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Evacuation dynamic and exit optimization of a supermarket based on particle swarm optimization

Lin Li[1], Zhonghai Yu[2*], Yang Chen[3]
School of Resources and Environmental Science, Wuhan University, Wuhan 430079, China

1 lilin@whu.edu.cn
2* Corresponding author. Tel.: +86 15072390573.
E-mail address: cartofish@whu.edu.cn (Z. Yu).
3 arthurxiaoc@gmail.com

Abstract: A modified particle swarm optimization algorithm is proposed in this paper to investigate the dynamic of pedestrian evacuation from a fire in a public building – a supermarket with multiple exits and configurations of counters. Two distinctive evacuation behaviours featured by the shortest-path strategy and the following-up strategy are simulated in the model, accounting for different categories of age and sex of the pedestrians along with the impact of the fire, including gases, heat and smoke. To examine the relationship among the progress of the overall evacuation and the layout and configuration of the site, a series of simulations are conducted in various settings: without a fire and with a fire at different locations. Those experiments reveal a general pattern of two-phase evacuation, i.e., a steep section and a flat section, in addition to the impact of the presence of multiple exits on the evacuation along with the geographic locations of the exits. For the study site, our simulations indicated the deficiency of the configuration and the current layout of this site in the process of evacuation and verified the availability of proposed solutions to resolve the deficiency. More specifically, for improvement of the effectiveness of the evacuation from the site, adding an exit between Exit 6 and Exit 7 and expanding the corridor at the right side of Exit 7 would significantly reduce the evacuation time.

Keywords: particle swarm optimization; route calculation; evacuation dynamic; FDS; fire spread.

1 Introduction

Public safety incidents are prone to occur during an emergency event due to the high density of pedestrians. Crowds of people in public areas, such as shopping malls or supermarkets, exhibit a wide variety of characteristics and thus exhibit different behaviours during an emergency. The modelling of this variety of behaviours during an evacuation in an emergency as well as for managing crowds even under normal circumstance is a significant challenge. Aiming at saving lives and reducing injuries, modelling pedestrian dynamics is regarded as one of the most appealing fields in traffic science and engineering[1]. The study of evacuations under a certain setting through simulations is an available means to provide solutions to such problems.

It is known that some part of human behaviour in an emergency is an instinctive reaction, but such behaviour remains far from being clarified. Because simulations of real-life evacuations are nearly impossible to conduct, a variety of modelling methods have been used to study human evacuation dynamics. Some models have addressed aspects of human behaviour, such as the Social Force Model[2-4], the Lattice Gas Model[5-8], the Discrete Choice Model[9, 10], the Floor Field Model[11] and the Ant Trial Model[12]. Other models emphasise simulation models of the evacuation process, such as Particle Flows Fluid Mechanics[13-16], Cellular Automata[17-23] and