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DOI
10.1080/23249935.2022.2099034

Publication date
2023

Document Version
Final published version

Published in
Transportmetrica A: Transport Science

Citation (APA)
Tang, T. Q., Nicolas, A., Lee, S., Daamen, W., & Song, Z. (2023). Special issue on the dynamics and behaviours of pedestrian groups. *Transportmetrica A: Transport Science*, *19*(1), Article 2099034. https://doi.org/10.1080/23249935.2022.2099034

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Transportmetrica A: Transport Science

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ttra21

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To cite this article: Tie-Qiao Tang, Alexandre Nicolas, Seungjae Lee, Winnie Daamen & Ziqi Song (2023) Special issue on the dynamics and behaviours of pedestrian groups, Transportmetrica A: Transport Science, 19:1, 2099034, DOI: 10.1080/23249935.2022.2099034

To link to this article: https://doi.org/10.1080/23249935.2022.2099034

TRANSPORTMETRICA A: TRANSPORT SCIENCE
2023, VOL. 19, NO. 1, 2099034
https://doi.org/10.1080/23249935.2022.2099034

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EDITORIAL

Special issue on the dynamics and behaviours of pedestrian groups

ABSTRACT
In the study of pedestrian dynamics, the consideration of group behaviours is essential, as group interaction within crowds is a common phenomenon and significantly influences pedestrian behaviours. This special issue highlights the importance of pedestrian group behaviours and examines the subject using a wide range of methods, such as experiments, modelling, and algorithms. The works comprising this special issue can hence provide ideas for future studies on pedestrian dynamics and can also serve as a long-term reference for modelling pedestrian group behaviours.

ARTICLE HISTORY
Received 27 June 2022
Accepted 1 July 2022

KEYWORDS
Pedestrian flow; dynamics; group; model; simulation

1. Introduction

Given the development of the economy and culture, extensive gathering activities have in public places have been on the rise in recent years. The safety of gathering crowds is an issue that has received a great deal of attention. The study of pedestrian dynamics is of considerable significance for the design and optimisation of pedestrian transportation facilities and also for the formulation of improvements to crowd egress safety and efficiency. Accordingly, relevant research in this area has attracted substantial attention from scholars. In the study of pedestrian dynamics, the consideration of group behaviours is essential, as group interaction within crowds is a common phenomenon and significantly influences pedestrian behaviours. This special issue highlights the importance of pedestrian group behaviours and examines the subject using a wide range of methods, such as experiments, modelling, and algorithms. The works comprising this special issue can hence provide ideas for future studies on pedestrian dynamics and can also serve as a long-term reference for modelling pedestrian group behaviours. The 15 research papers included in this issue are summarised below.

In an evacuation process, the delays incurred by pedestrians with impaired mobility are considered to be a serious issue. In the research undertaken by Tang et al. (2021), an improved cellular automaton model is proposed to study the evacuation of a hospital registration hall with a mixed crowd of pedestrians. The simulation results reveal that pedestrians with inconvenient mobility have some negative impacts on evacuation efficiency, and that these negative impacts will be more prominent as the number of pedestrians increases. This research can help administrators to better understand the non-emergency evacuation process of heterogeneous pedestrians and design reasonable evacuation strategies for unexpected emergencies in the hospital registration hall.

In a study conducted by Han, Liu, and Li (2021), a guidance model is proposed to plan evacuation paths for pedestrians with limited vision. The proposed model considers the effects of three major objective factors – namely, the length of paths, the density of exits, and congestion – on pedestrians' route choices. The distribution of pedestrians selecting different exits is defined as a feature of intermediate states during evacuations. Reinforcement learning (RL) is used to optimise the guidance model parameters. Evacuation efficiency is improved by optimising a series of intermediate states. A reciprocal velocity obstacle technology is used to build an evacuation model to verify the results of the study. Numerical simulations have shown that the guidance model can alleviate congestion, balance the utilisation of exits, and shorten evacuation time by guiding pedestrians' route choices.

Hu and Bode (2021) present the first meta-analysis related to the dynamics of pedestrian crowds. More specifically, they explore whether integrating evidence from six experimental studies helps bring clarity to the effect of social groups on egress times. In their meta-analysis, the aggregated findings suggest that social groups increase average egress times, but there is insufficient evidence to reject the null hypothesis of no effect. The conflicting results across published studies are thus likely to have arisen by chance, as experiments are statistically underpowered in determining a small effect. This study is directly useful to our understanding of the role of social groups and the extent to which they must be considered in pedestrian crowd management, architectural design, and risk prevention. In addition, this work may be a useful case study to initiate a discussion on quantitative meta-research in pedestrian dynamics.

Jang, Ku, and Lee (2021) investigate algorithms used to identify, classify, and characterise a pedestrian group based on location data and GPS base station information obtained from smartphones. The major variable employed in the study is travel speed, and the weights of the distance, travel time, and public transportation infrastructure are also considered. Travel speed is used to distinguish the pedestrian mode from other modes of powered transportation. Departure time, travel distance, and travel time are used to distinguish between pedestrians and peak-time passenger cars. In addition, distributions of pedestrians according to travel time and spatial range are analyzed by classifying the pedestrian group into main and access modes. The detection of the pedestrian group using mobile data, which can overcome the limitations of household traffic survey data, is helpful in ensuring highly accurate analyses of human activities.

Model calibration relies on empirical data, which is subject to measurement errors that can obfuscate calibration. King, Koltsova, and Bode (2022) assess the effect of errors in data on the calibration of the pedestrian destination choice model using data from an agent-based simulator. A novel and rigorous methodology for introducing errors into data is presented. This work offers a principled starting point to both inform data collection protocols for empirical pedestrian destination choice research and estimate the likelihood of successful calibration models on available data.

In a study conducted by Ding et al. (2021), a multi-state modelling framework is employed to transform the pedestrian simulation problem into the design of five modules. This framework substantially contributes to reducing modelling difficulty and improving maneuverability. Based on the framework, a velocity-repulsion model is constructed with a feature by which the faster a pedestrian walks, the greater the distance the pedestrian will

keep from others. As a design tool, the multi-state framework can also aid in the design of modification tasks for any specific scenarios.

In automated driving environments, the accurate prediction of human motion is essential to avoid fatal collisions. Artificial intelligence-oriented neural networks (ANNs) are highly efficient in realistically predicting human behaviour. Nasr Esfahani, Song, and Christensen (2022) design a novel LSTM-based deep neural network capable of learning the unique walking behaviours of individuals with and without disabilities. Data from a large-scale pedestrian walking behaviour experiment involving individuals with disabilities are used to train and test the network. This study is one of the first to incorporate the various walking behaviours of heterogeneous groups of individuals into pedestrian trajectory prediction, which improves the research model.

One major difficulty in group detection is feature extraction. In the work of Li et al. (2021), a novel pipeline is designed to extract and cluster multiple features found in crowded scenes. Both interactive trajectory descriptors and visual context features are used to detect socially related groups. A unified, graph-based cluster method is proposed to minimise the inconsistent components of each affinity matrix, while maximising consistent components to effectively exploit the different features. The public pedestrian datasets demonstrate that the proposed method can achieve superior detection performance and density robustness when compared with existing methods.

Abundant evidence has shown that social groups have different attributes and movement characteristics when compared with individual pedestrians. Hu et al. (2022) investigate the movement characteristics of the two-people social group with a strong relationship in terms of unidirectional flow through well-controlled experiments. Their study provides empirical data in support of the fundamental diagram and microscopic movement characteristics of the two-people social group with a strong relationship, which can provide a theoretical basis for model verification and crowd management.

The campus is a specific site that brings large student groups together. Under the impact of an epidemic, there is still a gap in the on-campus emergency management research. In the research of Li and Yin (2021), a pedestrian-based epidemic spreading model is proposed to explore the epidemic-spreading process on college campuses. The core modelling work of this study describes different exposure patterns and the respective infection risk resulting from them. The model provides a mathematical basis for estimating the risk of disease transmission from indoor activities. The integration of pedestrian dynamics and epidemiology will refine our understanding of the transmission and control of epidemics.

In urban railway operations, the boarding and alighting process is among the most complicated of behaviours. Analyzing this kind of behaviour is the foundation for revealing the individual and group mechanisms of crowd motion. Qu et al. (2022) quantitatively discuss the individual and group behavioural characteristics of both boarding and alighting passengers. An improved cellular automaton model is proposed to describe the microscopic dynamics of the boarding and alighting process and is calibrated by the data collected from the video surveillance system in the Beijing Transportation Information Centre. This model can potentially be used for crowd management on platforms in subway stations, and it is also helpful in providing a scientific flow control strategy for managers.

Everyone has mood swings, often in accordance with their uncertain and dynamic social environment. Panic, as a tense emotion, can be highly contagious in an emergency. In the

work of Shang et al. (2022), a game-based approach for modelling pedestrian motion in dynamic environments is proposed. In the proposed model, various states and personalised emotion contagion in the crowd are taken into account. Panic, in this sense, is contagious, but so too is calm behaviour. This study illustrates that calm pedestrians are very effective at soothing a crowd in an emergency. If management personnel can go deep into the crowd to calm pedestrians, the panic may be rapidly reduced.

During an evacuation, pedestrians adopt different route choice strategies. This is attributable to pedestrians' unique knowledge of pedestrian flow evolution and walking domain information. Generally speaking, two main classes of strategies can be distinguished: Reactive agents choose their optimal route in light of the traffic information currently available to them, whereas predictive agents optimise their paths by minimising an overall cost integrating their predictions of the traffic that they will encounter until they reach their targets. In a study conducted by Lin, Zhang, and Hang (2022), a dynamic continuum route choice pedestrian flow model with mixed crowds of reactive and predictive agents is presented. The finite volume method and the method of successive averages are used to solve the model based on unstructured meshes. Simulations of an evacuation reveal subtle and density-dependent differences between the two classes of agents.

Population aging is a critical feature of twenty-first-century population development. As a typical vulnerable group, the movement characteristics of the elderly crowd deserve attention. Ren et al. (2021) study the stepping behaviour of elderly pedestrians, with density employed as one key variable. In their research, the impact of horizontal interaction on the stepping behaviour of elderly pedestrians is experimentally studied. The experimental data are useful in the establishment of computer models and can also deepen our understanding of the stepping behaviours of the elderly in different scenarios.

Finally, the existence of group structures is likely to impact the collective dynamics of a crowd, and possibly in a critical way when emergency situations are considered. Nicolas and Hassan (2021) reveal the prominent characteristics and effects of social groups that have been empirically established and delineate the primary strategies that have been advanced to model such groups, including their successes and their limitations. Their review offers a pedagogical discussion of the main strategies to model such groups, within different types of models, in order to provide guidance for prospective modellers.

2. Conclusion

Consideration of group behaviours in the study of pedestrian movements is imperative because of their ubiquity and their potential impacts on pedestrian flow dynamics. The 15 studies included in this special issue make an invaluable contribution to academic endeavours and real-world crowd management practices, by offering a critical perspective on past empirical and numerical results about social groups, exploiting current modelling strategies to arrive at new findings of practical relevance, and exploring a branch of AI-intensive modelling tools that definitely are on the rise. This special issue is dedicated to the authors of the studies included herein. They have accorded significant attention to the dynamics of pedestrian group behaviours and have exerted real effort to accomplish this. The guest editors would like to express their sincere gratitude to the editor-in-chief of the journal for providing the opportunity for this special issue to be published. Last but not least, the guest

editors wish to thank all of the reviewers for their time and outstanding work, which are vital in guaranteeing the quality of this special issue.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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