ADAPTIVE TACTICAL DECISIONS IN PEDESTRIAN SIMULATIONS: A HYBRID AGENT APPROACH

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MOTIVATIONS

Application of pedestrian simulation models:

off-line

- ***Planning of infrastructures and events:***
  - security
  - walkability
- ***Transportation Planning***

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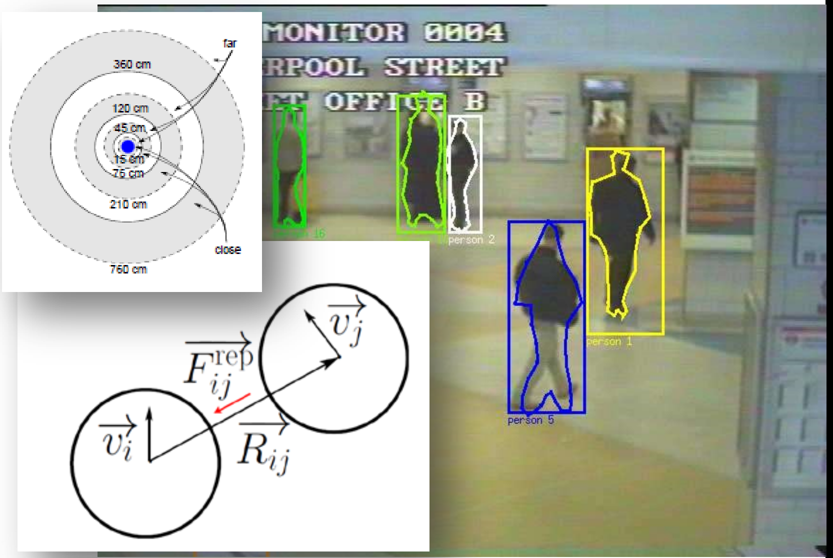
on-line

- ***Real-time Evacuation Systems***
- ***Surveillance***:
  - Improving tracking results
  - Characterizing the analyzed scene



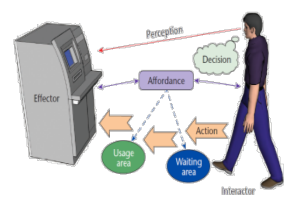
MICROSCOPIC MODELING – STATE-OF-THE-ART

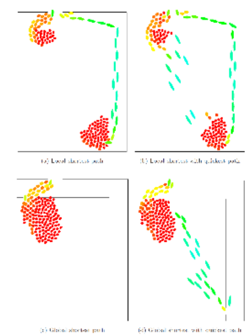
Strategic Level

Choice of the goals

Tactical Level

Plan computation
Activities scheduling
Choice of activity

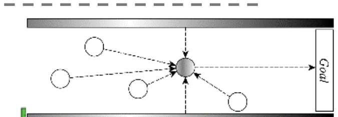




Operational Level

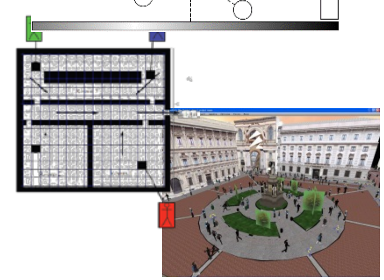
Movement execution

Force based

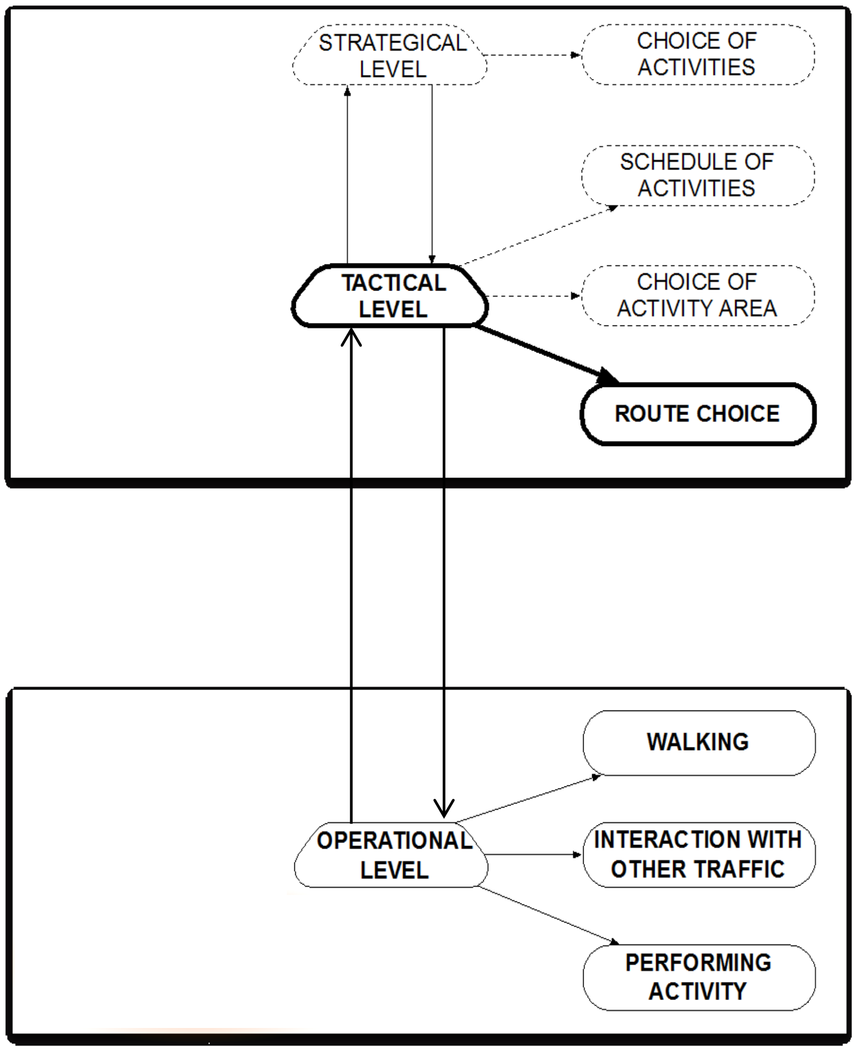


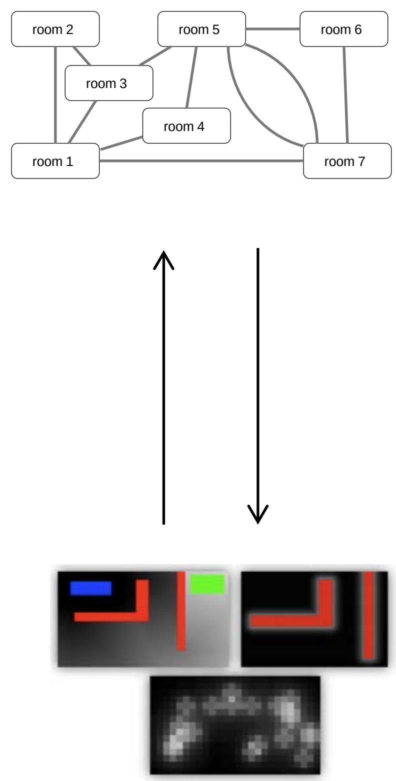
CA-based

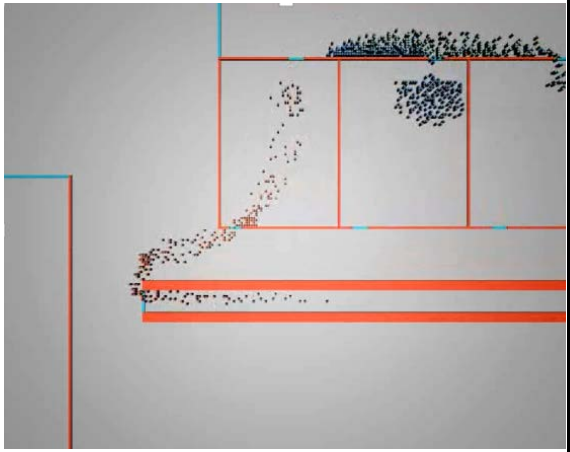
Agent-Based

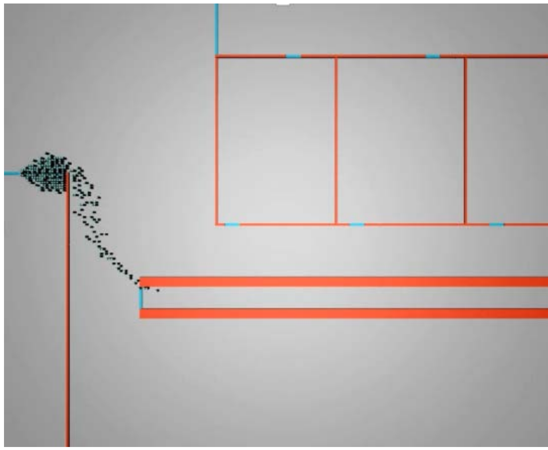


PEDESTRIAN DYNAMICS – THE 3 LEVELS OF BEHAVIOR



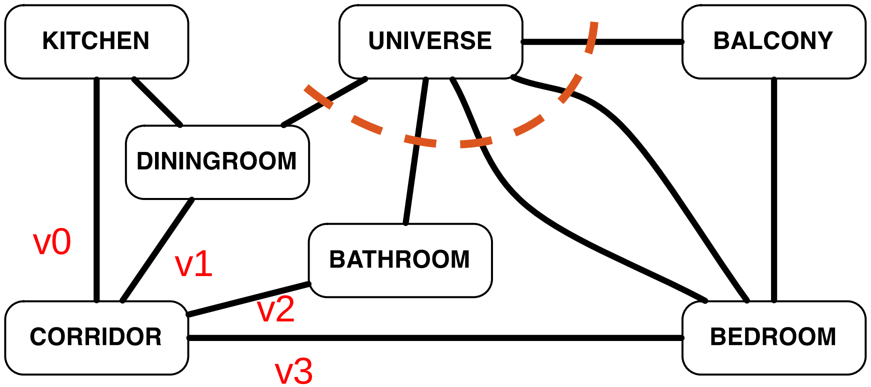






SUMMARY OF THE COGNITIVE MAP FEATURES

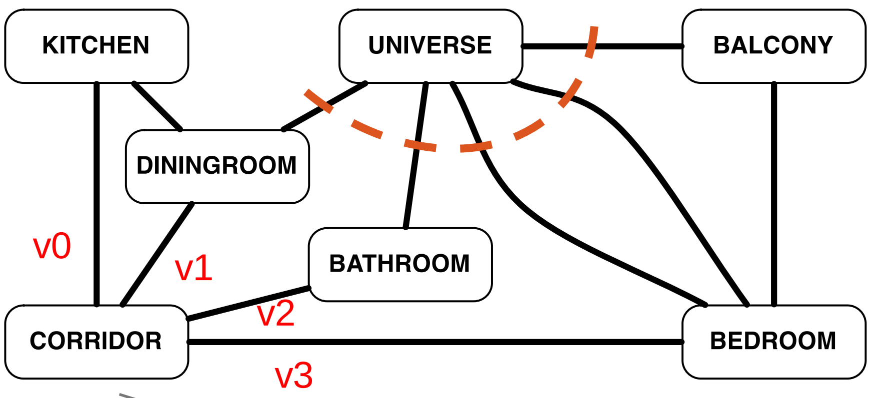
- It is a topological map, known entirely by all the agents
- It allows to characterize regions (e.g. ramps)
- It allows to logically represent the position of agents and other objects in the space (e.g. ticket machines)
- It does not contain any information about physical distances



	v0	v1	v2	v3
v0	---	…	…	…
v1	…	---	…	…
v2	…	…	---	…
v3	…	…	…	---

A BASIC APPROACH

- With the information on distances between navigational markers we can “reverse” the map…
- … and use one of the well-known routing algorithms (e.g. Dijkstra or Floyd-Warshall) to allow dynamic route choice
- Dynamic route choice must consider variation of the weights with the local dynamics (i.e. arising of congestion)
- But this is computationally heavy…

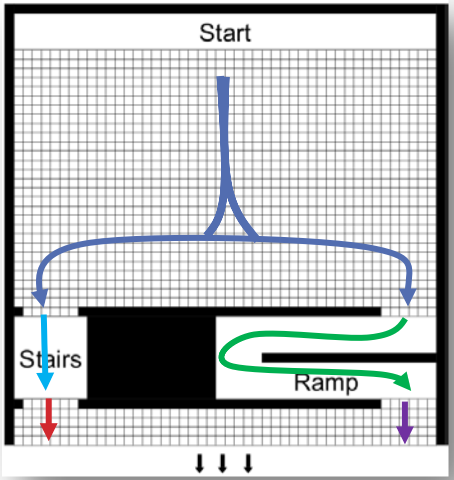


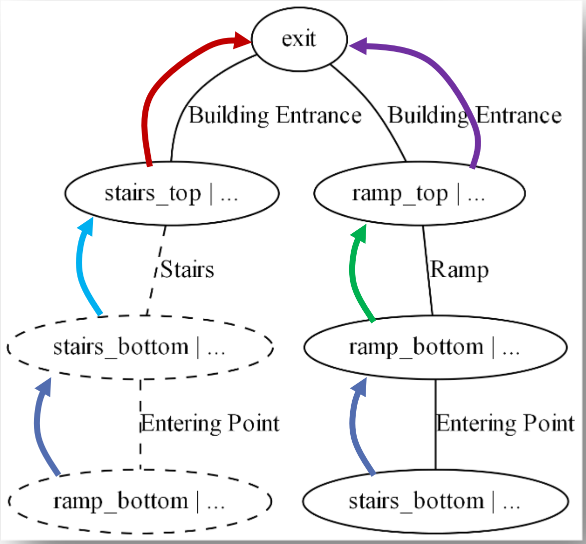
	v0	v1	v2	v3
v0	---	…	…	…
v1	…	---	…	…
v2	…	…	---	…
v3	…	…	…	---

DYNAMICALLY MANAGING THE TACTICAL LEVEL: INTRODUCTION TO THE PATHS TREE

- Given an arbitrary space, the agent should be able to plan a path toward its target, trying to minimize its traveling time and considering:
  - The types of environment that will be crossed → *static* elements
  - The emergence of congestion or other elements influencing the path conditions → *dynamic* elements

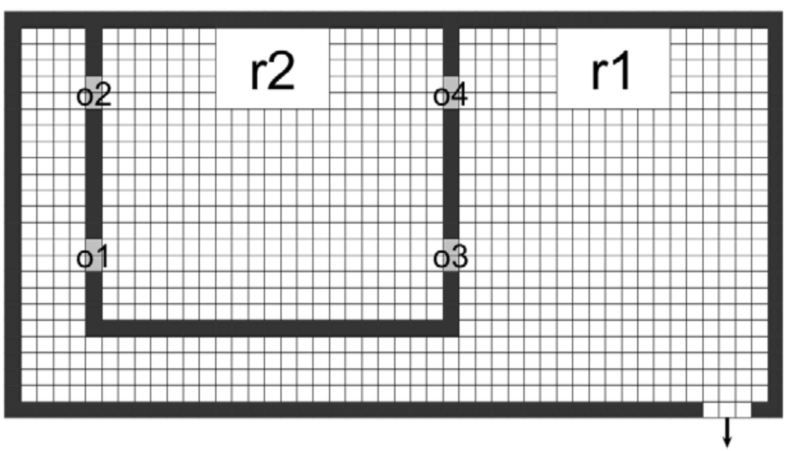
- The agent should be able to understand the changes in traveling times.
- The decision tree contains the average traveling time of each **minimal** path to a destination, estimated by considering static elements and the average speed of the agents.



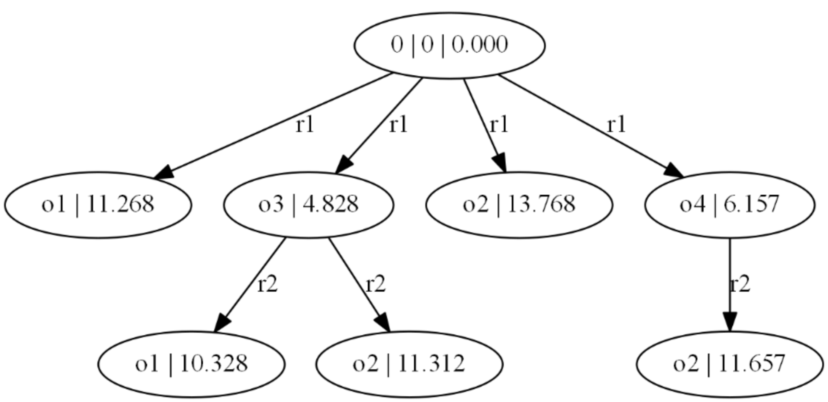


PATHS TREE – DEFINITION

Definition – Given the set of minimal paths towards a destination, the ***Paths Tree*** is a tree where the root represents the final destination and a branch from every node to the root describes a *minimal* path, crossing a set of openings (other nodes) and regions (edges). Each node has an attribute describing the expected minimal travel time to the destination.



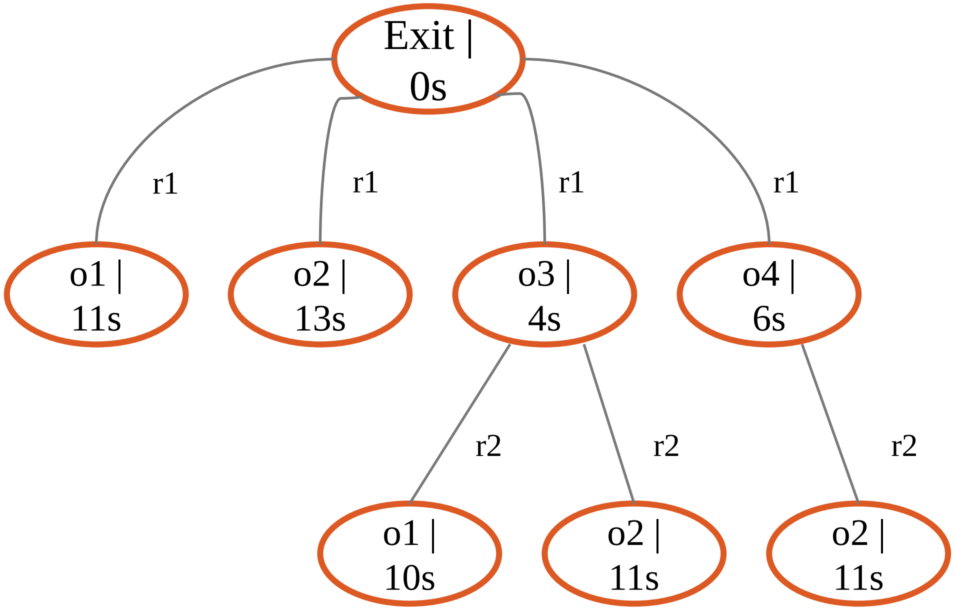
Example environment

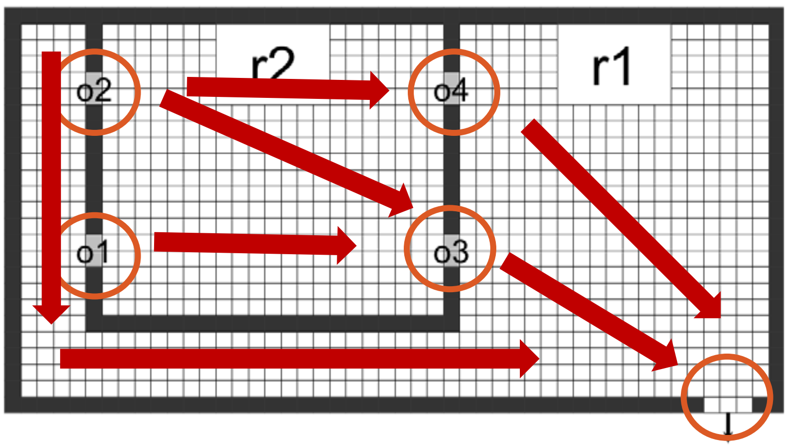


Respective Paths Tree

THE ALGORITHM FOR THE PATHS TREE COMPUTATION

- Generate the root with the destination and add to the **Expansion List (EL)**
- With a BFS strategy, iteratively expand the nodes in the **EL**, according to the *path minimality constraint*





PATHS TREE – USAGE BY THE AGENTS

- The time estimated by an agent for a path *p* is calculated as:

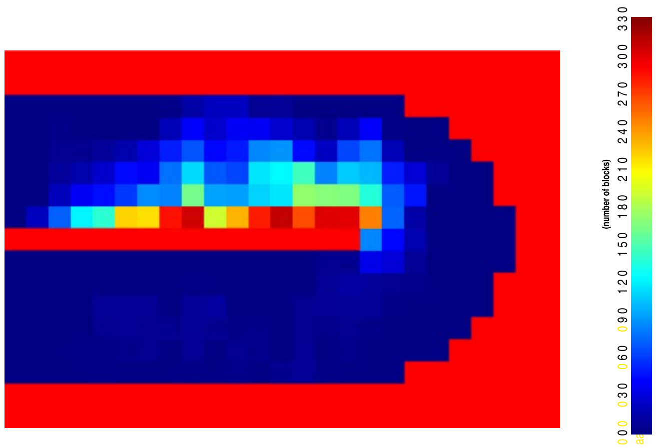
$$Time(p) = \tau_p + \frac{d(a, S(p))}{speed_a} + congestionDelay_a(p) + \xi_a$$

Where:

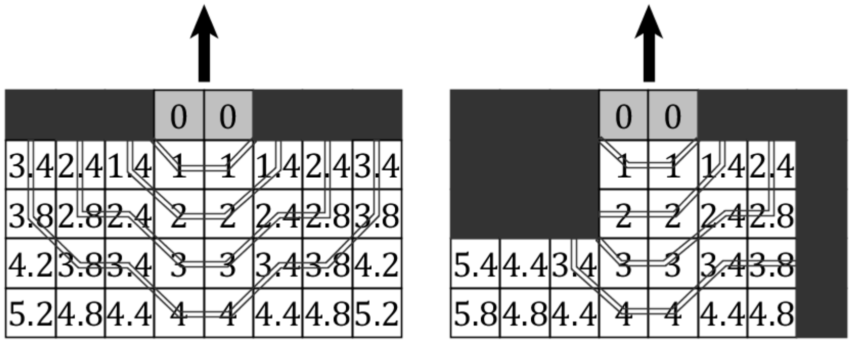
- τ_p : the expected travel time of the path p;
- $\frac{d(a,S(p))}{speed_a}$: the expected time to reach $S(p)$ from the position of the agent;
- $congestionDelay_a(p)$: the estimation of the delay introduced by each opening in the path, based on the memory of the agent a (which may or may not be updated for each opening);
- ξ_a : random error, whose entity can vary among the agents.

THE CONGESTION DELAY

- The *size* and the *speed* of the congestion around an opening (i.e. navigational marker) are calculated with an additional grid called **space blocks**.
- The space blocks grid stores all non-movement of agents at each step, cumulating values for a time window that will describe the *probability to move* per step, due to congestion.
- This probability is used to calculate an estimation of the size and the speed of the congested flow.
- A sensible variation of the congestion size will imply a plan re-calculation by the agents.



space blocks grid

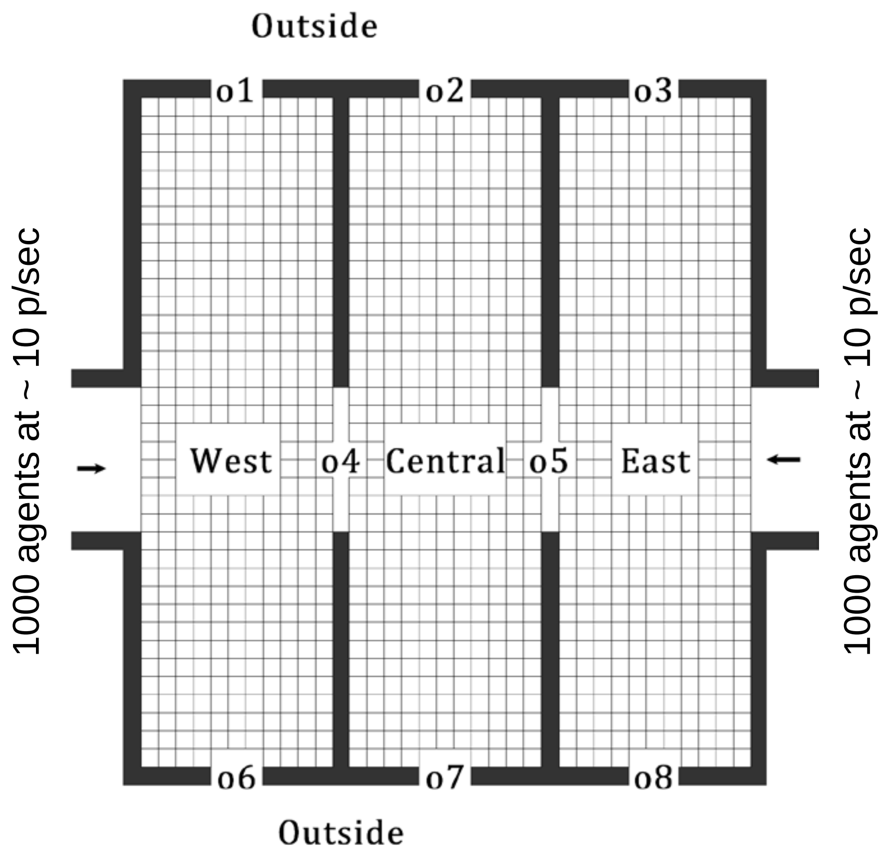


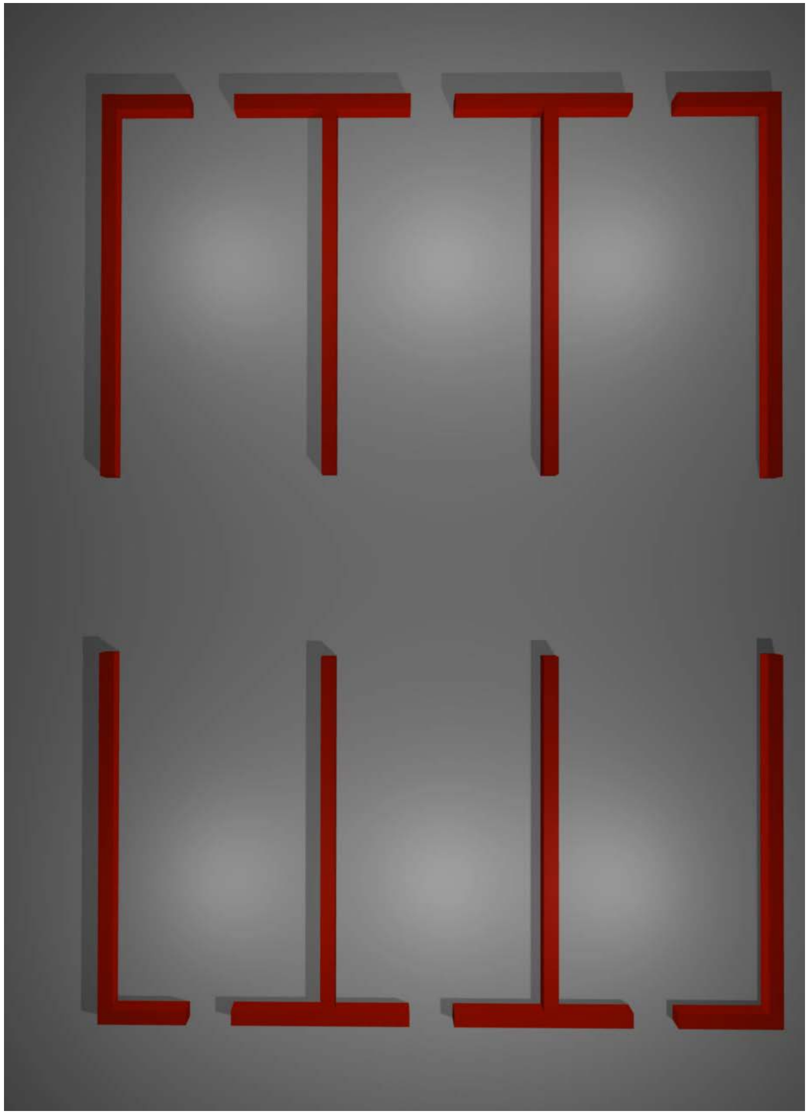
The floor field is used to expand the surrounding considered for congestion size

EXPERIMENTAL APPLICATIONS

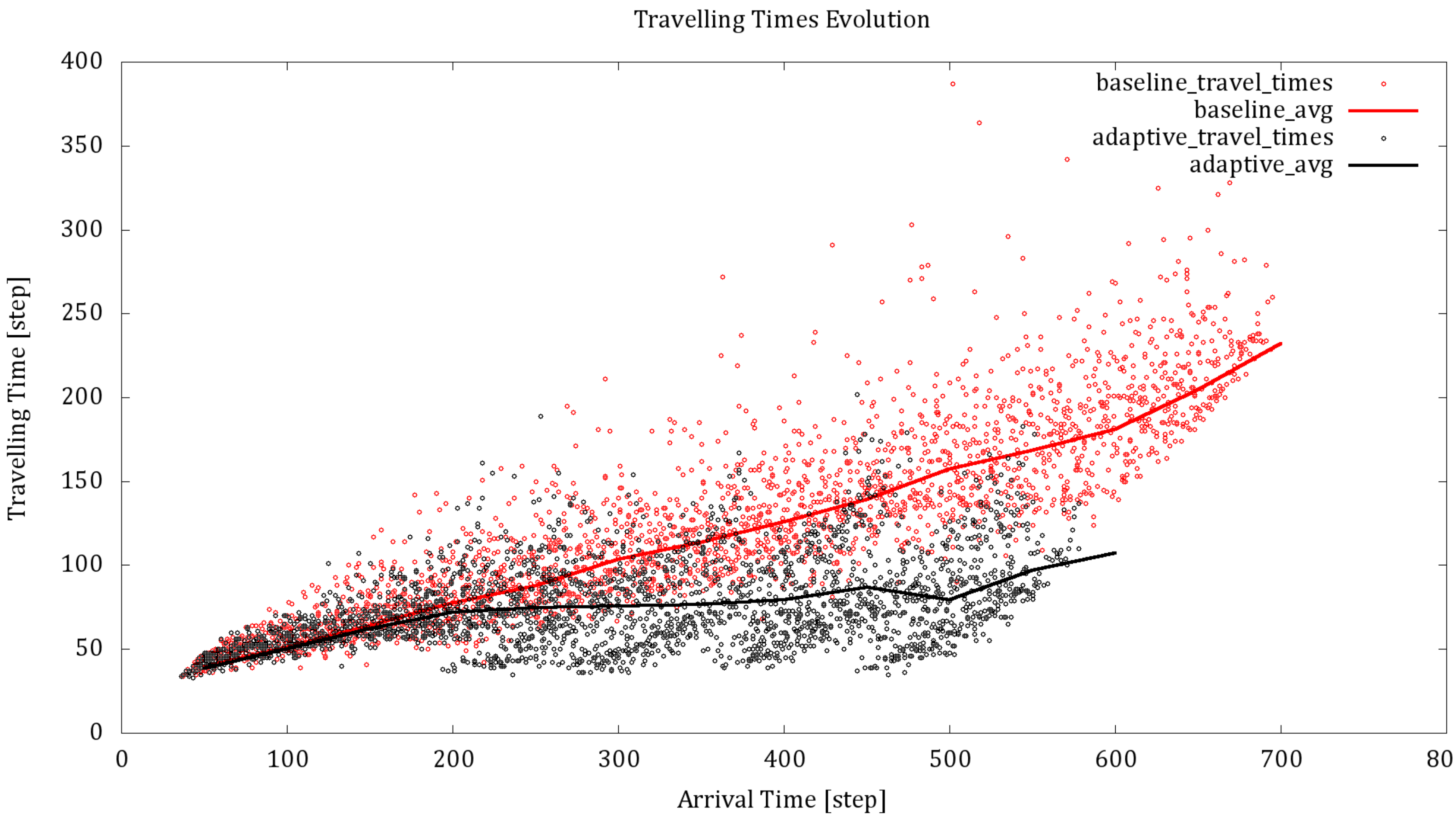
FIRST RESULTS OF THE MODEL

AN EVACUATION OF A LARGE POPULATION OF PEDESTRIANS





QUANTITATIVE RESULTS

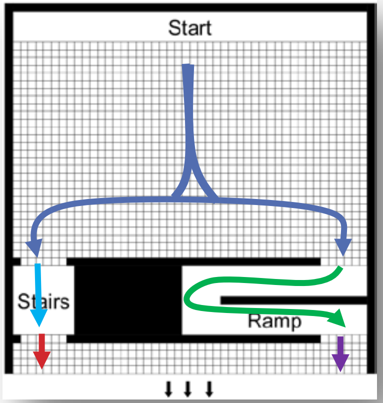


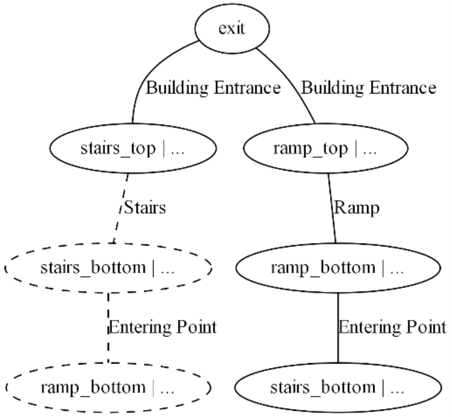
A MORE QUALITATIVE SCENARIO

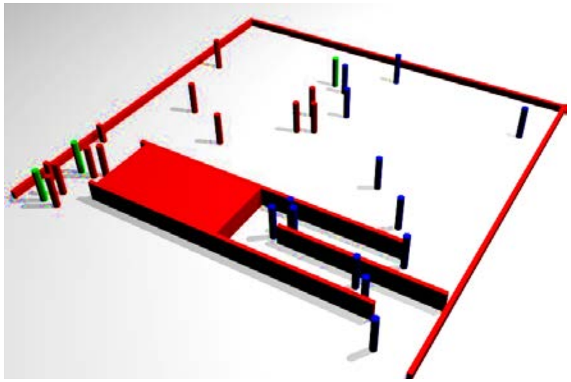
Three classes of agents configured:

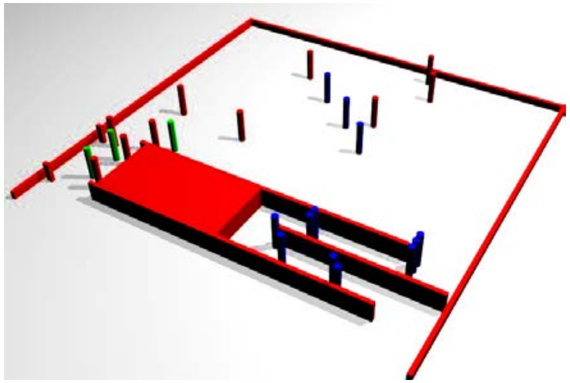
- *normal*: it is a normal agent, with no particular preferences;
- *special*: it is a special agent, with a low base speed and which is slowed even more on stairs and ramps;
- *selective*: it is a selective agent, which deliberately avoid stairs and escalator.

The incoming flow did not generate any congestion, thus no change of the route choice is generated in this scenario









CONCLUSIONS AND FUTURE DIRECTIONS

- Relatively fast method to allow dynamical decisions at tactical level
- It integrates a method to estimate the congestion delay
- Qualitatively, the results show that the agents adapt their path to reach the exit in a shorter time
- Future directions are aimed to:
  - Introduce events and dynamical information on the environment, influencing the agents decisions
  - Consider tactical decisions of groups
  - Discuss possible ways of validation

THANK YOU!

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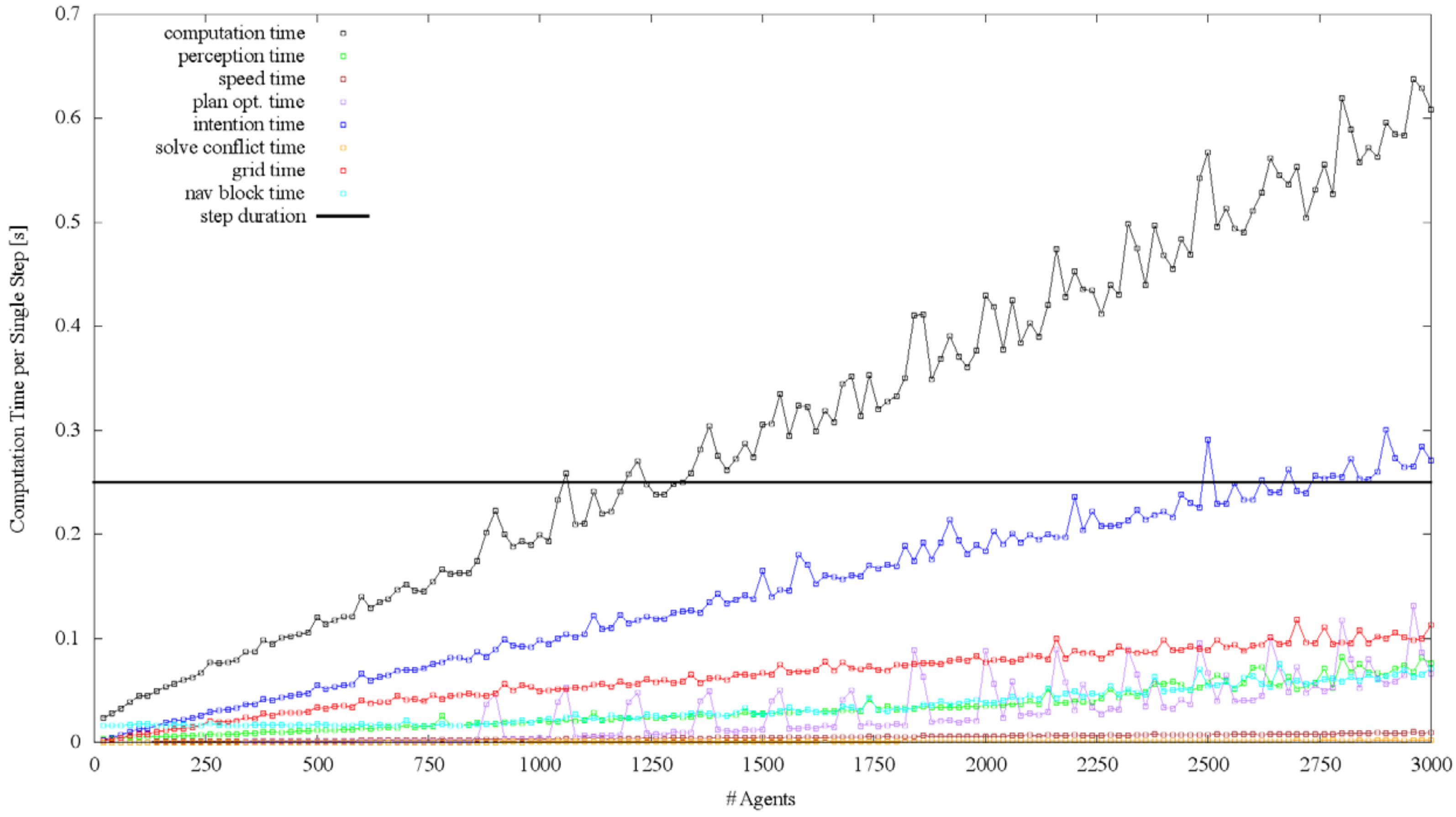
COMPUTATION TIMES



PEDESTRIAN DYNAMICS MODELING AND SIMULATION – STATE OF THE ART