Assessment grid for pedestrian models in a railway station context

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Abstract

This assessment grid is dedicated to evaluating pedestrian models in the context of railway stations, including massive passenger flows and train arrivals and departures' influence on the pedestrian demand. The evaluation is done for both scientific and industrial goals, and thus includes criteria about the possible use of such models in operations. For example, is the model capable of running simulations fast enough to help a global station management system take decisions in real time. Global methodology is explained in the main article, "On pedestrian traffic management in railway stations: simulation needs and model assessment", submitted for review for 21st EURO Working Group on Transportation Meeting (EWGT 2018) on April 20th, 2018.

The evaluation addresses four aspects of pedestrian models: (1) access conditions (2) application conditions (3) crowd dynamics issues and (4) modeling and simulation. These questions are derived from a literature review (Duives, Daamen, &Hoogendoorn, 2013; Nelson, 1995; Caramuta et al., 2017), empirical knowledge of pedestrian behavior, and previous research (Kabalan, Leurent, Christoforou, & Dubroca-Voisin, 2017). This evaluation grid has been designed to provide a quick overview of a model's capabilities. We consider that giving a global score is irrelevant since the motives of the users can vary widely.

General indicator
Level 0: No / The model cannot deal with that item.
Level 1: Mainly no / The model has difficulties to deal with that item.
Level 2: Mainly yes / The model deals with that item, with some limitations.
Level 3: Yes / The model perfectly deals very with that item.

Access conditions
Availability
Is the model available and documented? Is its source code known?
Level 0: the model is neither available nor published. It is only described in research papers or known by industrial press.
Level 1: black box. The model is available as a software program but its functionalities are not documented. Its efficiency has not been proven by research.
Level 2: (a) the model has been published as a proprietary software and provides a complete documentation about its functionalities. Research shows that these functionalities are at a state-of-the-art level at the time of publication. (b) The model has been published as open source software, technically documented, but lacks research about the principles it uses.
Level 3: the model is open-source, fully documented, and a result of advanced research.

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Provider
> Company or institution providing and developing the model.

Nature of provider
> **Company:** provides the model commercially.
> **Academic:** provides the model as a part of its research
> **Other:** to be discussed.

Usability
> Is software easy and efficient to use?
> Level 0: only expert users can run simulations. Experience takes months to gain.
> Level 1: user experience is painful and user interfaces are not friendly, but it is possible to use the software with less than a week of formation.
> Level 2: UX design work has been made and it is possible to run simulations effectively in a few days.
> Level 3: UX has been carefully designed and makes interface both easy-to-use and very efficient.

Costs
> Difference between investment and operation can be made.
> Costs are given on the basis of a single license, or 10 licenses.
> They are illustrative and provided by the editor.

Application conditions

OS
> Operating systems compatible with software.

IT compatibility
> Level 0: the model is not compatible with standard IT systems and can only run on his own.
> Level 1: the model can be p   lugged with standard IT systems if specific developments are made.
> Level 2: the model has generic interfaces making it able to exchange with other software programs.
> Level 3: each option of the model is configurable by full-documented APIs or similar interfaces.

Automation
> Level of automation has an impact about the resources needed to use the model, and so far on its global cost.
> Level 0: the model has to be used manually, or only experts can settle automation.
> Level 1: simple cases can be automated for recurrent uses of the model.
> Level 2: usual simulations can be run thanks to the data provided by a global system**.**
> Level 3: all simulations can be run thanks to the data provided by a global system

IT safety
> Real pedestrian data used in the model can be strategic. Good execution of the code can also ensure the reliability of the results given by the model
> Level 0: no protection is guaranteed.
> Level 1: a basic protection system is implemented in software.
> Level 2: core source code has been proven and guarantees consistent results, important data can be protected.
> Level 3: software has been conceived with an IT-risk perspective. Data is protected by design.

Crowd dynamic issues

Reproduction of known crowd phenomena
> Does the model successfully reproduce known crowd phenomena? Is the behavior adapted to the specific context of transportation?
> (a) Does the model faithfully reproduce crowd dynamics: 1. Crowding at bottlenecks at the entrance of stairs, gates, narrow corridors, validation gates, etc. 2. Reproduction of fundamental diagrams, and notably accurate diminution of flow with density of pedestrians.3. Reduced counterflow in case of bidirectional and multidirectional flows?
> (b) Does the model faithfully reproduce collective phenomena? As described in (Duives et al., 2013), that includes: 1. Lane formation, 2. Herding, 3. Zipper effect, 4. Faster-is-slower effect. 5 and 6, respectively stop-and-go waves and turbulences, are examined apart due to their link with transport and safety issues.

(c) Is crowd behavior consistent in a transportation context: 1. Irregular repartition on the platforms. 2. Incomplete boarding of waiting passengers at platforms served by trains with different missions. 3. Massive unidirectional flow at the arrival of a train, and their interaction with pedestrian attempting to board? 4. Fail-to-board in case of train congestion.

Level is evaluated using the general indicator for each of these components.

High pedestrian densities

(a) Can the model reproduce specific crowd movements that occur when the density exceeds 3 to 5 p/m²?[2] That includes stop-and-go waves, impossibility to reach the desired speed for numerous pedestrians, and accumulation of people in certain spaces.

(b) Can the model reproduce turbulences that occur when the density exceeds 5 p/m²? That includes crowd disasters, with fatalities due to overpressure, and then enhanced embarrassment to the flow.

Modeling and simulation

Description of areas

(a) How fine is the description of pedestrian areas inside the station? We postulate that precision has a positive correlation with accuracy of model, negative with speed of computation, and positive with time of mapping (ie calibrating space in the model).

Level 0: areas are represented as simple as possible (by simple polygons in a microscopic model for instance). This simpler model can increase speed of computation but is not able to represent complex situations

Level 1: areas are described and can have different characteristics. Some elements having an effect on flows can be modeled.

Level 2: areas can be quite complex and reproduce details of the station. All elements of the station having an important effect on flow can be modelized, including dynamic elements such as moving walkways.

Level 3: each element of the station can be modelled and has an effect on pedestrian flows.

(b) What are the boundaries of the represented space? Including areas of influence outside the station, for instance at the entrance, could permit to deal with certain events which involve urban pedestrian dynamics[3]. In the case of multimodal and multifunctional stations, models may not be able to represent other transportation modes or functions like shops; so it may exist model boundaries inside the station. The third dimension may also be considered or not, as the height of the ceiling could influence pedestrian behavior (Fujiyama, 2005).

This item was not shown in the final article as there no particularly interesting differences between the models.

Description of pedestrian behavior

(a) How fine is the representation of pedestrian routes? Should they be manually integrated or can they be automatically computed using Origin-Destination matrices?

Level 0: pedestrian routes are given by the modeler and cannot be computed.

Level 1: pedestrian routes are computed thanks to O/D matrixes or based on the needs of the pedestrian, with simple behaviors.

Level 2: pedestrian routes are computed by the model with adaptation to certain contexts of the station or needs of the traveler.

Level 3: pedestrian routes are recalculated as a function of events, such as congestion, desired levels of comfort and train movements.

(b) Are pedestrian behavior and characteristics adapted to variability related to culture and location? Such characteristics include speed, diameter of personal space, size of pedestrians…

Level 0: characteristics of pedestrian behavior are fixed by the model and cannot be known.

Level 1: characteristics are fixed by the model, known but cannot be edited.

Level 2: characteristics are known, and some elements can be edited to adapt to a particular background.

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[2] That value depends on the conditions, including physical environment, multidirectionality of flows, cultural background, etc.

[3] As an example, closure of a station due to overcrowding can lead to an accumulation of pedestrians outside the station, in urban public space.

Level 3: characteristics are fully editable to meet the specific environment particularities.

Compatibility with railway models

Is the model compatible with railway models? Within which conditions? Is the platform-train interface modeled?

(a) Is it possible to plug the model to a railway model?

Level 0: it is technically or functionally impossible to connect the model to a railway model.

Level 1: a railway model could be connected via specific development or manually.

Level 2: platform train-interface is modeled, and flow of pedestrians depends on train arrivals and departures managed by the railway model.

Level 3: the model has been built to meet the specific railway context and is centered on the platform-train interface and its effects on both station pedestrian flows and railway traffic.

(b) If platform-train interface (PTI) is modelled, how fine is the description? A list of criteria to take into account can be found in (Elleuch, Donnet, Buendia, & Tijus, 2017).

Level 0: PTI is not modelled.

Level 1: PTI is modelled as a simple relation all along the platform, with homogenous repartition of travelers or as a single-event (sudden appearance of the entire set of passengers).

Level 2: repartition of passengers on the platform is heterogeneous and boarding and alighting times depends on the number of pedestrians at each carriage, door, or section of a train.

Level 3: passenger exchange is modelled at each door of the train by taking into consideration specific characteristics such as specific behaviors in certain areas, different widths of doors, different gaps, etc.

Flexibility of the model

What is the flexibility of the model?

(a) Can it be adapted for specific conditions, situations and management strategies? (see also Description of pedestrian behavior)

Level 0: model cannot be adapted. It is only valid within its context of creation or similar contexts.

Level 1: model can be adapted to specific background by changing simple characteristics, such as speed of pedestrians, dimensions of passengers, etc.

Level 2: model can be largely adapted to specific context including cultural behaviors differences, size, effects of operational strategies and actions.

Level 3: model is fully adaptable to specific context; all the environment variables can be changed, rare situations and operational strategies and actions can be modelled.

(b) Can it be improved? (see also Availability).

Level 0: model cannot be improved.

Level 1: specific developments can be done to adapt certain parts or the model.

Level 2: most of the model can be improved to adapt it to different contexts.

Level 3: model is open source or free software.

Speed of execution

That indicator is based on past executions of the model. Estimative speed is provided by the editor or by previous research.

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