Numerical simulation of a preventative evacuation using a multi-agent framework

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Context of pedestrian evacuations

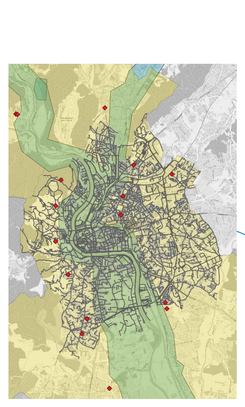
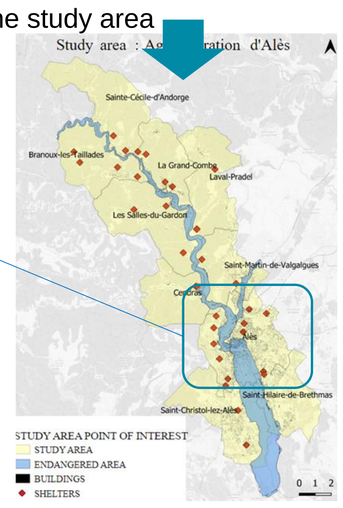



In conjunction of a possible **rainfall event** and the presence of a flood control dam, this paper explores the **evacuation of population** as a response to a **NaTech hazard**. The hazard of dam failure is thus a cascade reaction of a prior meteorological hazard, which directs the work towards preventive evacuation. It is also **fully pedestrian**.

This work questions the possibility to model and simulate a **full pedestrian evacuation** using a **multi-agent framework.**

- To **enhance** the understanding of preventive evacuation process
- To **build a simulation** of an evacuation using a Multi-Agent System
- To **model** a standard evacuation process using UML
- To **apply** the simulation to a study case

The study area

With a specific focus on the Ales (central municipality of the study area).

Methodology

1

Starting from various information material, the first aim is to reach a global understanding of « **what is an evacuation ?** »

Using **operational feedbacks** and **literature review** on the process to identify actors and interactions.

2

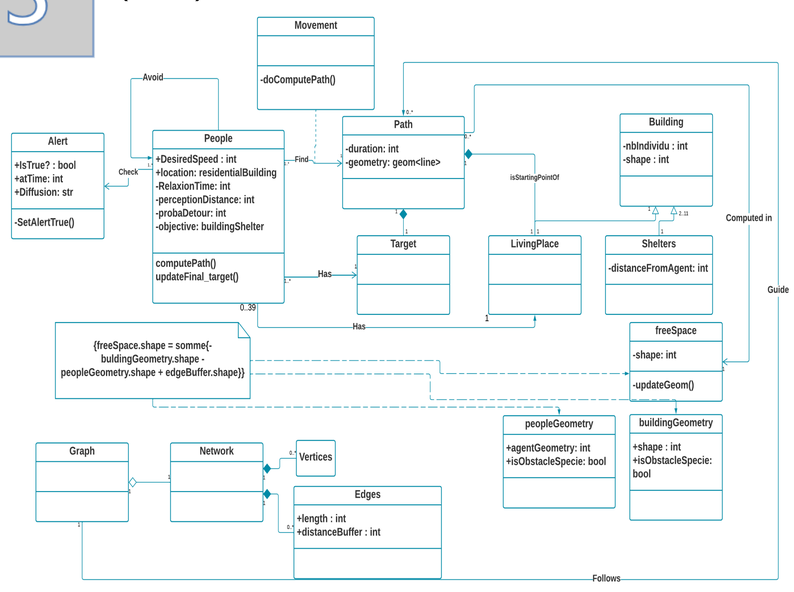
Highlight of **key points** and identification of **main problems.**

- **Herding effects [1]**, **stop & go, bottleneck** caused by the **pedestrian density**.
- **Contextual and organizational** factors variance
- **Non-obedience** / lack of knowledge of a significant part of the population

- Lack of **global approach** of the process
- No **fully pedestrian** simulation
- Non-efficient **crisis scenarios**

3

Reusable model using a standard modelling language (UML)



4

The simulation

Simulation

An environment

Peoples

Each dot **embodies a person** concerned by the evacuation process.

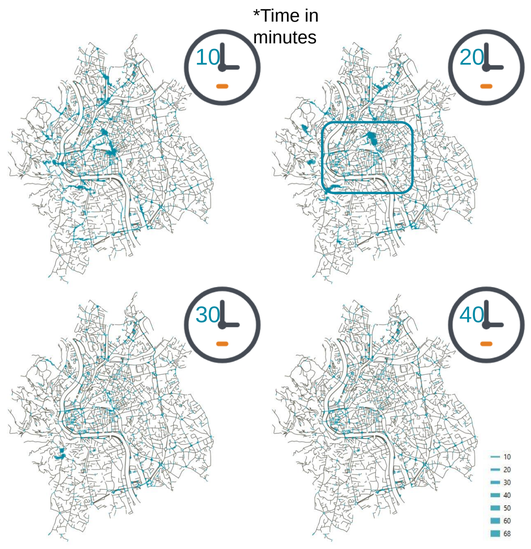
Algorithms

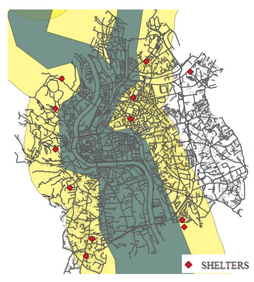
- Pathfinding
- Avoidance
- Behavior

Using a simplified **Social Force Model [2]** allows to render pedestrian micro-dynamics.

Results

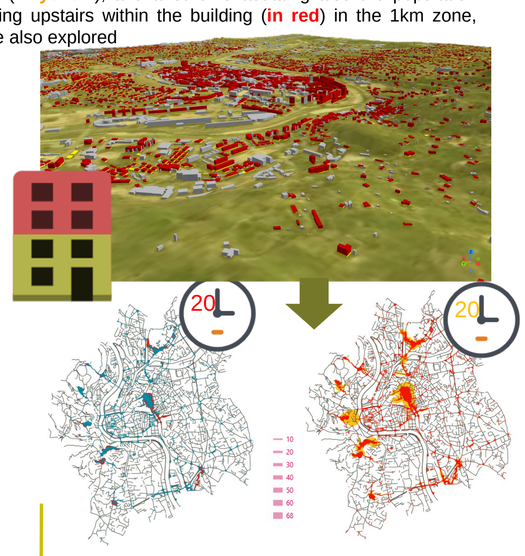
*Time in minutes





The standard simulation consider only peoples leaving under two meters height and less than **200 meters** away (**blue** area) from the river. as concerned by the alert.

Two scenarios, one considering a larger zone (1km) around the river (**in yellow**), and another evacuating also the population leaving upstairs within the building (**in red**) in the 1km zone, were also explored

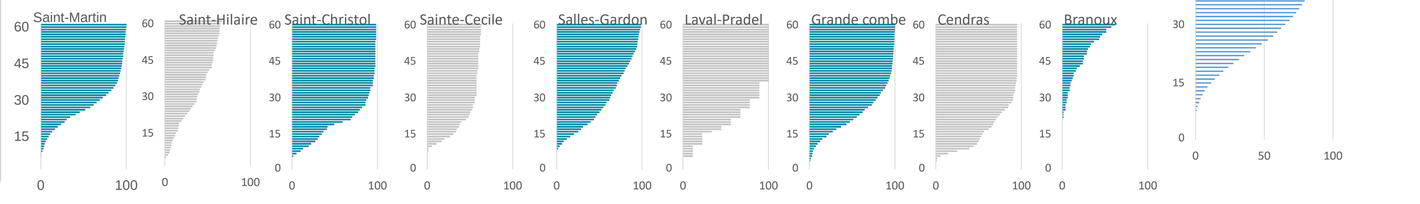


Using the **perfect readiness hypothesis**. Results show a peak in network demand around 20 minutes after the alert.

Municipality	Number of shelters	Population concerned	Population / Shelters	Evacuation time (in second)
Alès	11	3'673	334	65
Branoux-les-Taillades	4	84	21	115
La Grande Combe	4	401	100	60
Laval-Pradel	2	4	2	40
Salles du Gardon	4	444	111	99
Sainte-Cécile d'Andorge	2	96	48	84
Saint-Christol	2	104	52	58
Saint-Hilaire de B.	1	198	198	135
Saint-Martin de Val.	2	568	284	121
Cendras	2	153	77	42

Same areas appear to be congestioned, highest density reached shows **225 peoples in road sections of 248m².**

According to the table, evacuation time tends to **be reduced** when the number of people for a shelter is lower. Mapped evacuation data also shows **high pedestrian density** at the density at the east-north exit.



Conclusion and perspectives

The use of a **Multi-agent system** framework is well suit to simulate pedestrian evacuation. Results demonstrate realistic egress times, and serious possibilities to fulfill **various indicators**. It is thus, an interesting first contribution to be completed with better integration of **human behaviors** complexity, and contextual scenarios.

References

[1] Moussaïd M., Helbing D., Garnier S., Johansson A., Combe M., Theraulaz G., 2009, Experimental study of the behavioral mechanisms underlying self-organization in human crowds, Proceedings of the Royal Society B: Biological Sciences, 276(1668), pp. 2755–2762. doi: 10.1098/rspb.2009.0405.

[2] Helbing D., Molnár, P., 1995, Social force model for pedestrian dynamics, Physical Review E, 51(5), pp. 4282–4286. doi: 10.1103/PhysRevE.51.4282.