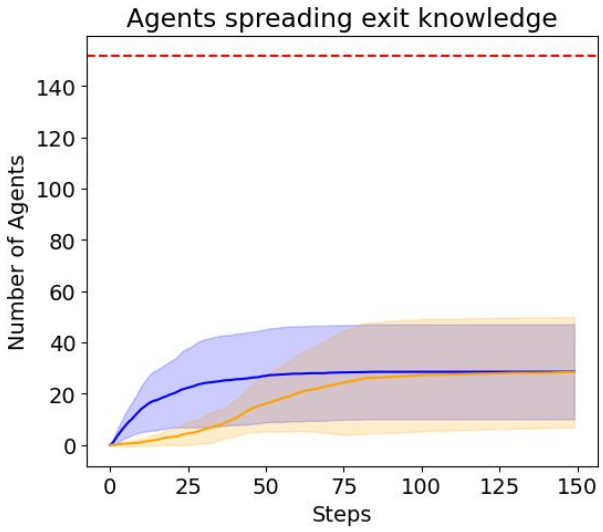
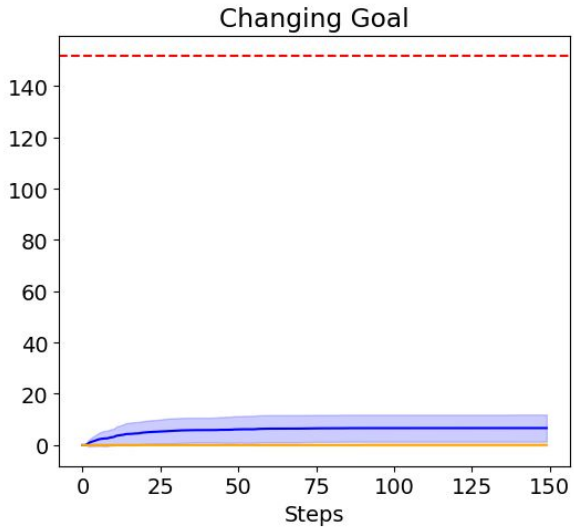
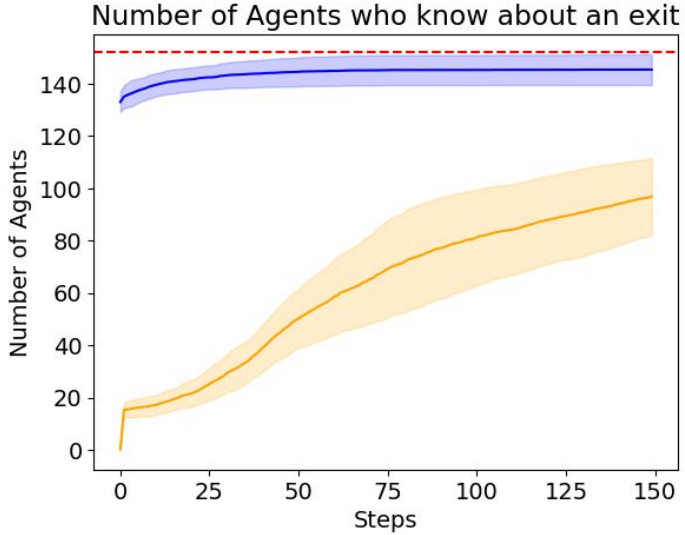
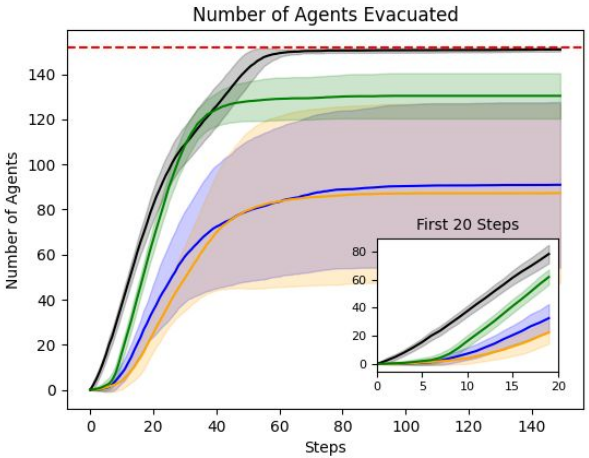


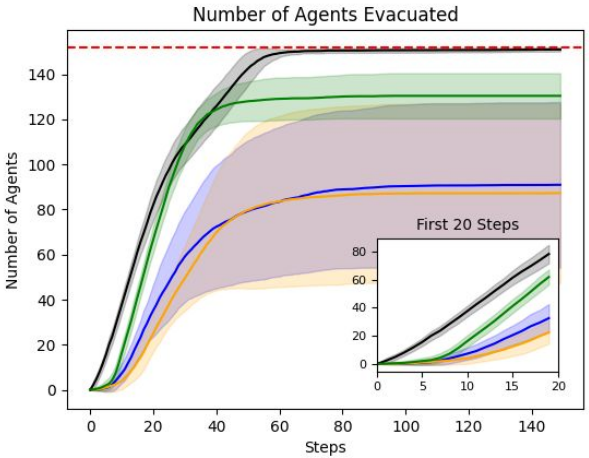


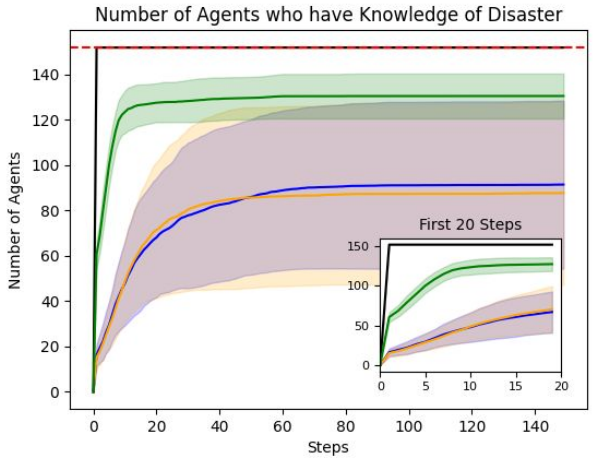




Intervention Strategies

Base Model
Signage
Disaster Announcement
Evacuator
Total Agents





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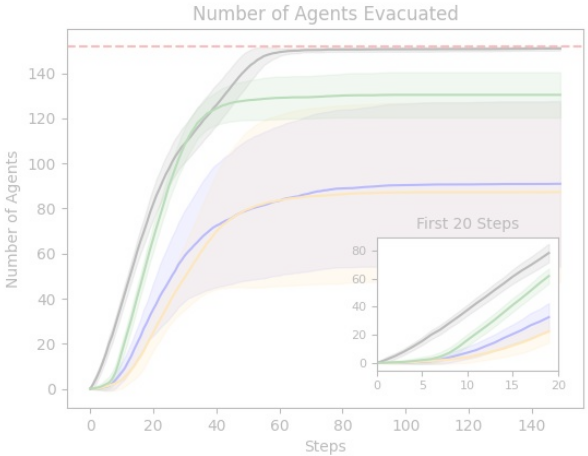

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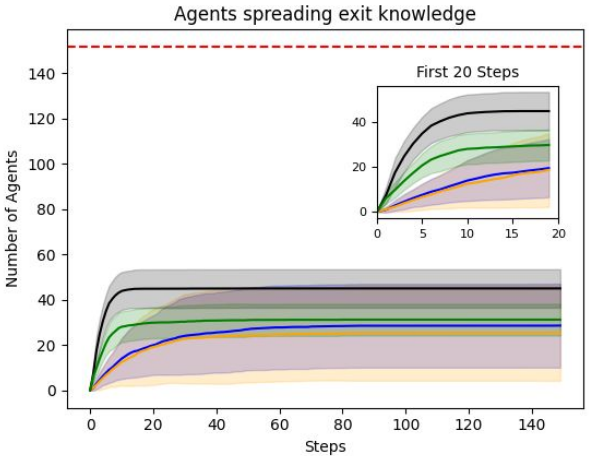

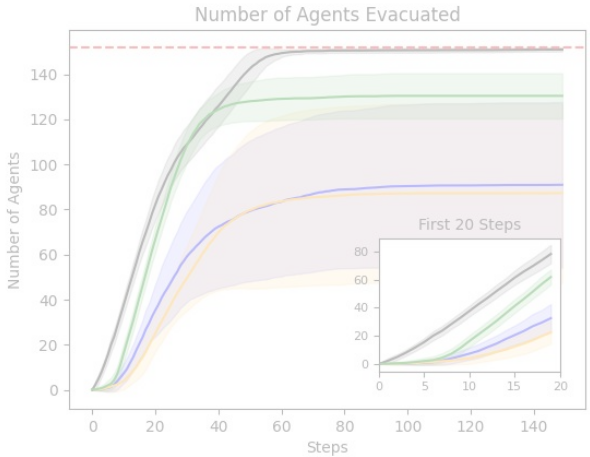

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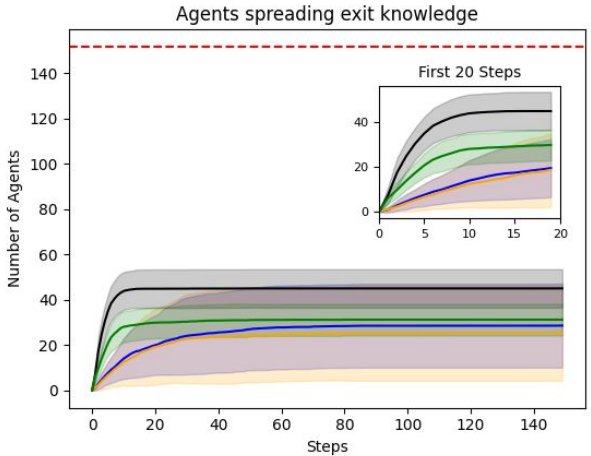

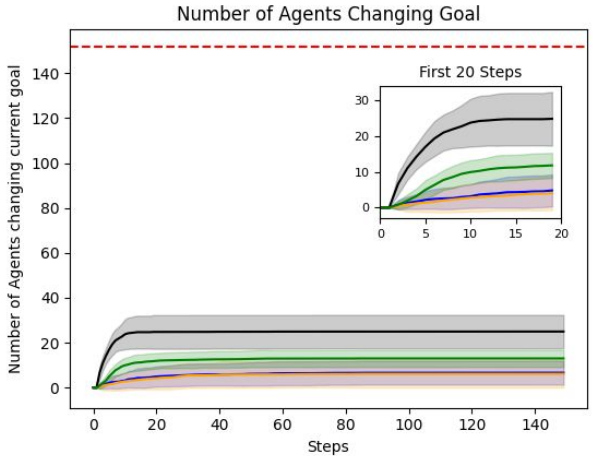

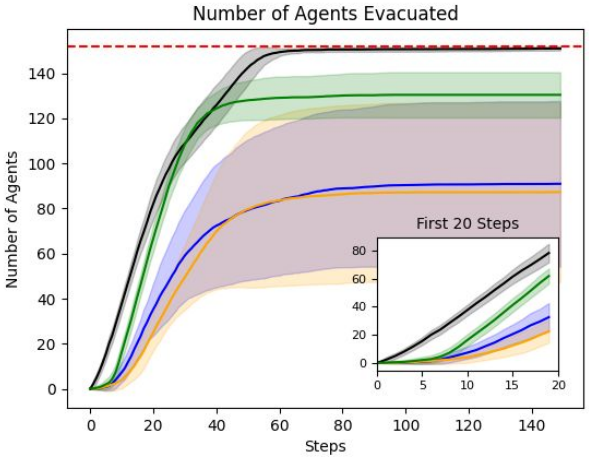

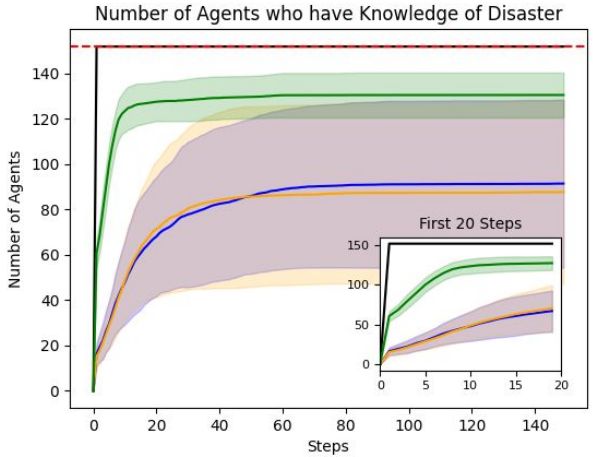

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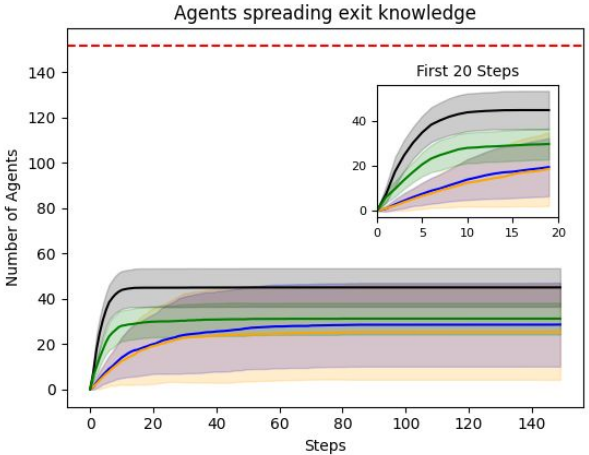
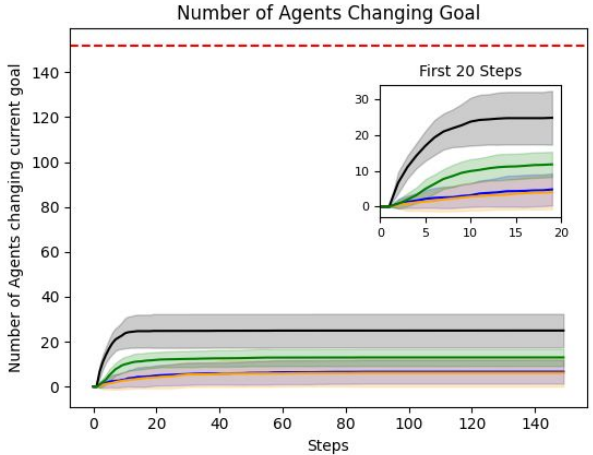


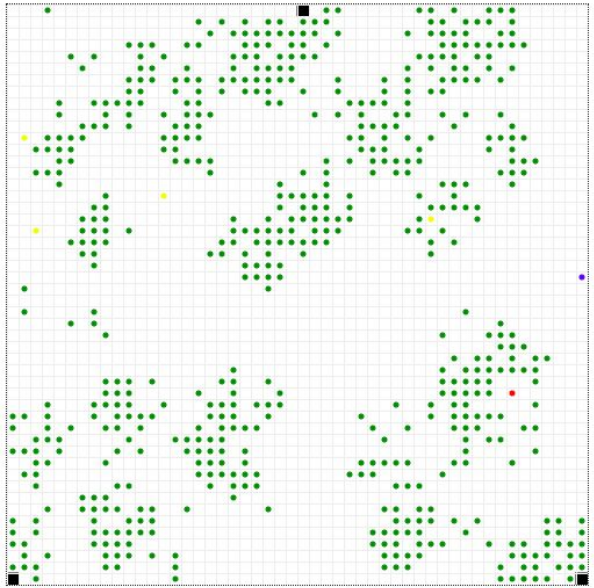


04

Conclusion and Discussion

Key findings

- Cluster formation as emergent behaviour
- Disaster knowledge > environmental knowledge
- Outlier agents save lives



Conclusions

- Environmental familiarity leads to faster, but incomplete evacuation compared to a model without prior knowledge

- Disaster announcement and evacuator presence leads to faster evacuation but not signage

Discussion

- Signage implementation
- Environmental knowledge through information spreading
  - Future: Experiments with radius size variations.
- Social force extension (e.g. groups)
- Bigger grid and obstacles (increased importance of environmental knowledge?)
- Combination of interventions
- Global sensitivity analysis

Thank you

References

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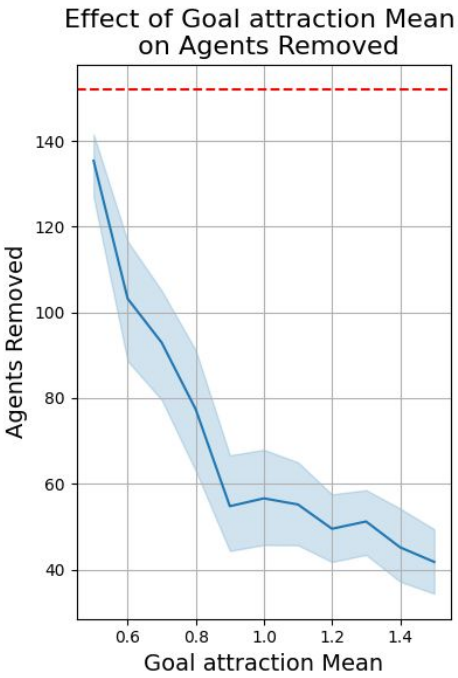
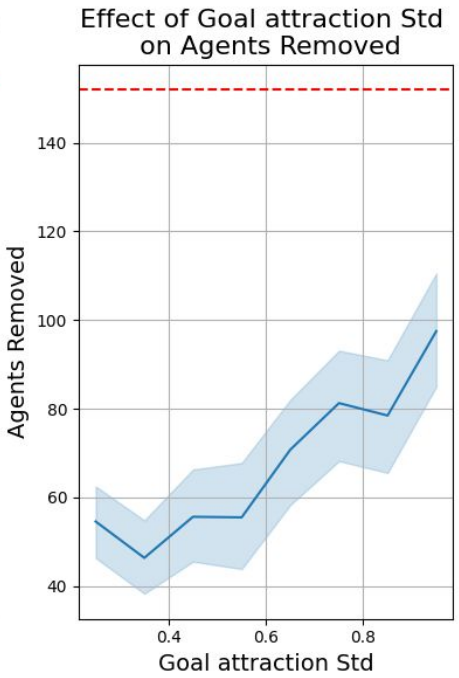
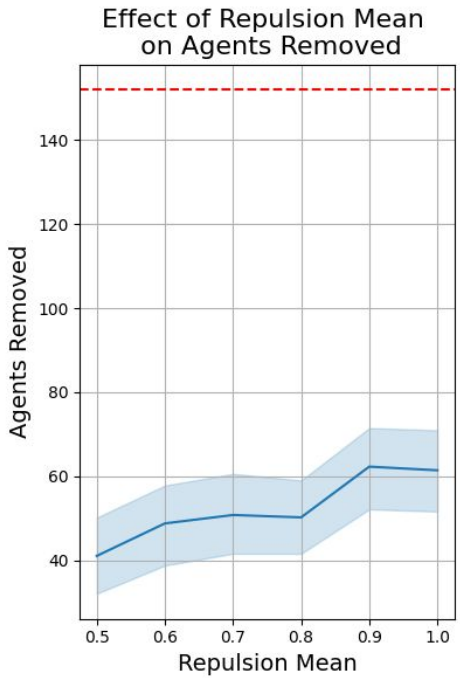
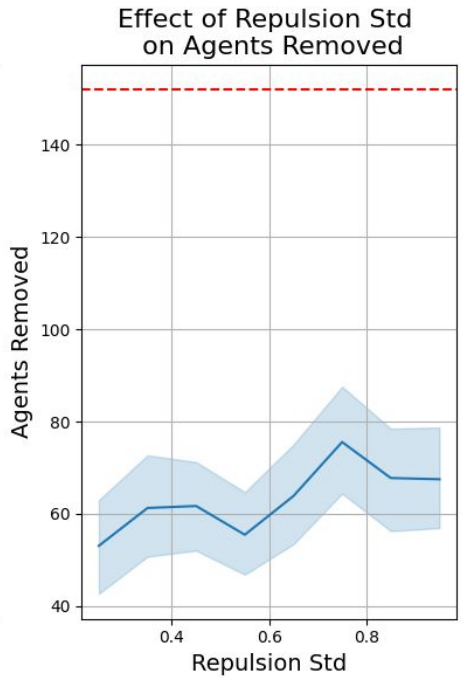
Experiment for base of exit knowledge

Number of known exits	1	2-3	4
People	3	20	5

Parameter settings of the model

```
width = 25
height = 25
N = int(0.25 * width * height)
fire_radius = 10
social_radius = 2
p_spreading = 0.2
p_spreading_environment = 0.3
p_env_knowledge_params = [3/25, 20/25] # threshold 1 (no knowledge), threshold 2
(one door known)
evacuator_radius = social_radius * 4
fire_avoidance_radius = 1
gumbel_params = [1,0.5,1,0.5] # mean and std of goal_attraction + mean and std of
social_repulsion
print(width // 10)
print(width // 13)
exits = [ {"location": (width // 2, height - 1), "radius": 5},
          {"location": (0, 0), "radius": 3},
          {"location": (width - 1, 0), "radius": 3}]
grid = CanvasGrid(portrayal, width, height)
```

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