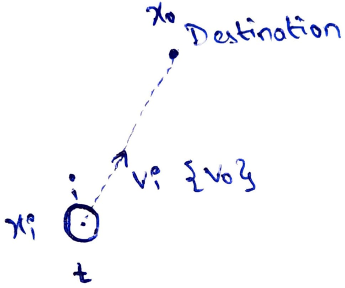
# Blackbox

1. microscopic chars
2. macroscopic chars
3. Some models
4. observations

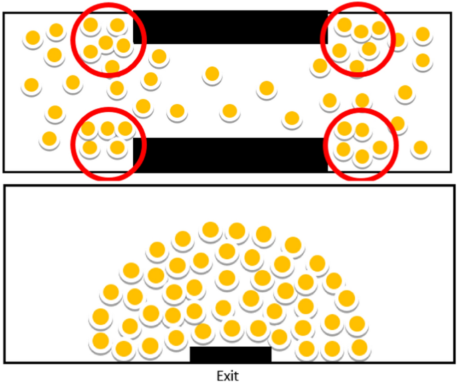
# microscopic chars

- unit chars $r_0$ $x_0$ $v_0$
- unit prefs $x_i$ $v_i$
- agent based modelling



# macroscopic chars

- crowd density
- geometrical constraints
- maximum crowd pressure
- panic situation- evacuation time




- collective or system modelling

# Some models

- Binary Force model
  1. units repel each other
  2. unit is attracted to its destination with acceleration $\alpha$ force of attraction
  - crowd dynamics as a result of superposition of binary forces
- Social Force model - Helbing
  1. Visual cues within field of vision of unit to determine optimal path of least obstruction
  2. The parameters $v_i$, $\alpha_i$ are optimised based on the feedback from environment.
  3. Additionally body forces act on units along with contact forces along geometric boundaries.
- Nodal Analysis
  1. The geometric area is divided into several convex nodes and the densities of the nodes are calculated at time instants to determine crowd params.

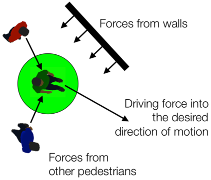



Figure: Binary Force model

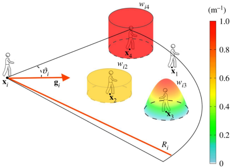


Figure: Social Force model

# A comparison

**Binary Force model** :Easier computation, however inaccurate as units prefer deviating from the existing path rather than confront an obstacle and slow down.
**Social Force model** :Advantageous over binary force model, that it considers an optimal path of least obstruction with existence of forces at closer body contact *(high crowd densities)*.
**Nodal Division model** : It is a system based model i.e., the impact of the system parameters dominates the individual prefs of units and are only used if the units are identical.

# Limitations

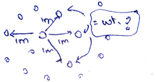


Figure: Binary Force model limitations

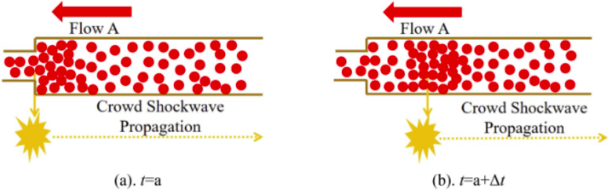



Figure: Social Force model limitations

# Observations

On increasing crowd densities $=>$ increasing chances of crowd turbulence

- Unavoidable collisions
- Stop and Go waves at choking points resembling fluid vortices behind obstacles due to local perturbations.
- undesirable crowd turbulence

# Where to draw a line?

We have unit based models on one side and system based models on other, where do they **converge**?

# Assumptions

- Treatment of crowd agents as **disks**
- **Markov models:** The desired velocity and direction of the crowd particle is determined by the present conditions of state completely independent of the path until that instant.
- **Lateral velocity:**
- **Small crowd velocities:** To neglect the impact of high-speed collisions in the crowd.
- **Wall or obstacle:** Determined as continuum of discrete units.
- Randomised disk areas to avoid symmetric force collisions.

# Using Social Force model

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

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

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

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

# Limitations

- **Knowledge of environment:** The driving force assumes the knowledge of destination in prior optimising a shorter route.
- **Neglection of attractive forces:** Pedestrian cooperation behaviour is neglected and each unit acts as an individual actor in decision making.
- **Boundary effects:** Based on the model, crowd agents repulse from edges of narrow doors preventing evacuation due to insufficient velocity and get stuck in a stable potential well.

# TODO

- Create a minimum viable code to simulate crowd movement with a single exit.
- Place obstacles and calculate their efficiency
- Optimise weight parameters in the social force model
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