CNRS - INP - UT3 - UT1 - UT2J

Institut de Recherche en Informatique de Toulouse

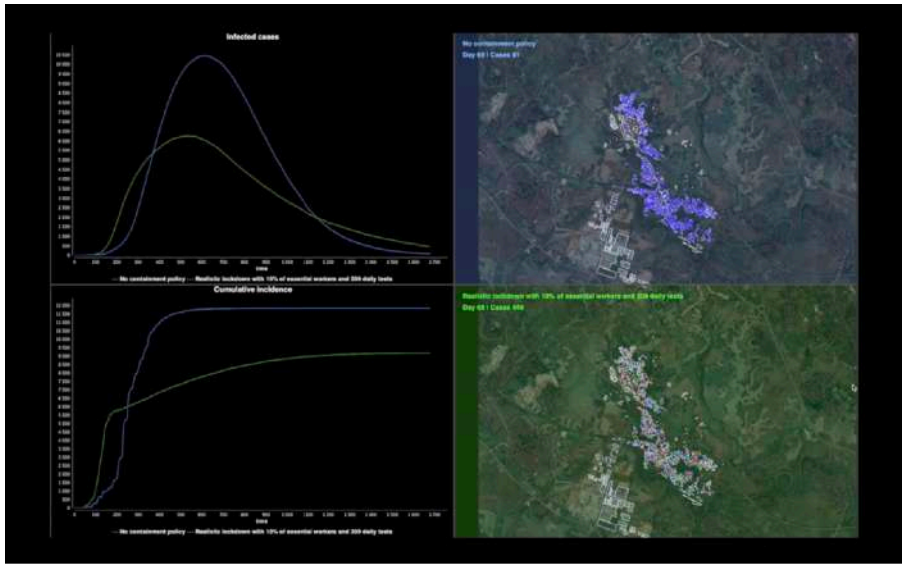
Multi-Agent modelling of Dense cRowd dynAmicS (MADRAS project)

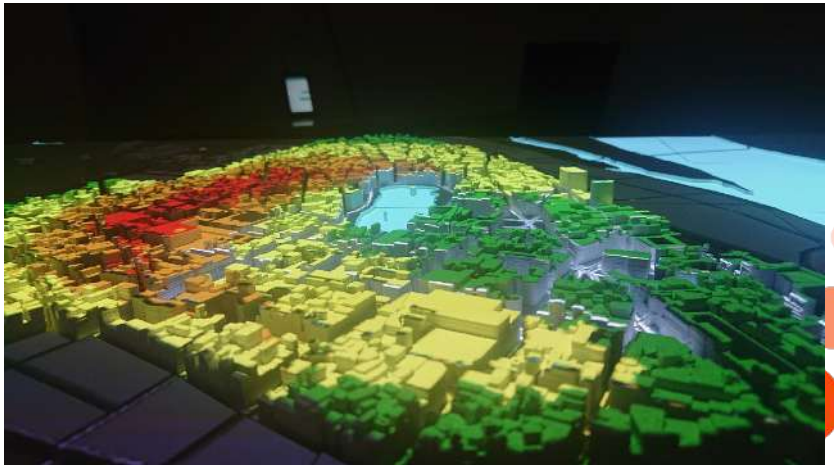
Benoit Gaudou, Nicolas Verstaevel
(Travail en collaboration avec Huu Dang Tu et Frédéric Amblard)

Université Toulouse Capitole, IRIT, Dept. ICI, équipe SMAC

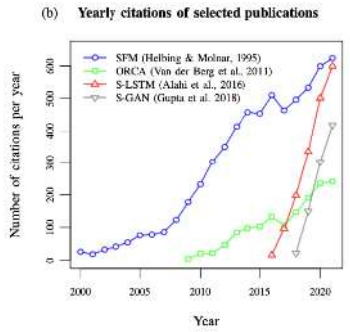
Overview

- Main research topic : **agent-based modeling and simulation**
- **Application fields** : mobility, urban planning, epidemiology, socio-agro-ecosystems, crisis management …
- Tool : **GAMA platform**





MADRAS project



- **Objectives:**
  - Agent-based models to predict and understand **dense crowds dynamics** (2 to 8 ped./m2)
  - Application to a large-scale case study: Fête des lumières, Lyon.

- Models will combine (and compare) various approaches:
  - (i) **neural networks model** that will be trained on available data to predict pedestrian motion as a function of their local environment and trajectory,
  - (ii) **physics-based model** coupling a decisional layer, where a desired velocity is selected according to an empirically validated collision-anticipation strategy, and a mechanical layer, which takes care of collisions, contacts, and body shapes,
  - (iii) **agent-based model** providing a versatile behavior allowing agents to switch dynamically between a library of models on operational, tactical and strategical levels depending on the density.

Application case: The Fêtes des Lumières (Lyon)

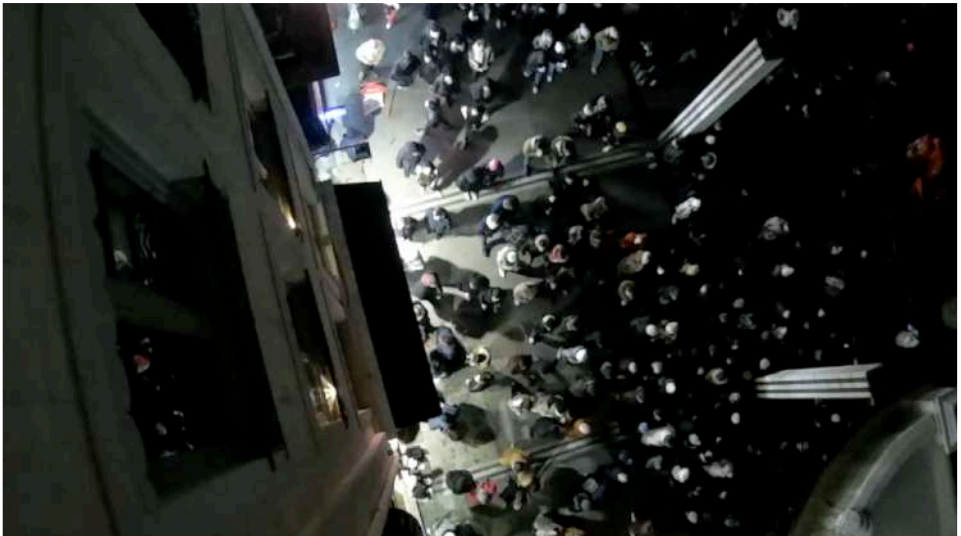
Festival of Lights (2022)

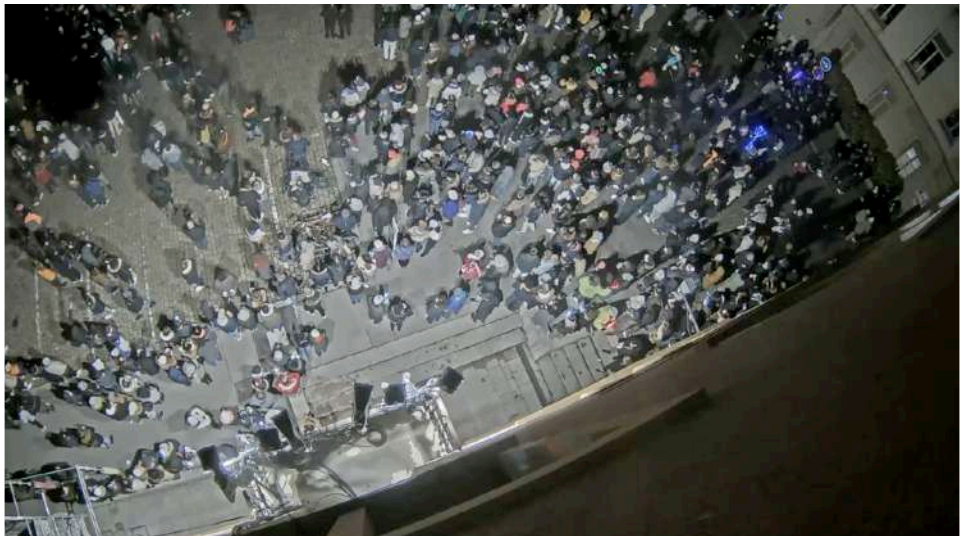
- ~30 illuminated spots
- more than 2 millions people over 4 days

Most crowded spots:

- Place des Terreaux (150 000 p/night)
- Place Saint-Jean (80 000 p/night)

https://www.le-tout-lyon.fr/fete-des-lumieres-2-millions-de-visiteurs-les-trois-spots-qui-ont-attire-le-plus-de-spectateurs-117634.html#:~:text=La%20Ville%20de%20Lyon%20a,trois%20lieux%20de%20pr%C3%A9dilection%20identifi%C3%A9s.





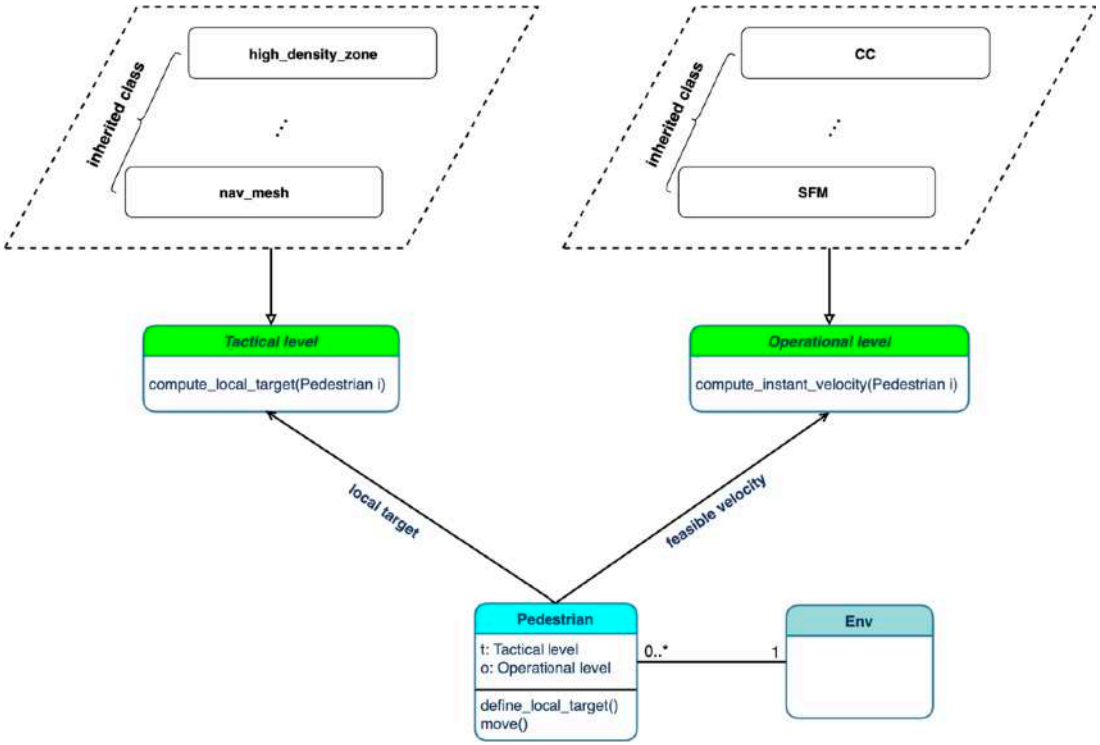
MADRAS project: IRIT team's objectives

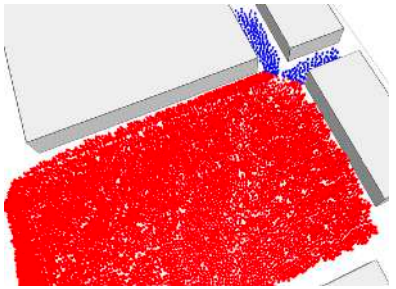
- An agent-based model:
  - Taking into account the 3 levels (strategic, tactical and operational)
  - Large-scale simulation
  - Can be applied to any 2-dimensional GIS environment
  - **Density-dependent decision-making behavior**
  - **Dynamic switch between different modeling algorithms** (from Social Force Model to data-driven approach (ML)).

Festival of Lights in Lyon

Contribution: model coupling and dynamic switch

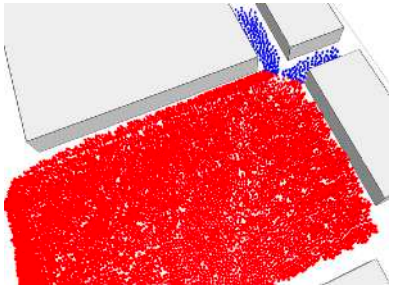
- Definition of a modular agent architecture allowing it to switch models on both tactical and **operational levels**.
- As a proof of concept, **2 implemented models (SFM for low-density areas and Continuum Crowd model, for high-density areas)**

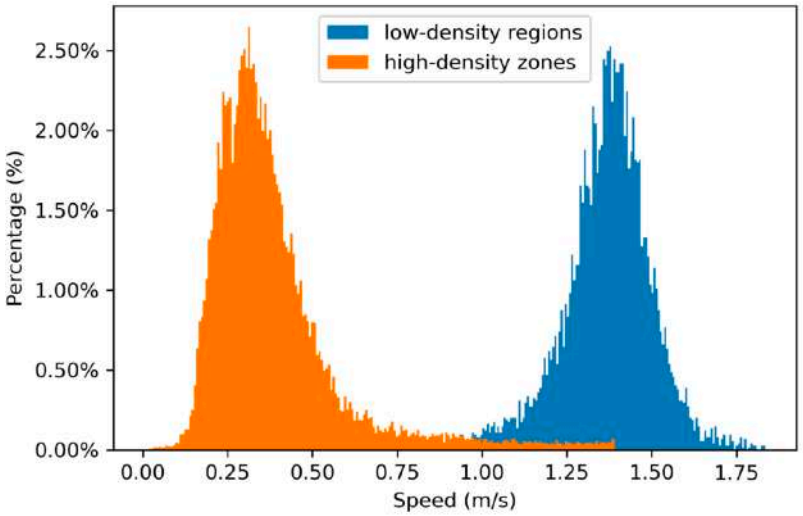




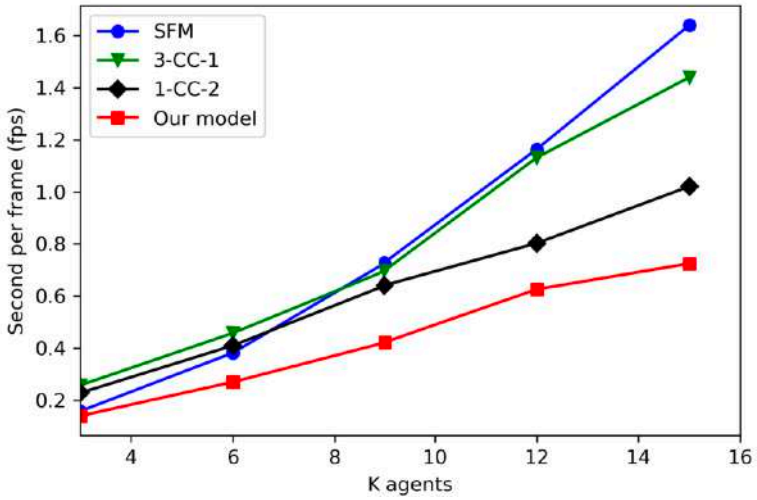
Model coupling and dynamic switch

- Simulation with 4 situations:
  (i) Social Force Model everywhere (SFM),
  (ii) Continuum Crowd everywhere (1-CC-2),
  (iii) 3 Continuum Crowd models (3-CC-1),
  (iv) Continuum model on the square and SFM on 2 exit roads (our model).





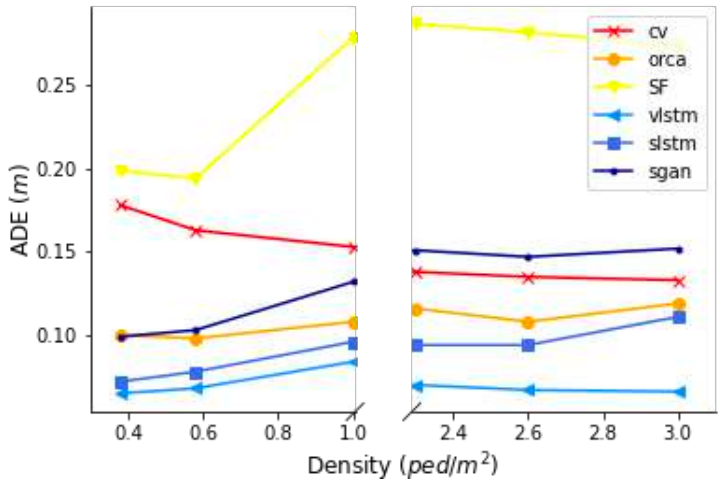
Verifications: Speed distribution over the 2 areas (our model)



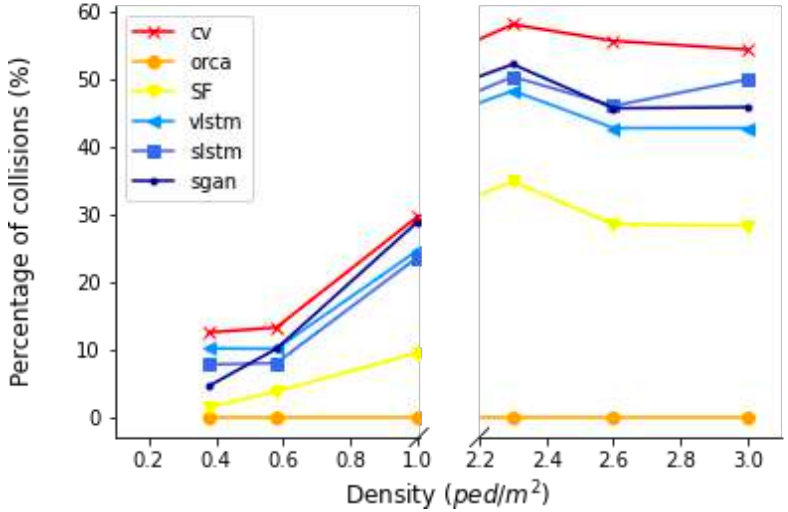
Results: Comparisons of execution times

Machine Learning of pedestrian and density

- Tests on an existing dataset (from Julich Center, di-directional flow).
- Impacts of the density, the algorithm and the metrics :



Results of distance error-metric (ADE).



Results of collision metric

- Study in terms of feature selection: Relative distance, Relative velocity, Mean space, Frontal effect, Distance to wall, Preferred speed, Time-to-collision

Project expected results

- Datasets
- Study of pedestrian behaviors depending on the density
- Improvement of models (mechanistic, data-driven …) to adapt dense situations (body shape, feature selection, social structure…)
- Modular, multi-scale agent architecture switching between model depending on the density

Merci de votre attention !

Questions ?

MADRAS project: https://www.madras-crowds.eu/

GAMA Platform: https://gama-platform.org/