Modelling of crowd systems

Project Proposal review

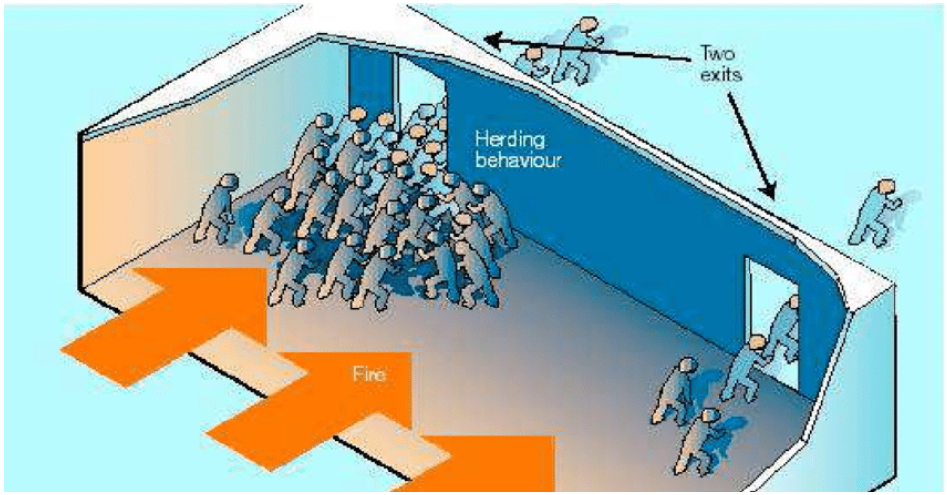
D Purnendra Reddy

September 22, 2022

Prof. Pallab Sinha Mahapatra

The problem - Objectives

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



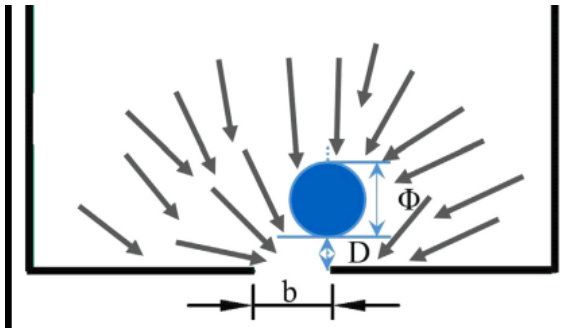
- **Option-1:** Make exits wider and design better evacuation routes.
- **Option-2:** Obstacle phenomenon- Impact of placing an obstacle at the upstream of exit. (preventing dense localisation of the crowd)
  - Relative dimensions to the exit
  - Proximity to the exit
  - Lateral shift in Obstacle placement from the central line of the exit
  - Shape of the obstacle

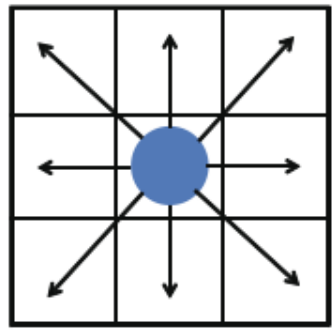
Problem: Unsupervised crowd evacuation

Literature review

Critical Issues observed

- **Uncertainty of 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.
- **Obstacle Performance.**
  - Understanding the underlying mechanisms of obstacle effect that influence the outflow of crowd at bottlenecks. [2]
  - 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. [3]





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

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

Methodology- Multi Agent System

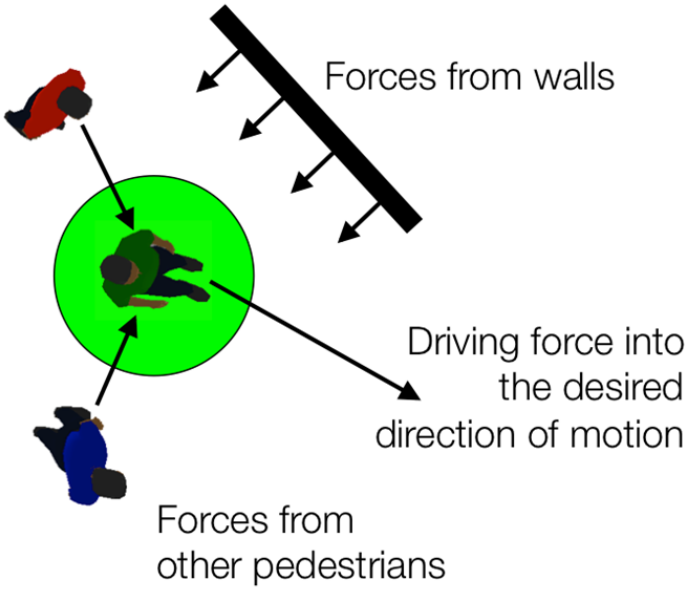


Figure: Social Force model[4]

- 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.
  - Arrive at parameters that determine crowd pressure and turbulence.
- Approach to Obstacles:
  - Standard obstacles like cylindrical columns are discretised as wall elements to estimate their force field.
  - Model is tested on obstacles under different test conditions.

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

Using Social Force model

$$m_i \frac{dv_i}{dt} = F_i^{desired} + F_{iw}^{obstacle} + F_{ij}^{pedestrian}$$

$$F_i^{desired} = m_i \frac{[v_{i_{max}}^o(t) - v_i(t)]}{\tau}$$

$$F_{ij}^{pedestrian} = we^{\frac{r_{ij}-d_{ij}}{w}}(\lambda+(1-\lambda)(\frac{1+cos\omega_i}{2})\bar{n}_{ij}+\mu g(r_{ij}-d_{ij})\Delta\bar{v}_{ij}(t)+w*(r_{ij}-d_{ij})\bar{n}_{ij}$$

$$F_{io}^{obstacle} = w.e^{\frac{r_i-d_{io}}{w}}\bar{n}_{io} + \mu g(r_i - d_{io})\Delta\bar{v}_{io}(t) + w*(r_i - d_{io})\bar{n}_{io}$$

Summary of Work done

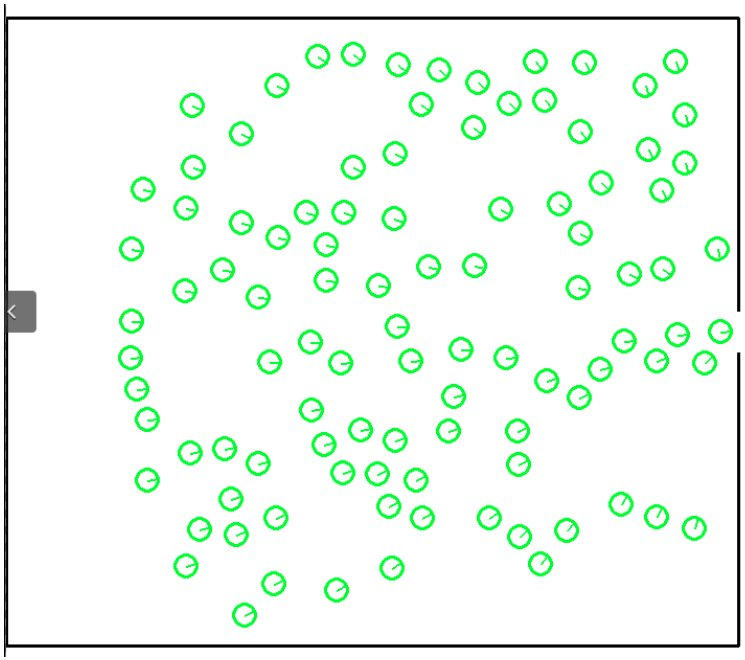


Figure: Simulation

- Completed Literature review.
- Modelled a crowd evacuation scenario without obstacles using python3.
- Working on validation of Helbing's social force model.

Future Timeline

- **JUN-AUG** Conceptual Understanding,Literature review & Code development
- **SEP-DEC**
  - Code development & Simulation
  - Validation of model
  - Identification of crowd dense areas near the exit
  - Placement of obstacles and Data collection
- **JAN-MAR**
  - Identification of Parameters influencing evacuation behaviour, it's optimisation and correlation
- **APR** Report