Generalized Collision-free Velocity Model for Pedestrian Dynamics

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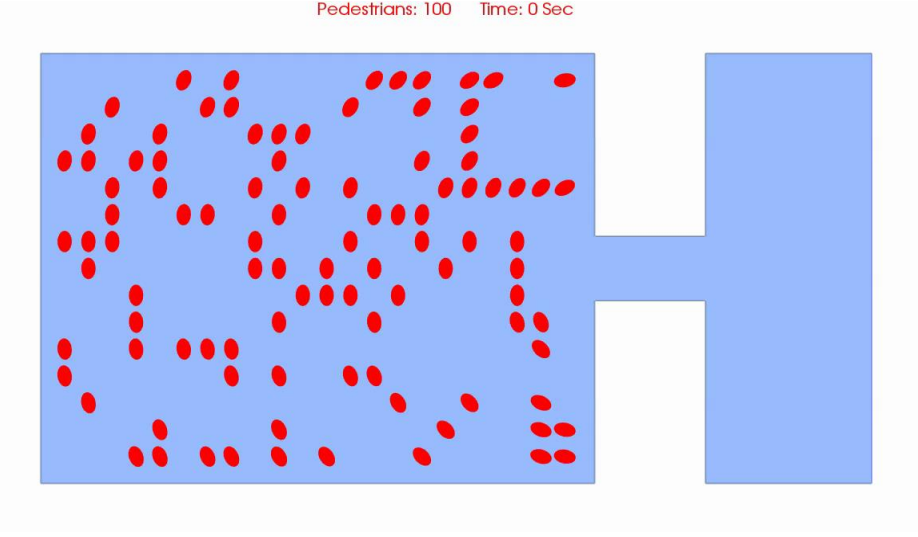
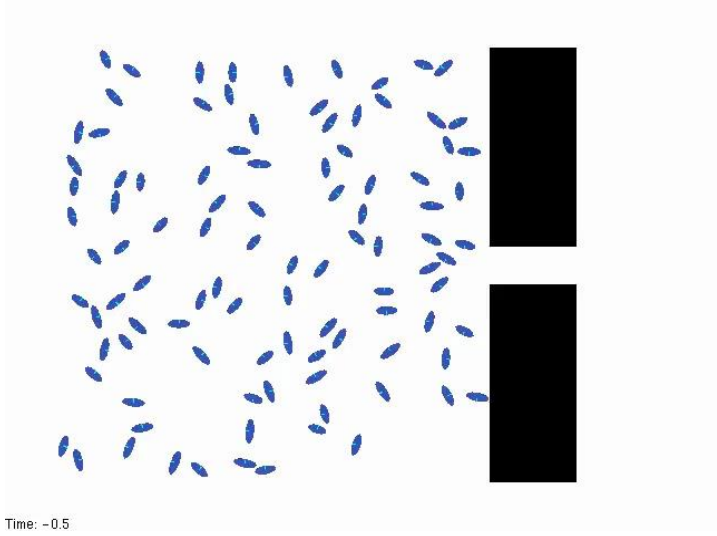
Motivation





Problems

1. backward movement
2. body turning with high frequency

Aim: A new model focus on

1. merging flow
2. collision avoidance
3. eliminating unusual behavior

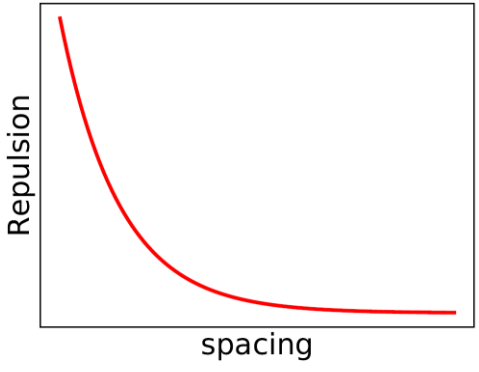
Collision-free velocity model

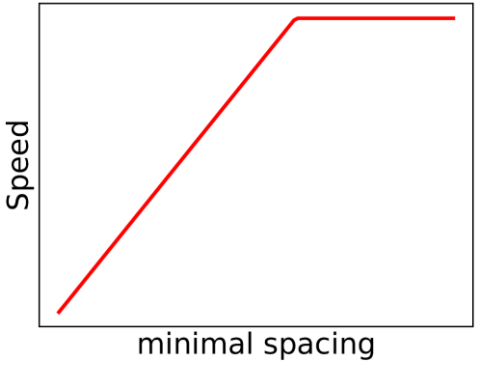
Model structure:

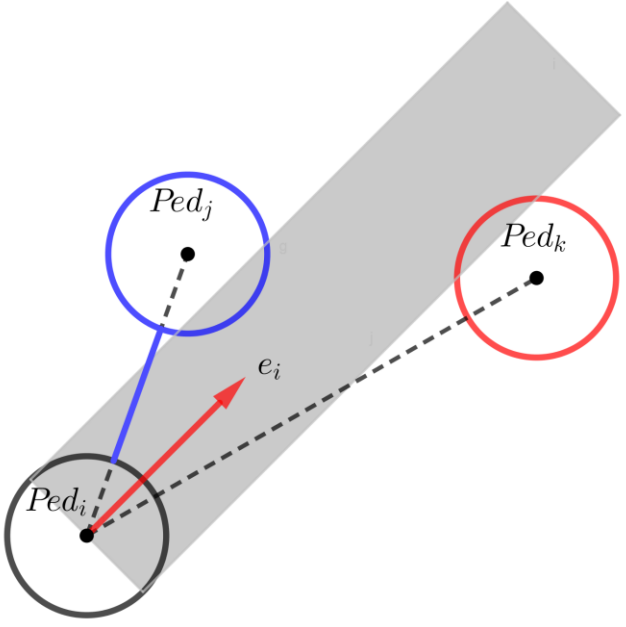
$$V_i = Speed_i(\min\ spacing) * \vec{e}_i(spacing)$$

Speed

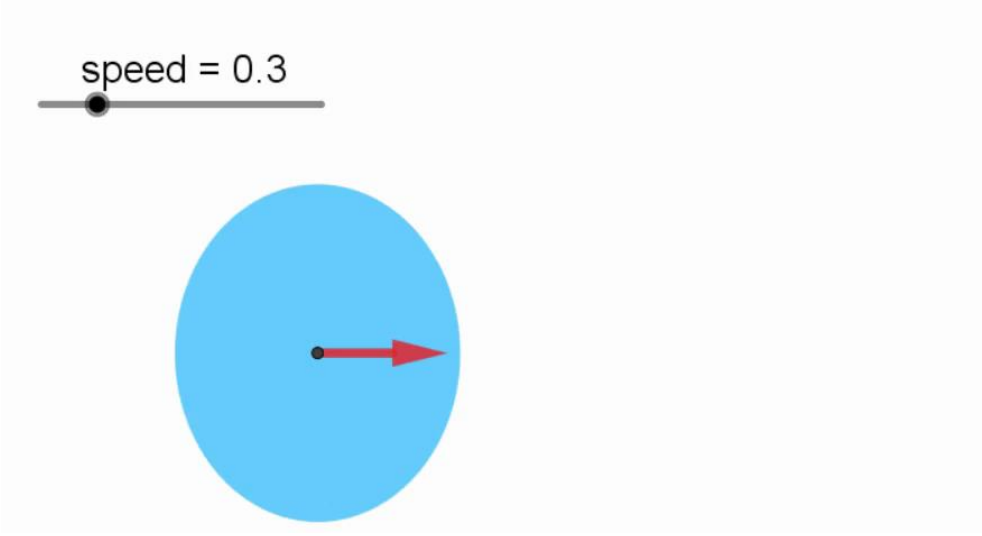
Moving direction







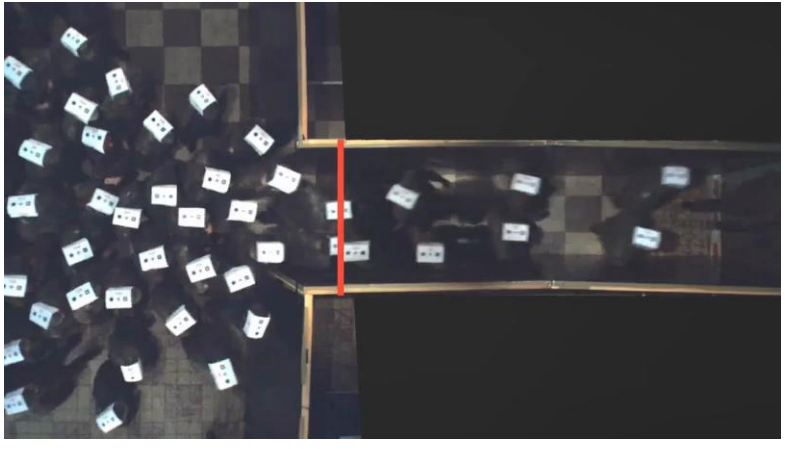
Extension to the model

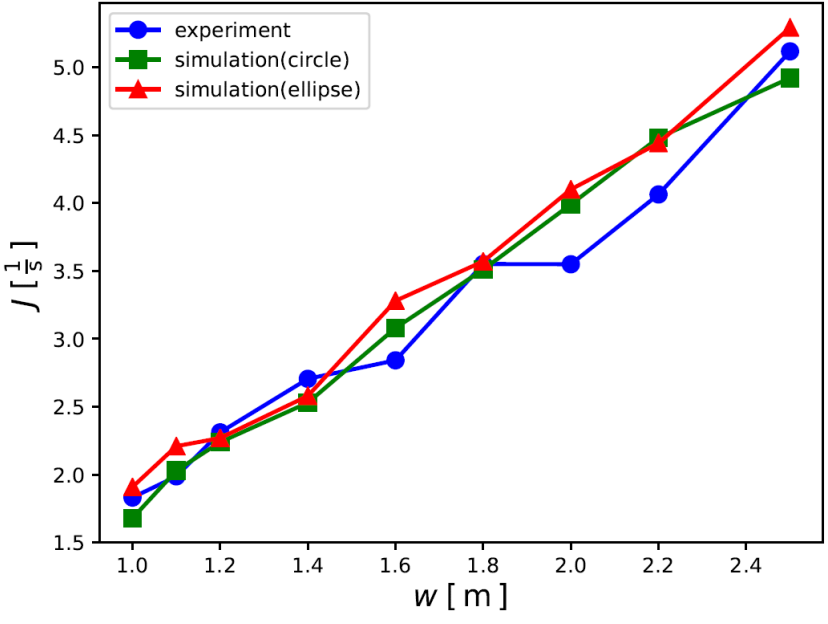


From circle to dynamical ellipse:

- Ellipse can describe the projection of pedestrian in 2D plane better.
- Calculation between ellipses is more complex.
- The distance between ellipse is estimated.

Comparison between circle and ellipse

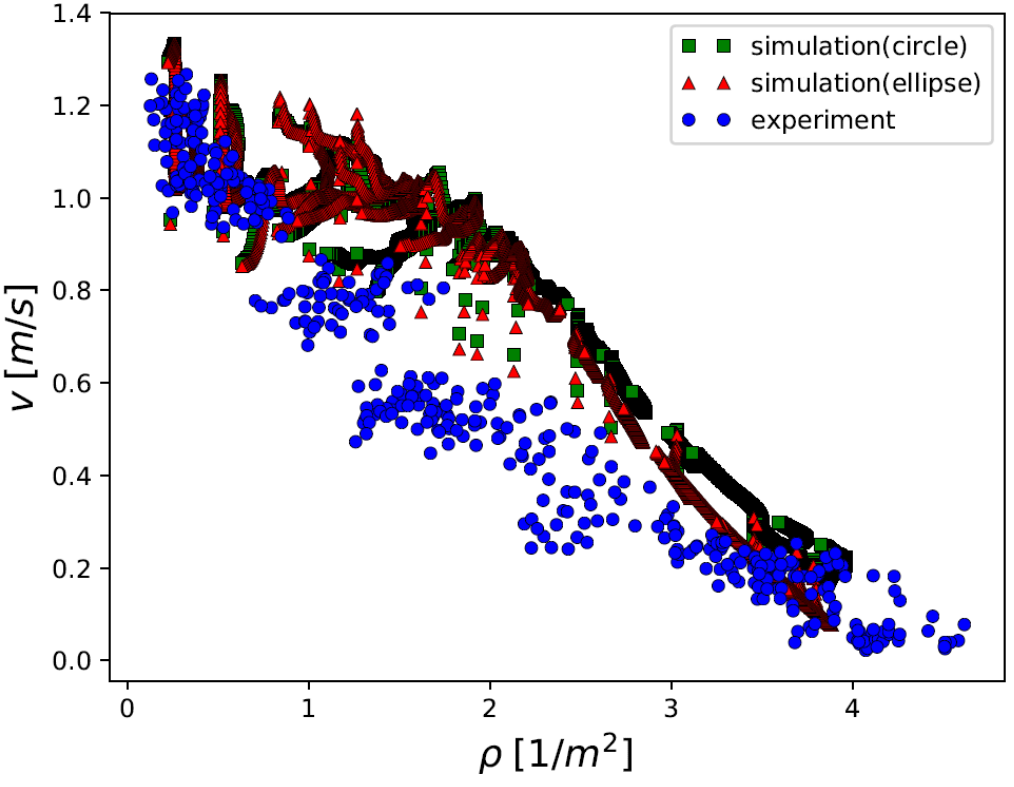




- **Width:** 1.0 ~ 2.5 m

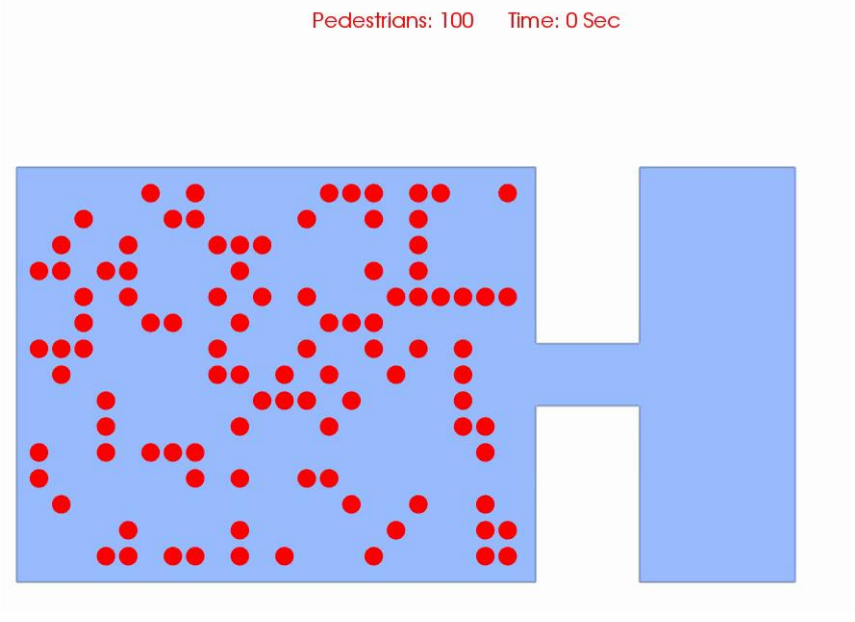
Comparison between circle and ellipse

- **Length:** 26 m
- **Width:** 1.8 m
- **N_{ped}:** 15 ~ 175

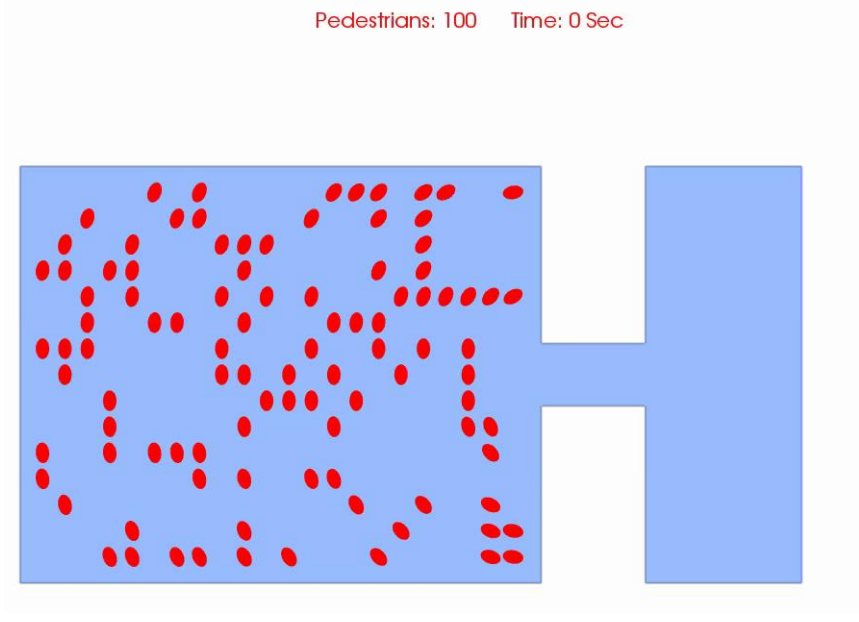


Comparison between circle and ellipse

Circle:

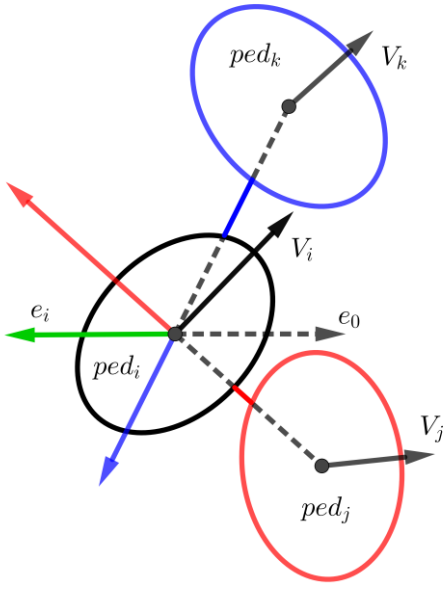


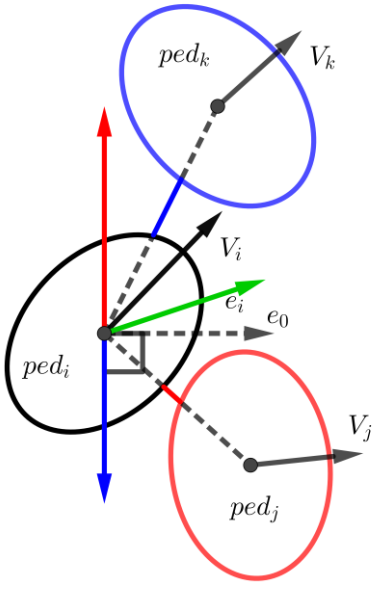
Ellipse:



New direction model

1. New way to calculate moving direction (to eliminate backward movement)



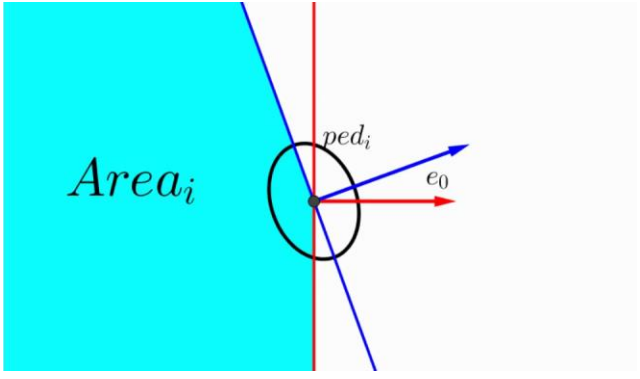


Influence of neighbors on pedestrian i:

- Always perpendicular to desired moving direction of pedestrian i
- Towards the left side of e_0 when neighbors are on the right side or front of e_0
- Towards the right side of e_0 when neighbors are on the left side of e_0

New direction model

2. Dynamical vision area (to reduce probability of blocking)



$Area_i$:

- Based on moving direction and desired direction of pedestrian i.
- Pedestrians **in $Area_i$** don't influence the moving direction of pedestrian i.

3. Smooth turning (to reduce the turning scale)

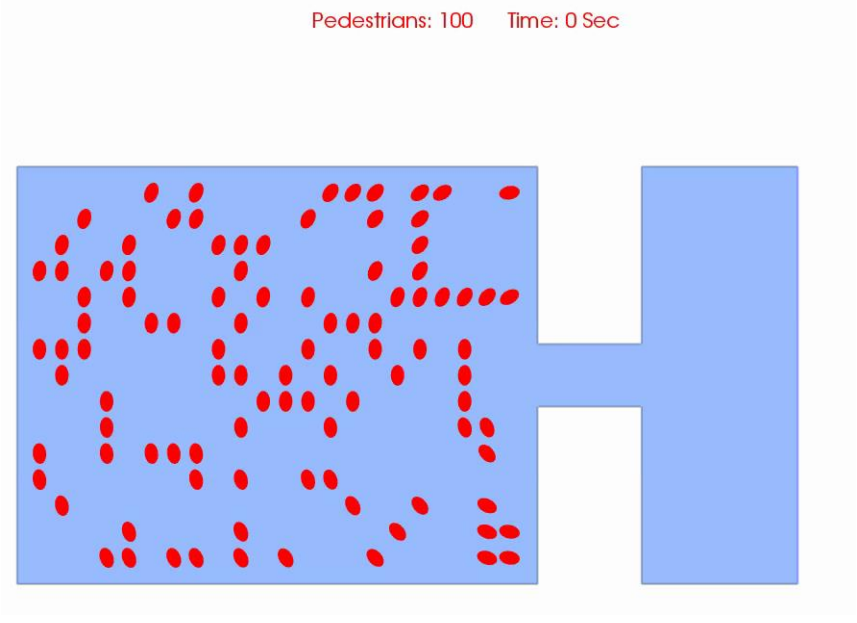
A new time parameter τ is used to slow down the turning process of agents

Moving direction: $\vec{e}_i^{\,M}$

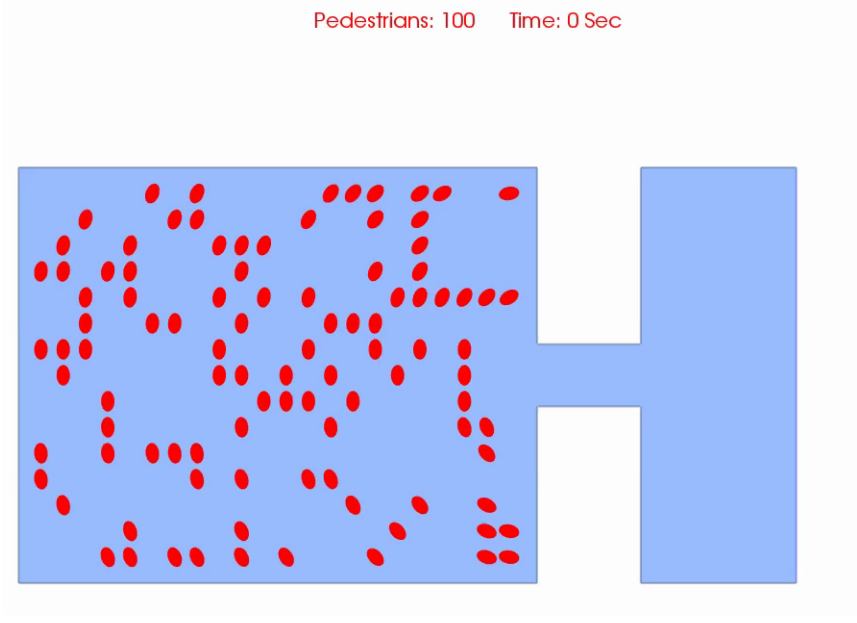
Original model: $\vec{e}_i^{\,M} = \vec{e}_i$ **New model:** $\dot{\vec{e}}_i^{\,M} = \frac{\vec{e}_i - \vec{e}_i^{\,M}}{\tau}$

New direction model

Original model:



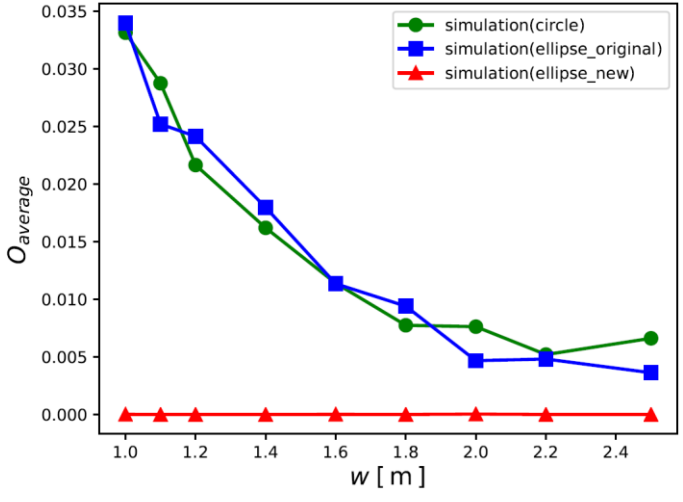
New model:



New direction model

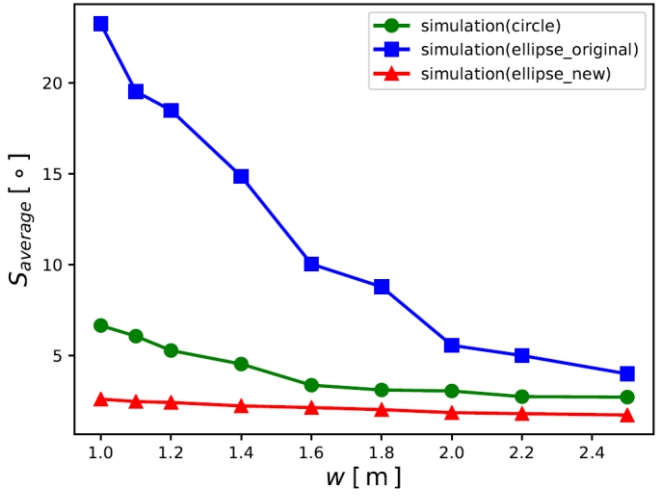
Backward moving index:

$$O_{average} = \frac{\sum_{i=1}^{i=N} \sum_{k=0}^{k=M_i} O_i(k * \Delta t)}{\sum_{i=1}^{i=N} M_i}$$



Shaking index:

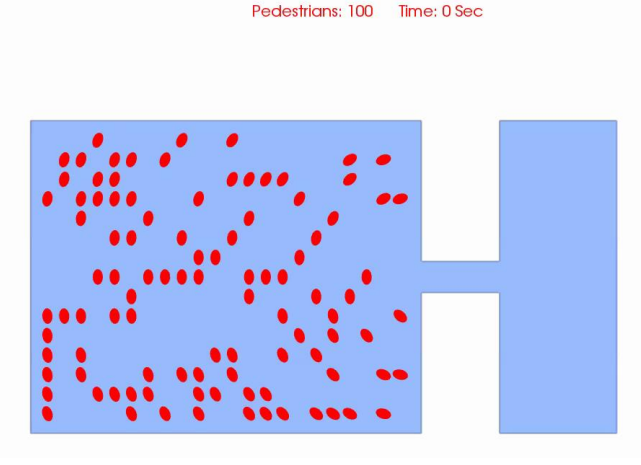
$$S_{average} = \frac{\sum_{i=1}^{i=N} \sum_{k=1}^{k=M_i} S_i(k * \Delta t)}{\sum_{i=1}^{i=N} (M_i - 1)}$$



Summary

Conclusion:

1. Difference between the performance of circle and ellipse is not very obvious in velocity model. The reason may be the approximation in the distance calculation between ellipses.
2. New direction sub-model can eliminate unusual behavior of agents in simulations.



Outlook:

Clogging occurs in front of the bottleneck sometimes when the width of bottleneck is very small.

Thank you for your attention!
Questions?