Neither Dumb nor Optimal: Plausible Wayfinding in Pedestrian Agent-Based Models

Extended Abstract

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ABSTRACT

Pedestrians are not robots: although observations show that they consider congestion when planning, there are evidences that their decisions are not optimal, even in normal situations. We present a model improving consolidated results mitigating the optimization effects of congestion aware path planning by making commonsense estimations of the effects of perceivable congestion, also embedding an imitation mechanism stimulating changes in planned decisions whenever another nearby pedestrian did the same.

KEYWORDS

agent-based simulation; pedestrian simulation; wayfinding

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1 INTRODUCTION

Pedestrian and crowd simulation is a consolidated research and application context, in which results that lead to technology transfer co-exist with open challenges for researchers in different fields and disciplines. The measure of success and validity of a model is not the *optimality* with respect to some cost function, as (for instance) in robotics, but the *plausibility*, the adherence of the simulation results to data that can be acquired by means of observations or experiments. The study of optimal movement plans can make sense in the case of the design of evacuation plans [1], but here we try to understand what would happen in normal situations. In previous works we defined a model for the simulation of wayfinding decisions, especially considering the possibility of considering the perceivable congestion in agents' path planning [5]: the achieved results were somewhere between basic path planning exclusively based on a "shortest path" heuristics and a globally optimal solution. Later results [6] allowed us to further enrich the model, on one hand to embed an imitation mechanism for which a change in the initially planned line of action can be perceived by nearby agents and it can trigger analogous decisions. On the other, it supported a calibration of the significance of the different components of the wayfinding model, that are path length, perceived congestion and perceivable recent changes in the intentions of nearby pedestrians. We improved and extendd the above work by further investigating effects of perceivable congestion on path planning and the effects of these modeling choices in a real-world scenario. New results show that the present model provides more plausible, although farther from optimality, overall simulation results.

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2 MODELING ROUTE CHOICE

Route choice decisions considers stylized facts about pedestrian behaviour: (i) they consider perceivable congestion; (ii) reasoning is imprecise, both due to the limited time available as well as to the imprecise estimations; (iii) they are influenced by nearby pedestrians also through imitation mechanisms, apparently conflicting with the general proxemic avoidance tendency [7]. The model must also provide a sufficient variability of the results (i.e. of the paths choices) and the possibility to be calibrated to reflect observed empirical data. The function that defines the probability of choosing a path is exponential with respect to the utility value associated to it. This is essentially analogous to the choice of movement at the operational layer: $Prob(P) = N \cdot e^{U(P)}$. More precisely, $U(P)$ comprises the three observed components influencing the route choice decision, which are aggregated with a weighted sum: $U(P) = \kappa_{tt} Eval_{tt}(P) - \kappa_q Eval_q(P) + \kappa_f Eval_f(P)$ where the first element evaluates the *expected travel times*; the second provides a commonsense evaluation of the *queuing* (crowding) conditions

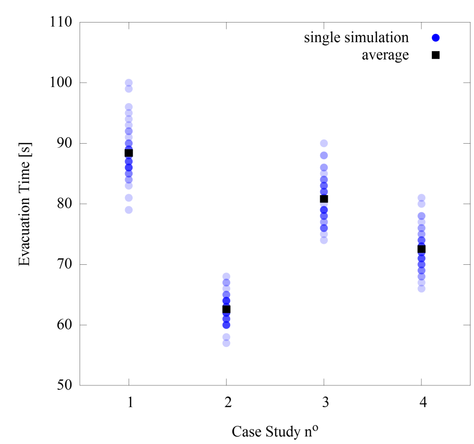

Figure 1: Comparison of evacuation times of the whole environment achieved among the 4 scenarios.

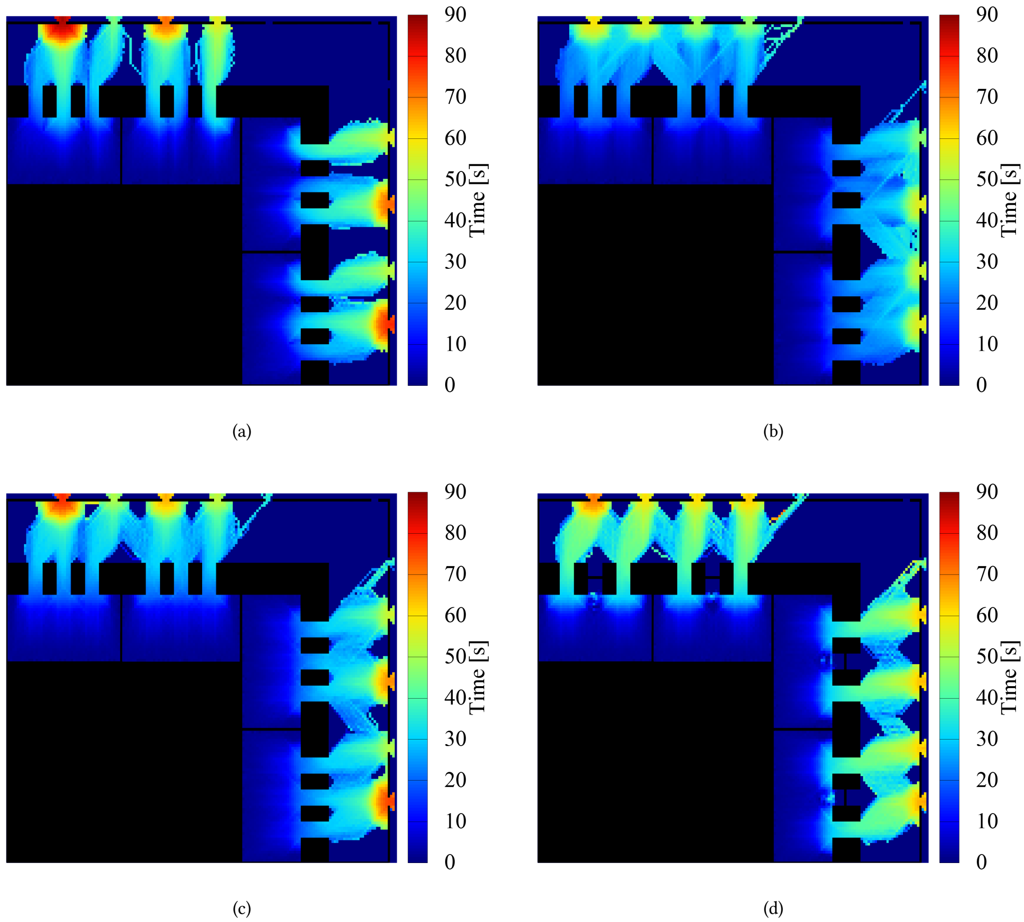

Figure 2: Egress times over the space in the simulated case studies, averaged over the 50 iterations.

through the considered path and the last one introduces a positive influence of perceived choices of nearby agents to pursue the associated path P (i.e. imitation of emerging leaders). All the three functions provide values normalized within the range $[0, 1]$, thus the value of $U(P)$ is included in the range $[-\kappa_q, \kappa_{tt} + \kappa_f]$.

3 SIMULATION OF A REALISTIC SCENARIO

We simulated a sample egress from a football arena similar to the one described by [8]. The simulated environment is composed of: 4 starting areas associated to the bleachers of the stadium, corridors connecting the bleachers to a large common atrium, where a total of 11 doors of 1.2 m of width provide the way out from the stadium. 250 agents are generated in random positions of the related start area at the beginning of the simulation, producing a total of 1000 pedestrians. Differences among pedestrians are introduced with respect to the desired walking speed, defined through a discretization of a Gaussian distribution described by μ = 1.4 m/s and σ = 0.2 m/s, to represent an egress situation in normal conditions.

Within the illustrated scenario, four case studies have been simulated with sets of 50 simulation runs, a number sufficient to achieve consistent results. Case Study N. 1 only uses the model at the locomotion layer [2] following the "shortest path" heuristic. Case Study N. 2 represents uses the wayfinding model proposed in [5] that essentially tries to select the *quickest path*, employing an analytically precise estimation of the impact of perceived congestion surrounding the nearest intermediate targets (that are supposed to be perceivable from the regions of which they represent a border). Case Studies N. 3 and 4 use the model described in this paper, but the fourth scenario is associated to a what-if scenario in which we closed the middle gateway connecting the bleachers to the atrium. Results are shown in Figure 1, and 2: the former shows the overall evacuation times of each run of the simulation sets of the case studies, while the latter shows the time needed to vacate each point of the scenario. The fourth case study represents a counterintuitive but effective design choice, since it makes more difficult to exit the bleachers area but, on the other hand, the atrium turns out to be much less congested, smoothening the flow towards the final exits, reducing the overall egress time. This kind of result is in tune with similar well-known paradoxes in the transportation field [3], and also present in pedestrian dynamics [4].

REFERENCES

[1] Ahmed Abdelghany, Khaled Abdelghany, Hani Mahmassani, and Wael Alhalabi. 2014. Modeling framework for optimal evacuation of large-scale crowded pedestrian facilities. *European Journal of Operational Research* 237, 3 (2014), 1105 – 1118.

[2] Stefania Bandini, Luca Crociani, and Giuseppe Vizzari. 2017. An Approach for Managing Heterogeneous Speed Profiles in Cellular Automata Pedestrian Models. *Journal of Cellular Automata* 12, 5 (2017), 401–421.

[3] Dietrich Braess, Anna Nagurney, and Tina Wakolbinger. 2005. On a Paradox of Traffic Planning. *Transportation Science* (2005).

[4] Luca Crociani and Gregor Lämmel. 2016. Multidestination Pedestrian Flows in Equilibrium: A Cellular Automaton-Based Approach. *Computer-Aided Civil and Infrastructure Engineering* 31, 6 (2016), 432–448.

[5] Luca Crociani, Andrea Piazzoni, Giuseppe Vizzari, and Stefania Bandini. 2015. When reactive agents are not enough: Tactical level decisions in pedestrian simulation. *Intelligenza Artificiale* 9, 2 (2015), 163–177.

[6] Luca Crociani, Giuseppe Vizzari, Daichi Yanagisawa, Katsuhiro Nishinari, and Stefania Bandini. 2016. Route choice in pedestrian simulation: Design and evaluation of a model based on empirical observations. *Intelligenza Artificiale* 10, 2 (2016), 163–182.

[7] Edward T. Hall. 1966. *The hidden dimension*. Doubleday New York Ed.

[8] A. U. Kemloh Wagoum, A. Seyfried, and S. Holl. 2012. Modelling dynamic route choice of pedestrians to assess the criticality of building evacuation. *Advances in Complex Systems* 15, 07 (2012), 15. arXiv:1103.4080