BIDIRECTIONAL CROWD FLOWS WITH INTRODUCTION OF OBSTACLES

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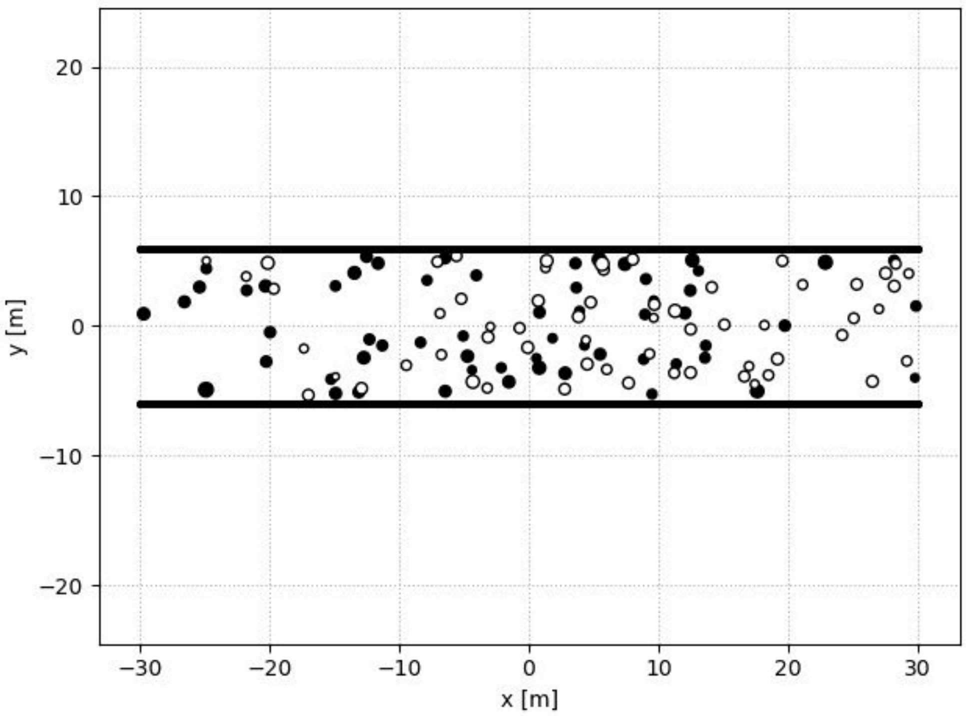
Bidirectional crowd flow

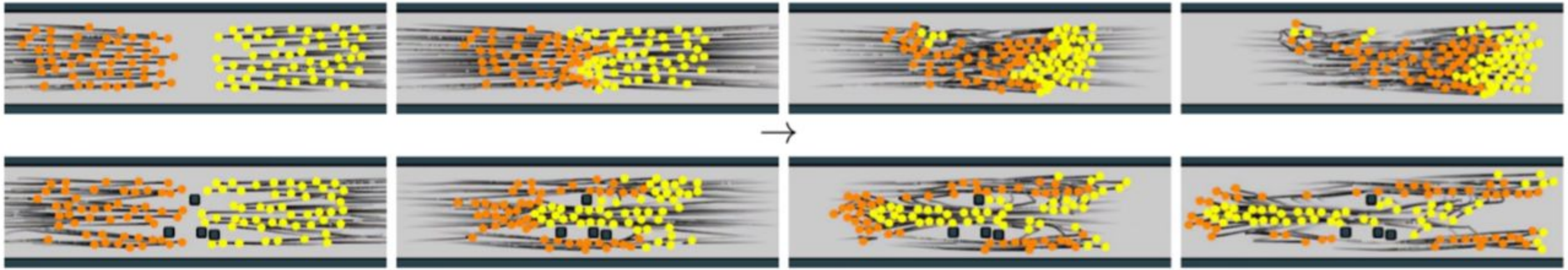
The social force model for pedestrian dynamics



- By Helbing & Molnár (1995)
- Motion of pedestrians can be described by "social forces"
- Focus on the formation of lanes of pedestrians with the same walking direction
- Bigger circle diameters mean higher velocity

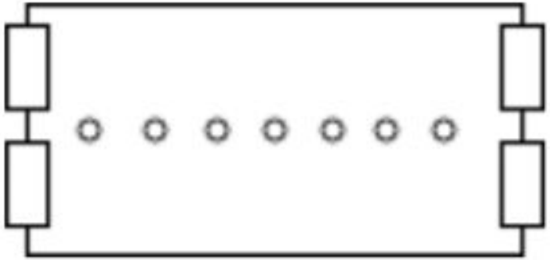
Environment optimization for crowd evacuation (2015)

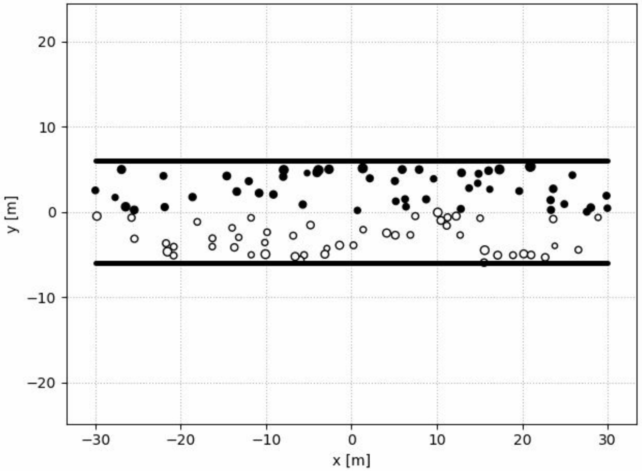
- strategically placed pillars can increase the throughput



The study of the influence of obstacles on crowd dynamics (2017)

- A straight line or column barrier increases average velocity of agents

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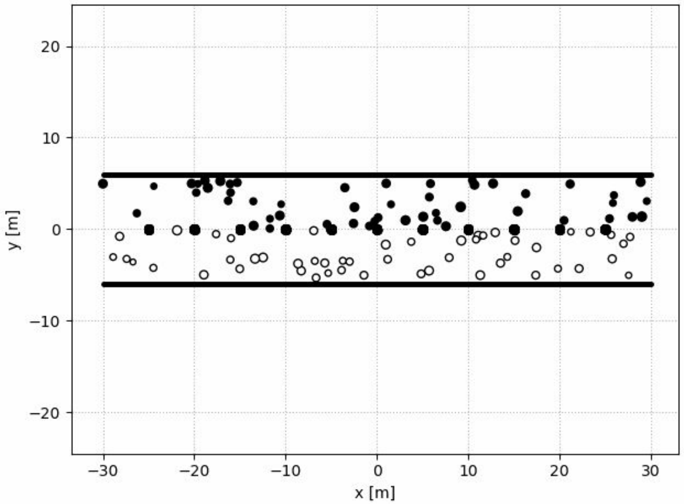
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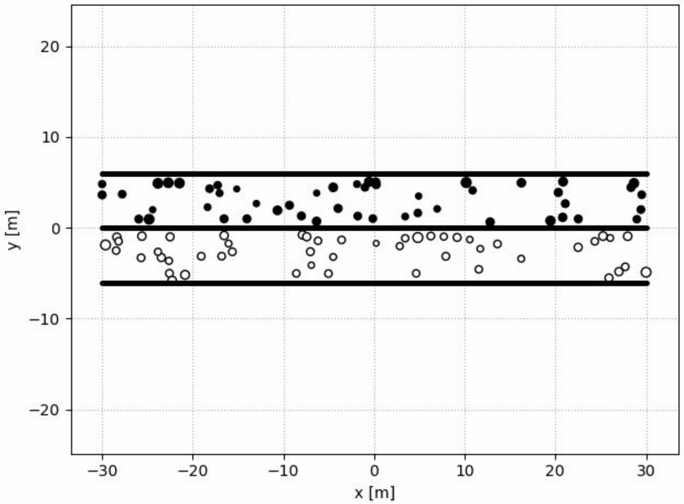
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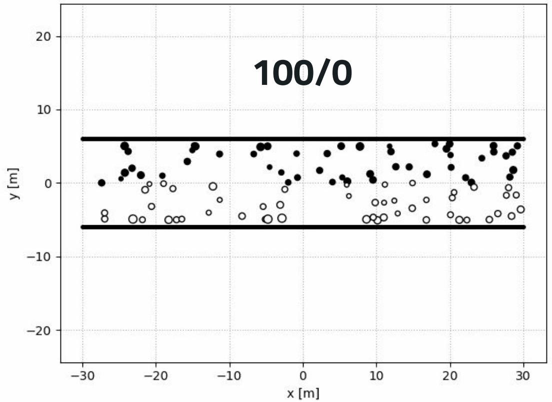
Research question

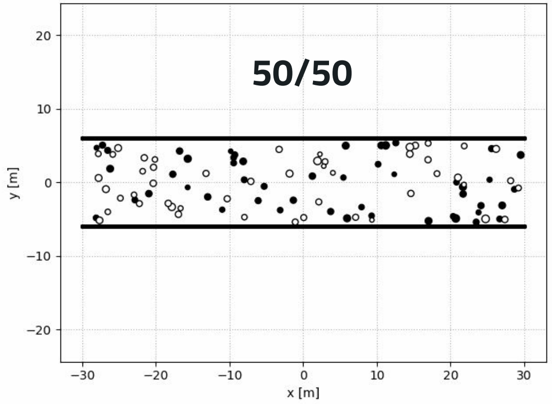
- **Which obstacles in a corridor increase the average velocity of a bidirectional crowd flow?**

- Is the result robust for different number of agents, N?
- Does the result change for different parameter settings?

Model settings and assumptions

- Corridor with bidirectional flow with different obstacles
- If agent exits corridor, new agent enters on other side
- Vary distribution of initial positions: 100/0, 80/20, 50/50
- 30 runs for 40 to 200 agents
- Measure the average velocity of agents





SOME FORMULAS THAT REGULATE THE MODEL

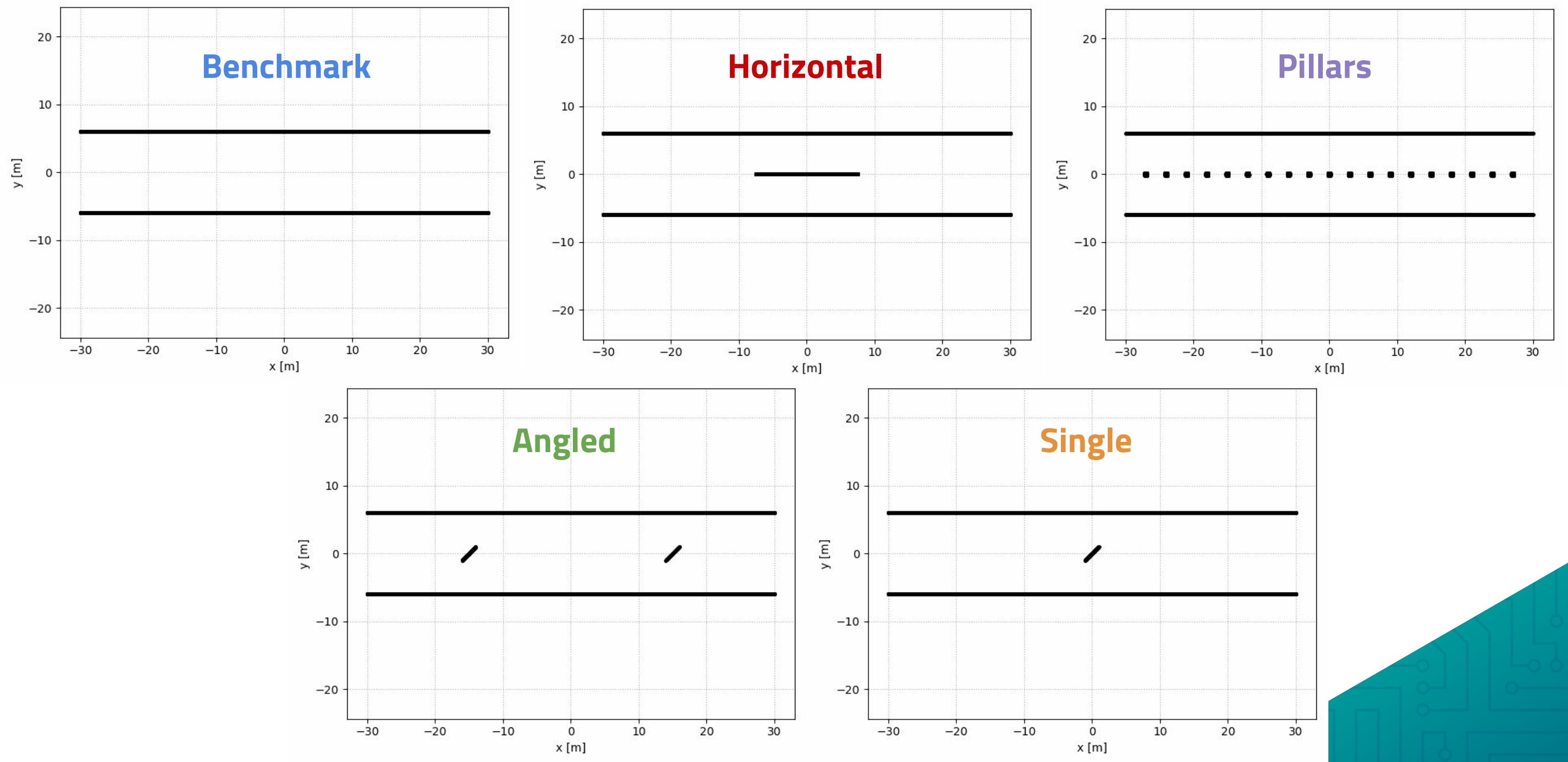
Desired direction $$\vec{e}_{\alpha}(t) := \frac{\vec{r}_{\alpha}^{k} - \vec{r}_{\alpha}(t)}{\left\| \vec{r}_{\alpha}^{k} - \vec{r}_{\alpha}(t) \right\|}$$

Acceleration term $$\vec{F}_{\alpha}^{0}\left(\vec{v}_{\alpha}, v_{\alpha}^{0} \vec{e}_{\alpha} \right) := \frac{1}{\tau_{\alpha}} \left(v_{\alpha}^{0} \vec{e}_{\alpha} - \vec{v}_{\alpha} \right)$$

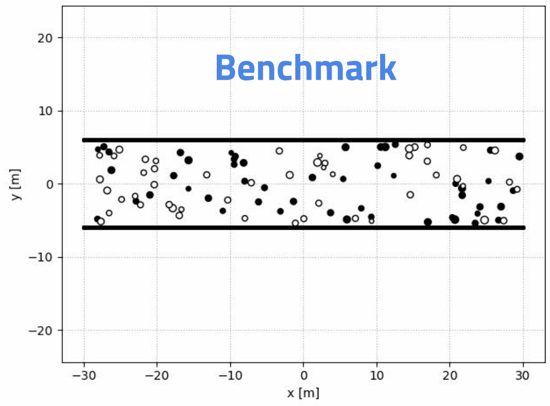
Pedestrians repulsive effect $$\vec{f}_{\alpha\beta}\left(\vec{r}_{\alpha\beta}\right) := -\nabla_{\vec{r}_{\alpha\beta}} V_{\alpha\beta}\left[b\left(\vec{r}_{\alpha\beta}\right)\right]$$

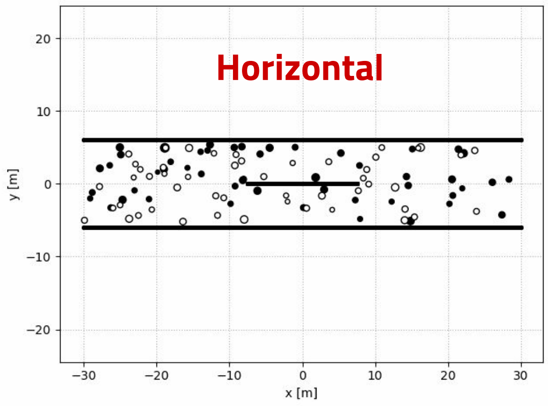
Border/obstacle repulsive effect $$\vec{F}_{\alpha B}\left(\vec{r}_{\alpha B}\right) := -\nabla_{\vec{r}_{\alpha B}} U_{\alpha B}\left(\left\|\vec{r}_{\alpha B}\right\|\right)$$

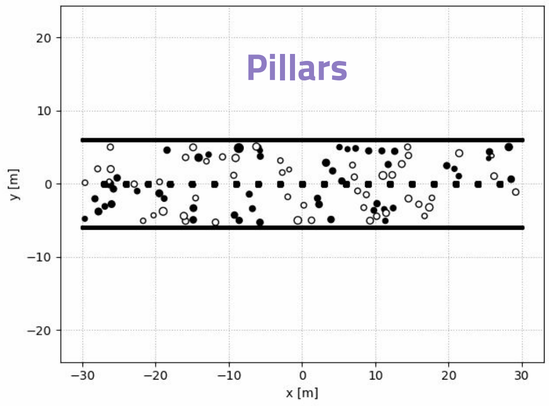
Obstacle modes

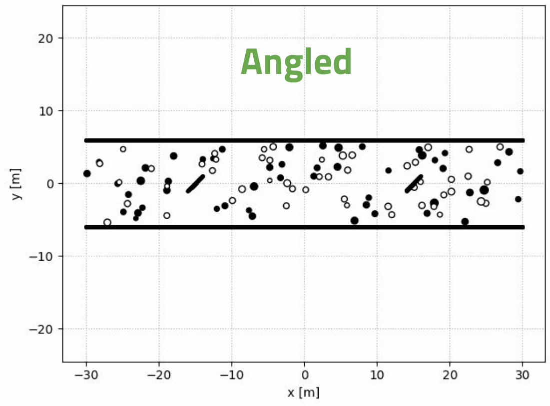


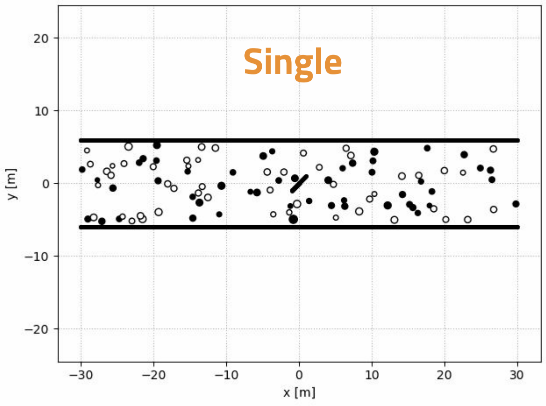
Obstacle modes with animation



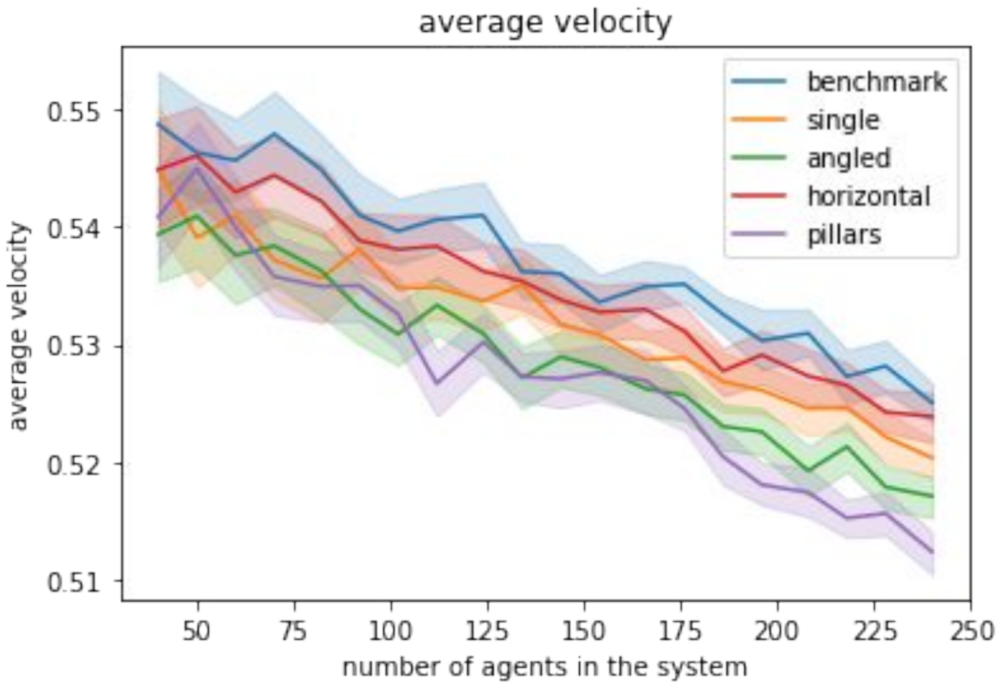




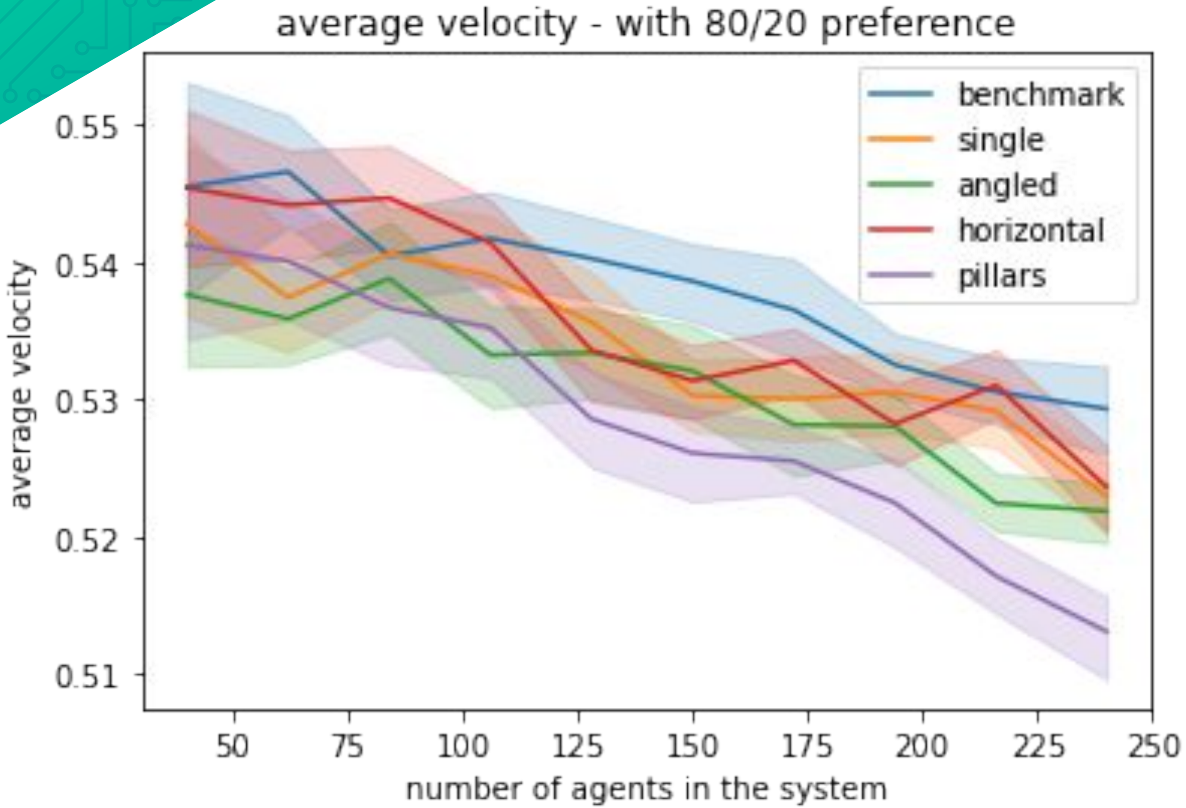




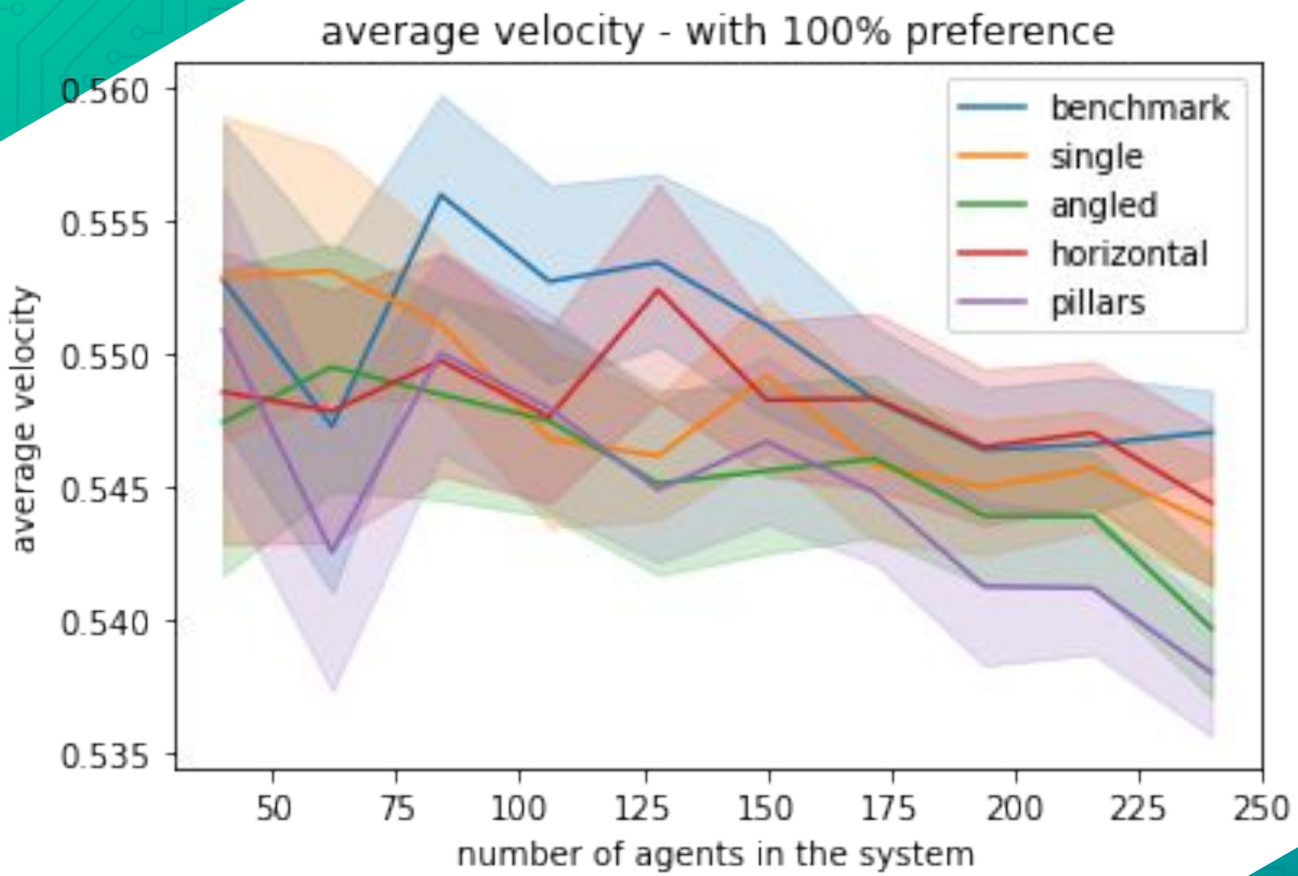
Results for 50/50



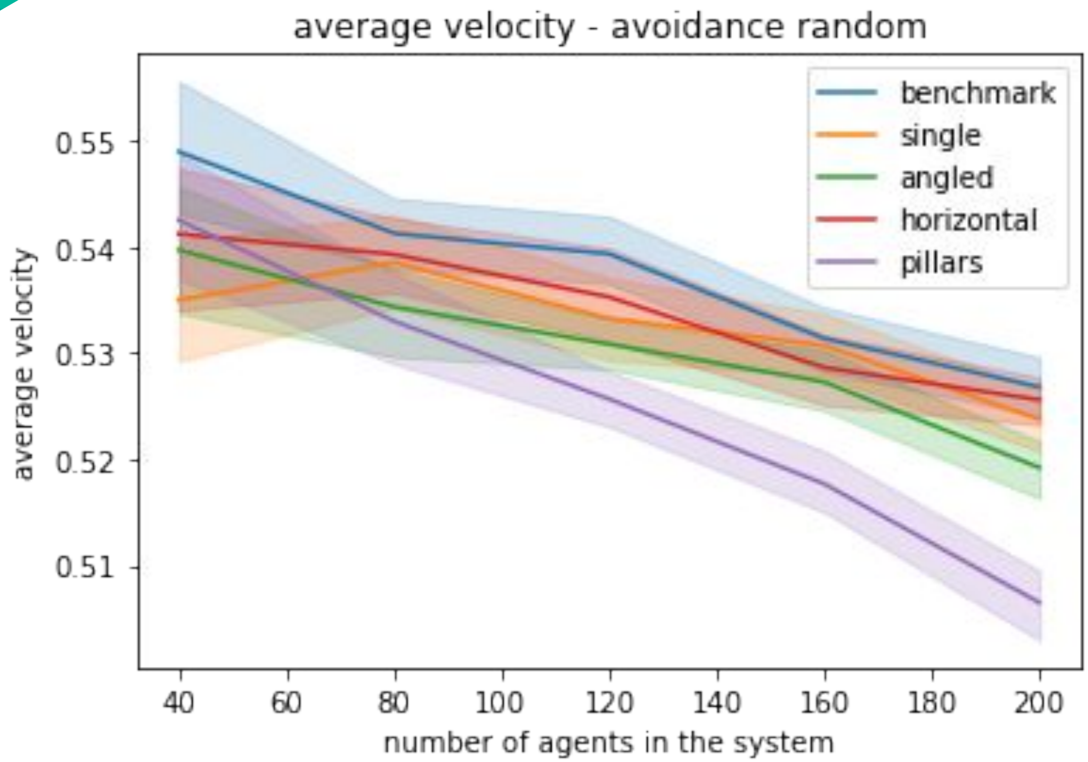
Results for 80/20



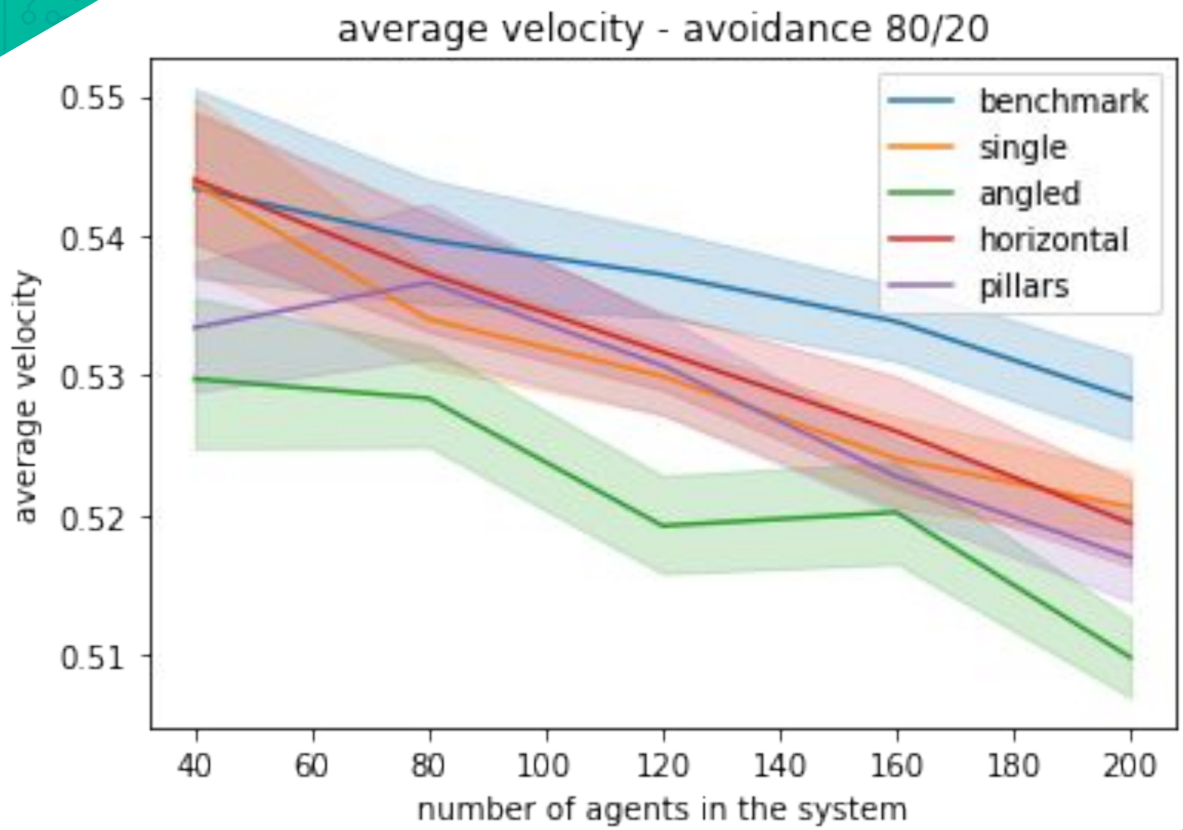
Results for 100/0



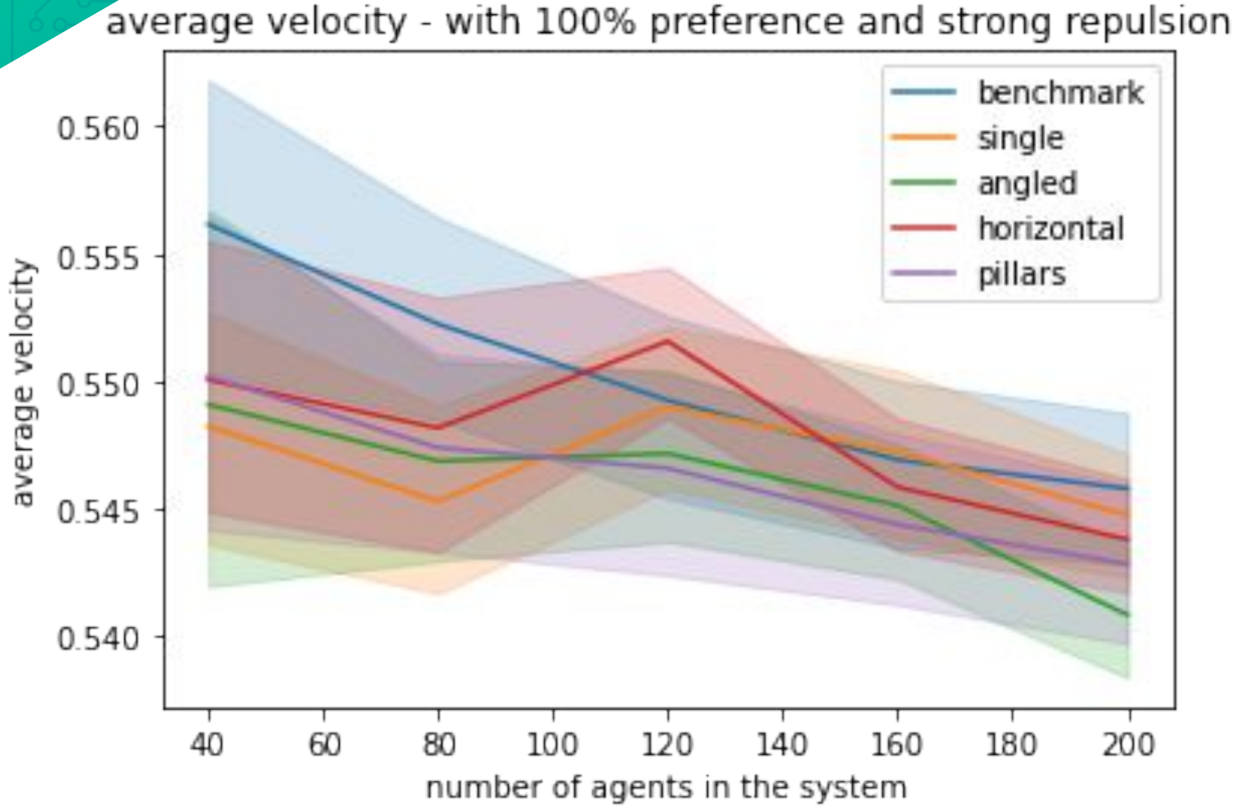
Results for 50/50 and stronger repulsion



Results for 80/20 and stronger repulsion



Results for 100/0 and stronger repulsion



Modification attempts

- Distribution of agents' initial position ✓
- Increased repulsion force towards obstacles ✓

- Goal destination ✗
- Width of the field of view ✗

- Density and size of the pillars ✓

Conclusions

- **Which obstacles in a corridor increase the average velocity of a bidirectional crowd flow?**
  - Is the result robust for different number of agents, N?
  - Does the result change for different parameter settings?

Deviations from the paper *'The study of the influence of obstacles on crowd dynamics' (2017)*:

- Non-periodic movement
- Choice of obstacles
- Initial position of the agents

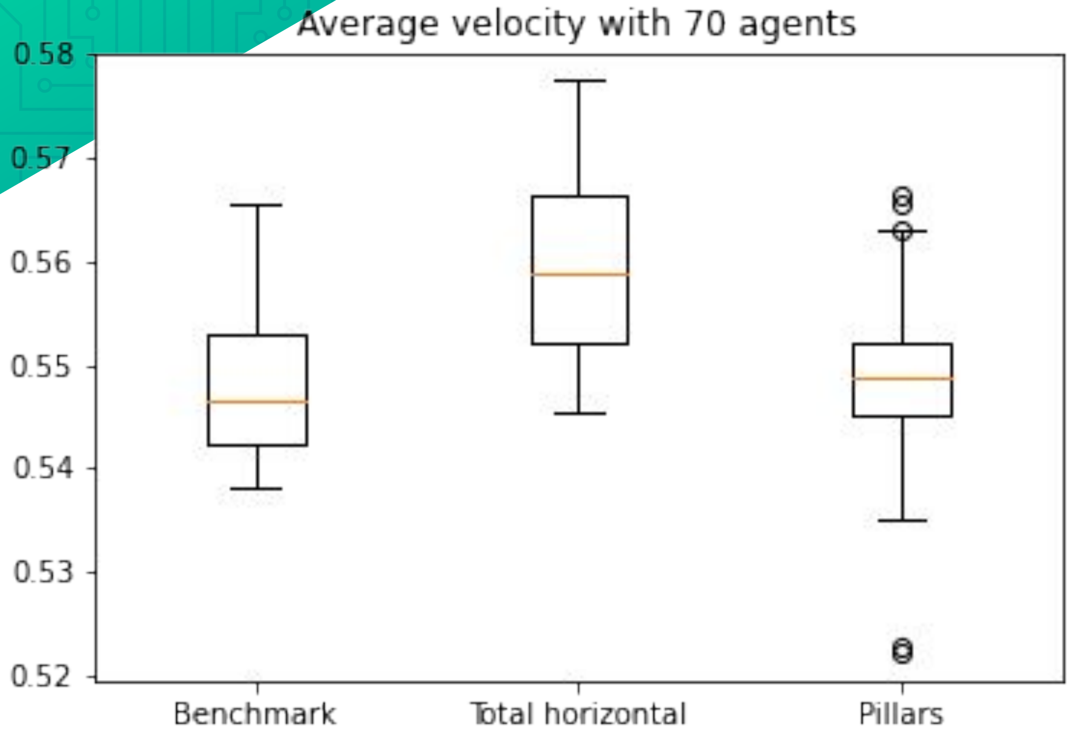
THANK YOU FOR LISTENING, ANY QUESTIONS?

Bibliography

- Dirk Helbing and Pèter Molnàr, Social force model for pedestrian dynamics, Phy. Rev. E 51 (1995)
- Oksana Severiukhina, Daniil Voloshin, M.H. Lees, Vladislav Karbovskii, The study of the influence of obstacles on crowd dynamics, Procedia Computer Science (2017)
- Glen Berseth et al., Environment optimization for crowd evacuation, Computer Animation and Virtual Worlds (2015)
- Mehdi Moussaid et al., The Walking Behaviour of Pedestrian Social Groups and Its Impact on Crowd Dynamics (2010)
- Mehdi Moussaid et al., Experimental study of the behavioural mechanisms underlying self-organization in human crowds (2010)
- Dirk Helbing et al., Self-Organized Pedestrian Crowd Dynamics: Experiments, Simulations, and Design Solutions

APPENDIX

Appendix A



Validation of our model and algorithm with the one from the paper *The study of the influence of obstacles on crowd dynamics (2017)*.

With an horizontal obstacle for all the pathway, the crowd moves faster than with an empty corridor; adding pillars also seems to increase the average velocity, but the difference from the benchmark is not significant.