PAAMS 23

International Conference

A multi-level density-based crowd simulation architecture

Huu-Tu Dang[1], Benoit Gaudou[1], Nicolas Verstaevel[1]

[1]UMR 5505 IRIT, University Toulouse Capitole, France

Corresponding author: huu-tu.dang@ut-capitole.fr

Outlines

- Motivation
- Introduction
- Methodology
- Application and Result
- Conclusion and Future work

Motivation

- Crowd dynamics **vary significantly** depending on factors such as time, environment, ...
- In the literature, influential models are known to work well under specific situations: **low-density** or **high-density**.
- How to simulate such situation in the video?

⇒ **Coupling models** to achieve a more comprehensive simulation across various crowd densities.

- How to combine/switch models in a more **generic way**?
- A general architecture that can be used to simulate different kinds of dynamics, not just pedestrian dynamics?

Place des Terreaux, Lyon, France

Huu-Tu et al., huu-tu.dang@ut-capitole.fr

Introduction

Strategic

Goal selection

Tactical

How to choose a path

Operational

Path adaptation

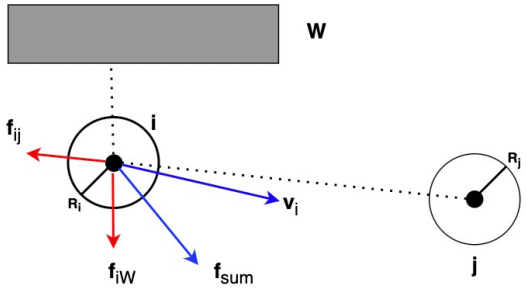
Serge Hoogendoorn, P.H.L. Bovy, and Winnie Daamen. “Microscopic pedestrian wayfinding and dynamics modelling”. In: Pedestrian and Evacuation Dynamics (Jan. 2002), pp. 123–155.

Huu-Tu et al., huu-tu.dang@ut-capitole.fr

Introduction

- Social Force Model [Helbing et al., 2000]:

$$m_i \frac{dv_i}{dt} = m_i \frac{v_i^0(t)e_i^0(t) - v_i(t)}{\tau_i} + \sum_{j \neq i} f_{ij} + \sum_{j \neq i} f_{iW}$$



- Lane formation, semi-circle at the bottleneck.
- Oscillation at high-density [Nuria et al., 2007].

Helbing, D., Farkas, I., & Vicsek, T. (2000). Simulating dynamical features of escape panic. *Nature*, *407*(6803), 487-490.
Pelechano, Nuria & Allbeck, Jan & Badler, Norman. (2007). Controlling Individual Agents in High-Density Crowd Simulation. Proc. Symp. Computer Animation. 2007. 99-108. 10.1145/1272690.1272705.

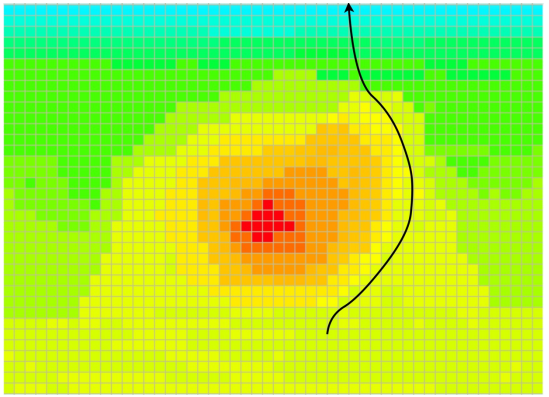
Huu-Tu et al., huu-tu.dang@ut-capitole.fr

Introduction

- Continuum Crowd (CC) model [Treuille et al., 2006]:

$$\begin{cases} \|\nabla\phi(x)\| & = C \\ v & = -f(x,\theta)\frac{\nabla\phi(x)}{\|\nabla\phi(x)\|} \end{cases}$$

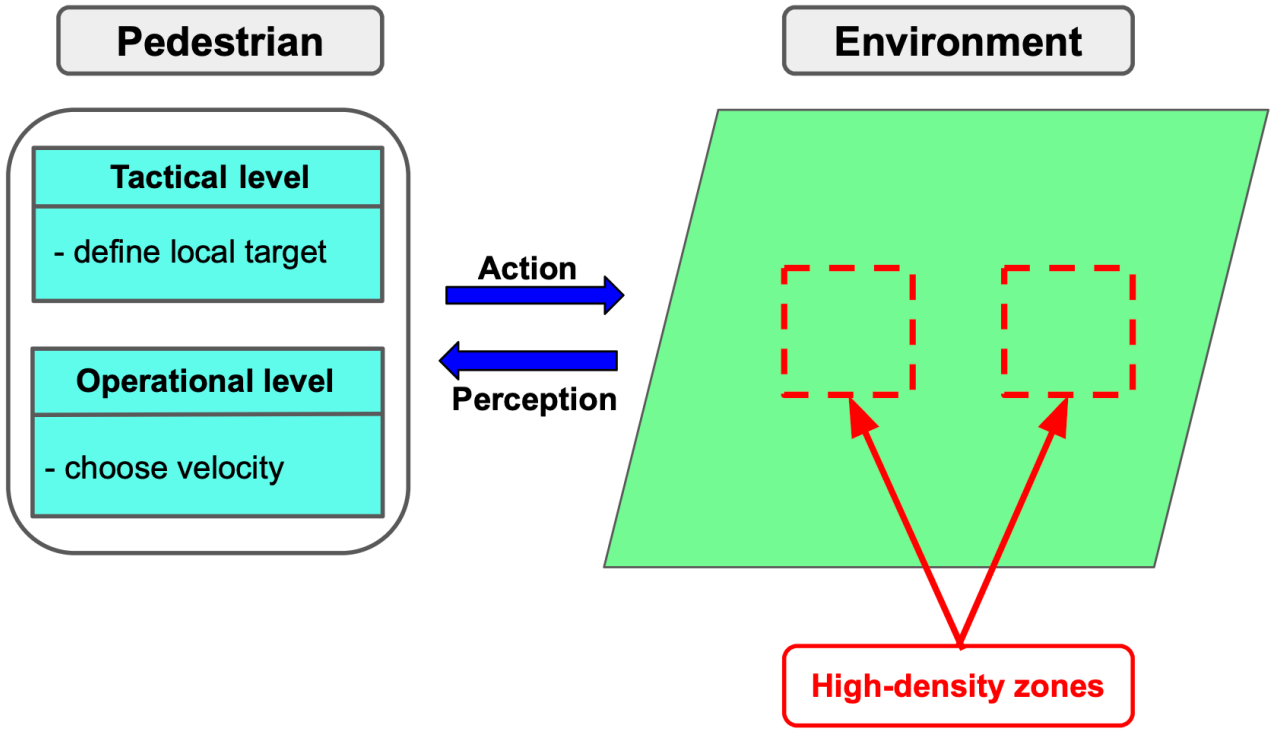
- Suitable for simulating large crowds in high- and extremely high-density situations.



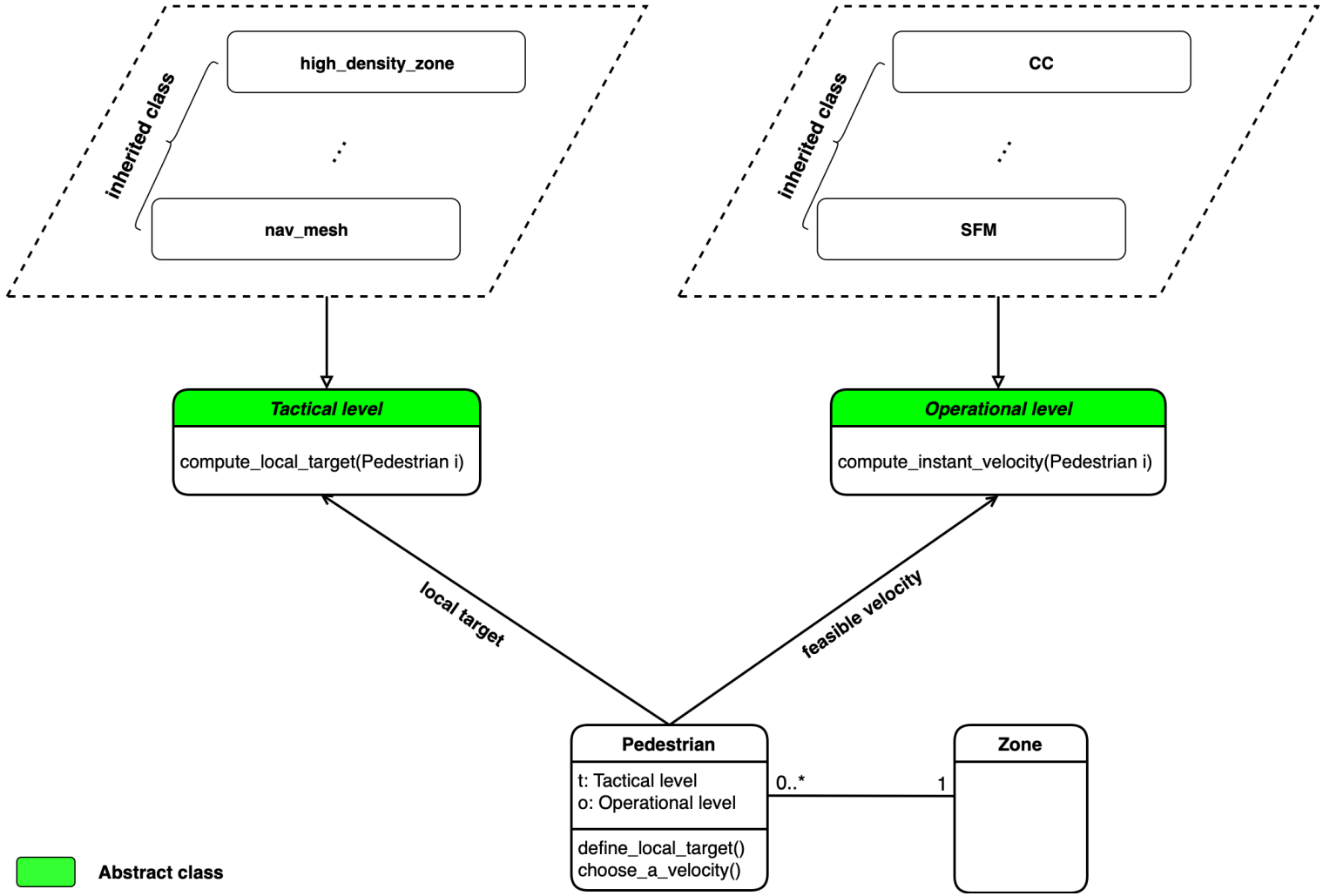
Treuille, A., Cooper, S., & Popović, Z. (2006). Continuum crowds. *ACM Transactions on Graphics (TOG)*, *25*(3), 1160-1168.

Huu-Tu et al., huu-tu.dang@ut-capitole.fr

Methodology



Huu-Tu et al., huu-tu.dang@ut-capitole.fr


high_density_zone
nav_mesh
inherited class
CC
SFM
inherited class
Tactical level
compute_local_target(Pedestrian i)
Operational level
compute_instant_velocity(Pedestrian i)
local target
feasible velocity
Pedestrian
t: Tactical level
o: Operational level
define_local_target()
choose_a_velocity()
0..*
1
Zone
Abstract class

Application: FoL case study

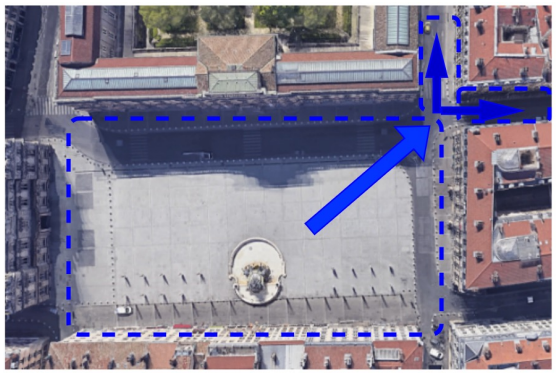
- Festival of Lights (2022):
  - 30 illuminated spots
  - More than 2 million people over 4 days
- Most crowded spots: Place des Terreaux
  - 1 single entrance
  - 2 main exits
  - 7-minute show
  - 150 K people / night

Festival of Lights (FoL), Place des Terreaux, Lyon, France[1]

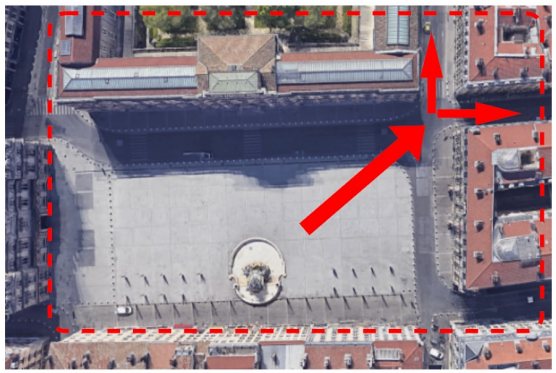
[1] **https://www.fetedeslumieres.lyon.fr/fr/oeuvre/grand-mix-au-musee-des-beaux-arts-de-lyon**

Huu-Tu et al., huu-tu.dang@ut-capitole.fr

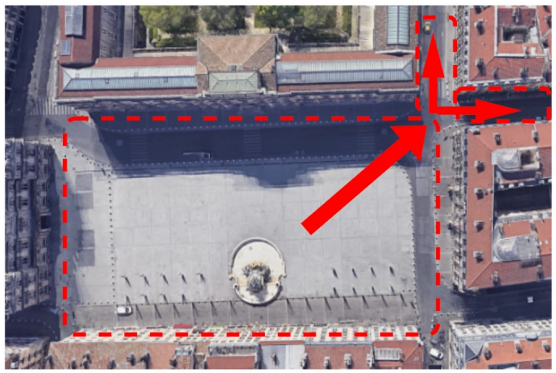
Application: FoL case study



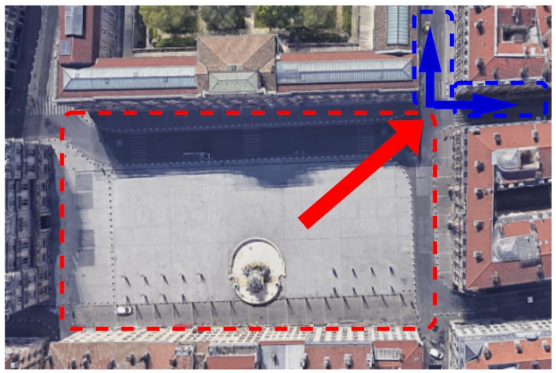
SFM-only



1-CC-2



3-CC-1



Our model

Simulated by SFM

Simulated by CC

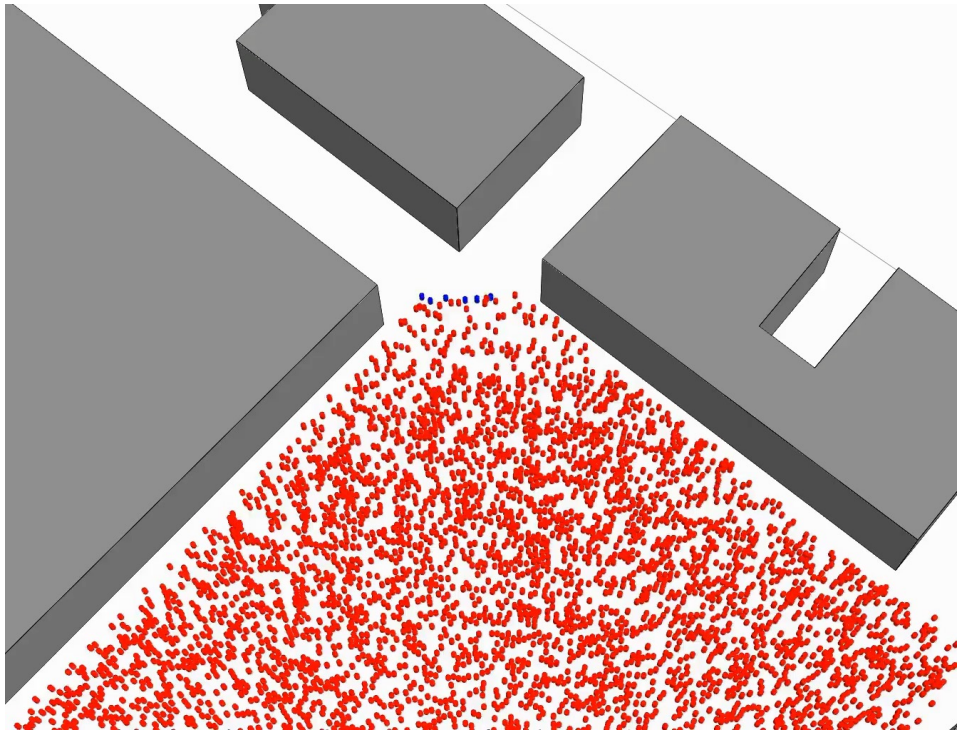
Experiment configuration

- Simulations are conducted on the **GAMA platform** [Taillandier et al., 2019].
- Initial condition: pedestrians are **uniformly distrubuted** in the plaza.
- Final condition: pedestrians reach the **end of the exits**.
- Evaluation metrics:
  - **Computation time.**
  - **Density map**
  - **Outflow** of pedestrians exiting the plaza to the two exits.
  - **Speed distribution** of pedestrians in low- and high-density zones.

Taillandier, P., Gaudou, B., Grignard, A., Huynh, Q. N., Marilleau, N., Caillou, P., ... & Drogoul, A. (2019). Building, composing and experimenting complex spatial models with the GAMA platform. *GeoInformatica*, *23*, 299-322.

Huu-Tu et al., huu-tu.dang@ut-capitole.fr

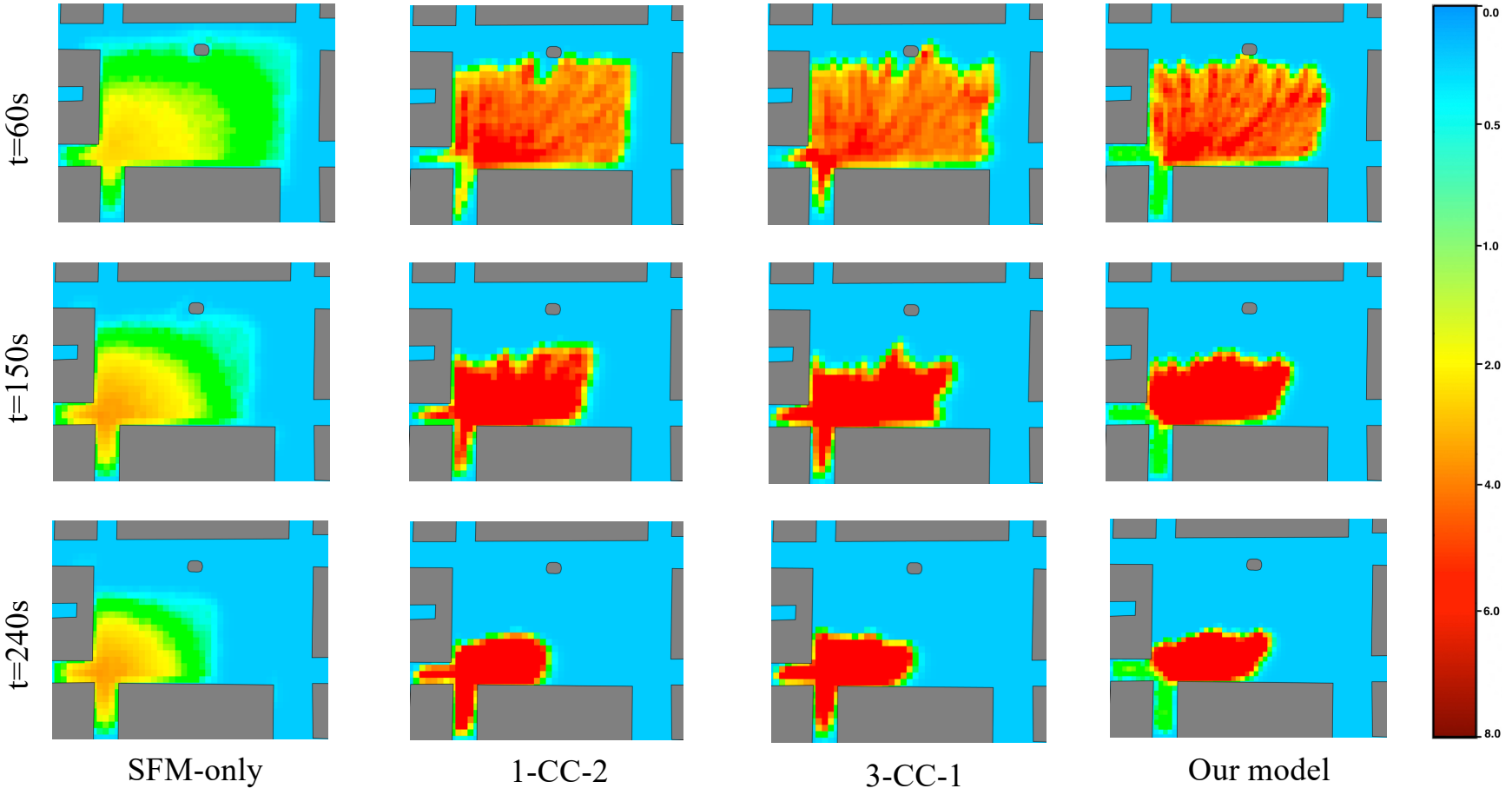
Result



Simulation of 6000 agents

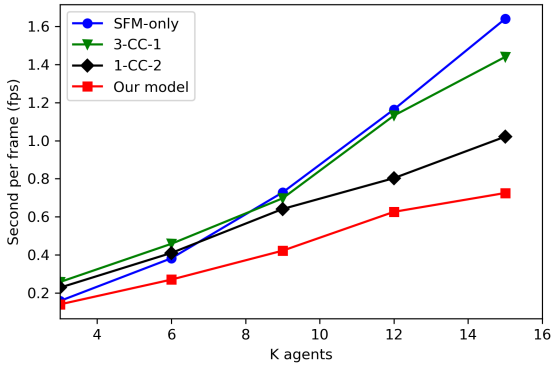
Huu-Tu et al., huu-tu.dang@ut-capitole.fr

Simulation of 6000 agents

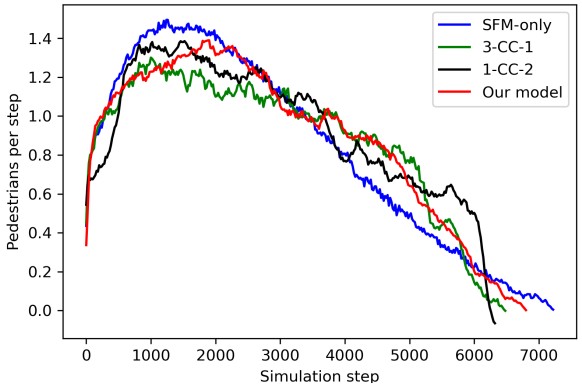


Huu-Tu et al., huu-tu.dang@ut-capitole.fr

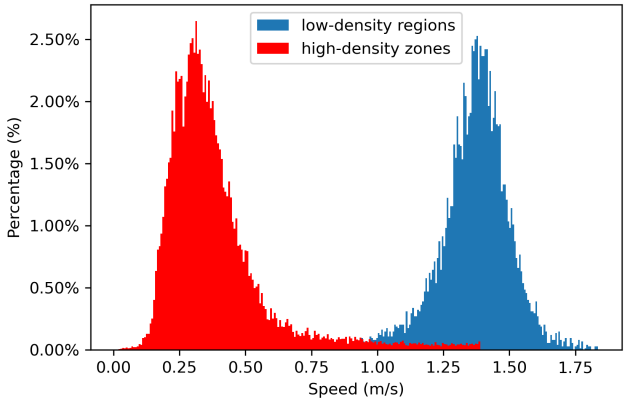
Result



Model performance



Outflow over simulation time



Speed histogram of the two regions (our model).

Conclusion and Future work

- Conclusion: a generic crowd simulation architecture
  - Effective simulation in **diverse-density situations**.
  - **Flexible** incorporation of various models.
  - Improved runtime performance.
  - Comparable pedestrian outflow results.
- Future work:
  - Model **calibration/validation** with **real-world data** obtained during the FoL.
  - **Dynamic** zones.

Huu-Tu et al., huu-tu.dang@ut-capitole.fr

Thank you for your listening !!!