Modelling of crowd systems

Project Proposal review

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The problem - Objectives

In a dense crowding scenario, evacuation efficiency places a significant role in preventing disasters.

- **Option-1:** Make exits wider and design better evacuation routes.
- **Option-2:** Obstacle phenomenon- Impact of placing an obstacle on the upstream of exit and its correlation with evacuation efficiency.
  - Relative dimensions to the exit
  - Proximity to the exit
  - Lateral shift in Obstacle placement from the central line of the exit
  - Shape of the obstacle

Objectives

1. Time optimisation: Prevention of clogging near exits speeding up the evacuation process.
2. Minimal cost of obstacle placement - simplicity of shapes
3. Ensure crowd pressures do not exceed dangerous limits close to the exit
4. Identify and define parameters that define evacuation efficiency.

Literature review

Critical Issues observed

- **Uncertainty over correlation and obstacle performance.**
  - **Positive**: Prevents friction between crowd agents near the exit to avoid stop and go turbulent waves. [1]
  - **Negative**: Reduces effective exit area decreasing crowd outflow.
  - Used cellular automaton model(Floor field) to arrive at the parameters that doesn't simulate real conditions as each person is restricted to a node and 8 possible directions. [2]
  - Understanding the underlying mechanisms of obstacle effect that influence the outflow of crowd at bottlenecks. [3]
- **Outdoor scenario:** Scope to study pedestrian streams in outdoor intersections or public squares by controlling the roundabout traffic in intersecting pedestrian streams. [4]

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[1] Zhao, Y., Li, M., Lu, X., Tian, L., Yu, Z., Huang, K., Wang, Y., Li, T., 2017. Optimal layout design of obstacles for panic evacuation using differential evolution. Phys. A: Stat.Mech. Appl. 465, 175–194.

[2] Lei Wang et al 2016 Chinese Phys. B 25 118901

[3] Zhongjun Ding et al J. Stat. Mech. (2020) 023404

[4] Shiwakoti, N., 2010. Crowd Dynamics Under Emergency Conditions: Using Non-human Organisms in the Development of a Pedestrian Crowd Model. Ph.D. Thesis. Monash University.

Methodology- Multi Agent System

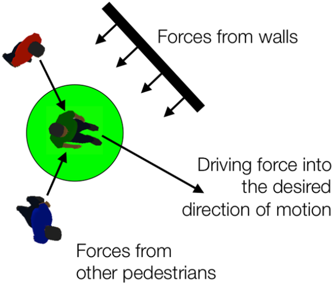

Figure: Social Force model[5]

- Approach to Model:
  - Evacuating a crowd from a room through a single exit.
  - Motion of a crowd agent determined through the superposition of forces from other agents and walls.
  - A driving force guides the agent to move towards their destination.
  - Standard obstacles like cylindrical columns are discretised as wall elements to estimate their force field.
- Obstacles:
  - Model is tested on obstacles under different test conditions.
  - Arrive at parameters that determine crowd pressure and turbulence.

[5] Laufer, Julian(2022). Passenger and Pedestrian Modelling at Transport Facilities.

Summary of Work done

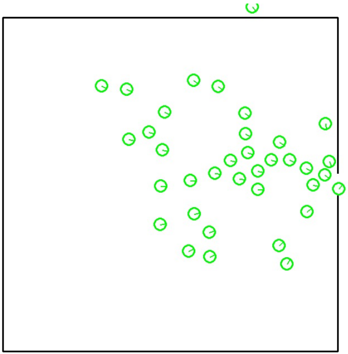

Figure: Simulation

- Identified Research gaps.
- Simulated a crowd evacuation scenario using python3.
- Working on validation of Helbing's social force model.

Future Timeline

- **JUN-AUG** Conceptual Understanding & Literature review
- **SEP-NOV**
  - Simulation
  - Validation of model
  - Parameter optimisation
- **JAN-MAR**
  - Object Placement and Data collection
  - Identification of parameters influencing crowd turbulence
  - Parameter optimisation and correlation
- **APR** Report