ICIT 2017 The 8th International Conference on Information Technology
doi:10.15849/icit.2017.0000

A simulation model for Crowd Evacuation of Fire Emergency Scenario

Noor Akma Abu Bakar, Khalid Adam and Mazlina Abdul Majid
Faculty of Computer System & Software Engineering
Universiti Malaysia Pahang
noorakma_ab@yahoo.com, Khalidwsn15@gmail.com, mazlina@ump.edu.my

Mario Allegra
National Research Council of Italy,
Institute for Educational Technologies(CNR-ITD),
Via Ugo Malfa 153, 90146 Palermo, Italy
mario.allegra@itd.cnr.it

***Abstract*— Human safety is an important issue when handling the crowd evacuation in order to avoid death and injuries. Human behavior changes from normal to panic behavior when they are in an emergency scenario such as building on fire. Modelling panic behavior on evacuee is a critical challenge as the human movement is unpredictable. Simulation (example: Discrete Event Simulation and Agent-Based Simulation) is a well-known method to investigate crowd evacuation. But the question here is: Which simulation method is suitable to model a realistic representation of crowd evacuation? Thus, in this paper, a simulation model based on Agent-Based Simulation (ABS) and Social Force Simulation (SFS) Model is proposed to improve on modelling fire evacuation in a closed space (building). To achieve the above research aim, three simulation models (ABS Model, SFS Model and a hybrid of ABS and SFS model) will be developed and compared. This paper will discuss on the development of conceptual model of these three simulation models. Later, the conceptual models will be used to represent the investigated simulation models**

Keywords—crowd evacuation; simulation model; social force model; agent-based model; hybrid model; simulation optimization; conceptual model

I. INTRODUCTION

The research of simulation model has been widely conducted in entertainment, crowd planning and management, traffic flow, architectural design and other similar applications for several decades ago [1-4]. From the literature review, many parties like industries, researchers and academicians studied about the human behavior. [5]. Normally, a simulation model is look like the real system of the phenomenon or scenario[6]. It is usually with the basic rules and general principles. A simulation model is an instrument to represent the real system. It is also as a support tool for prediction and decision making [7].

Moreover the simulation model use for examining the space and flow of traffic during both normal and emergency crowd circumstances [5]. These simulation models can acquire the more understanding in a present framework through the testing situation based on the particular simulation tools. The challenge in this topic is the difficulty of modeling the crowd evacuation due to diversity of human behavior[8]. In addition, to modeling the human behavior as realistic as possible is crucial for a good design [9]. Other than that, the non-linear human interactions in panic scenario are under extreme conditions[10]. The crowd condition getting rise because of the capturing the collective, emergence and randomize individual behavior [11].

The goal of this work is to have an improved and effective simulation model which is mimicking the panic scenario as real life case study[12]. Despite the aim of this research is divided into two elements as follows. A hybrid technique is combinatorial of two or more techniques which provide a greater advantage and to carry out the improved simulation model for crowd evacuation [13] [14] [15]. The second goal is to focus on the safety element which is to minimize the human exposure risk as an important component of the crowd evacuation [16].

The proposed model for simulating the crowd evacuation is using Social Force Model (SFM), Agent-based Simulation (ABS) and hybrid of SFM & ABS. These models are capable to dealing with human behavior for emergency scenario which is in building on fire [8, 17, 18]. On the other hand, the significance of the safety crowd evacuation simulation model is for the accurate prediction of any modification, plan and changes[19]. In order to have a safety crowd evacuation, some elements should be considered in this work. This may affecting the evacuation plan for the emergency cases happen as stated by [20].

The main contribution in this paper is the theoretical and conceptual model. Other than that, the work leads to

doi:10.15849/icit.2017.0000

[22] M.-L. Xu, H. Jiang, X.-G. Jin, and Z. Deng, "Crowd Simulation and Its Applications: Recent Advances," *Journal of Computer Science and Technology*, vol. 29, pp. 799-811, 2014.

[23] J. Ma, S. M. Xu, T. Li, H. L. Mu, C. Wen, W. G. Song, *et al.*, "Method of Bottleneck Identification and Evaluation During Crowd Evacuation Process," *Procedia Engineering*, vol. 71, pp. 454-461, 2014.

[24] D. Helbing, I. Farkas, and T. Vicsek, "Simulating dynamical features of escape panic," *Nature*, vol. 407, pp. 487-490, 2000.

[25] W. Lei, A. Li, R. Gao, N. Zhou, S. Mei, and Z. Tian, "Experimental study and numerical simulation of evacuation from a dormitory," *Physica A: Statistical Mechanics and its Applications*, vol. 391, pp. 5189-5196, 2012.

[26] R. Maidstone, "Discrete event simulation, system dynamics and agent based simulation: Discussion and comparison," *System*, pp. 1-6, 2012.

[27] P. Yang, C. Li, and D. Chen, "Fire emergency evacuation simulation based on integrated fire–evacuation model with discrete design method," *Advances in Engineering Software*, vol. 65, pp. 101-111, 2013.

[28] C. M. Macal and M. J. North, "Tutorial on agent-based modelling and simulation," *Journal of Simulation*, vol. 4, pp. 151-162, 2010.

[29] C. Ahn, J. Kim, and S. Lee, "An Analysis of Evacuation under Fire Situation in Complex Shopping Center Using Evacuation Simulation Modeling," *Procedia - Social and Behavioral Sciences*, vol. 218, pp. 24-34, 2016.

[30] V. Ha and G. Lykotrafitis, "Agent-based modeling of a multi-room multi-floor building emergency evacuation," *Physica A: Statistical Mechanics and its Applications*, vol. 391, pp. 2740-2751, 2012.

[31] G. Zhang, G. Zhu, G. Yuan, and Y. Wang, "Quantitative risk assessment methods of evacuation safety for collapse of large steel structure gymnasium caused by localized fire," *Safety Science*, vol. 87, pp. 234-242, 2016.

[32] G. Bernardini, M. Azzolini, M. D'Orazio, and E. Quagliarini, "Intelligent evacuation guidance systems for improving fire safety of Italian-style historical theatres without altering their architectural characteristics," *Journal of Cultural Heritage*, vol. 22, pp. 1006-1018, 2016.

[33] S.-c. Cao, W.-g. Song, X.-d. Liu, and N. Mu, "Simulation of Pedestrian Evacuation in a Room under Fire Emergency," *Procedia Engineering*, vol. 71, pp. 403-409, 2014.

[34] H. Yang, R. K. K. Yuen, X. Cheng, and H. Zhang, "Effect of Right-Hand Traffic Rules on Evacuation Through Multiple Parallel Bottlenecks," *Fire Technology*, vol. 50, pp. 297-316, 2013.

[35] L. Jiang, J. Li, C. Shen, S. Yang, and Z. Han, "Obstacle optimization for panic flow--reducing the tangential momentum increases the escape speed," *PLoS One*, vol. 9, p. e115463, 2014.

[36] H. L. Kluepfel, "A cellular automaton model for crowd movement and egress simulation," Universität Duisburg-Essen, Fakultät für Physik, 2003.

[37] S. Cao, W. Song, W. Lv, and Z. Fang, "A multi-grid model for pedestrian evacuation in a room without visibility," *Physica A: Statistical Mechanics and its Applications*, vol. 436, pp. 45-61, 2015.

[38] D. A. Marshall, L. Burgos-Liz, I. J. MJ, W. Crown, W. V. Padula, P. K. Wong, *et al.*, "Selecting a dynamic simulation modeling method for health care delivery research-part 2: report of the ISPOR Dynamic Simulation Modeling Emerging Good Practices Task Force," *Value Health*, vol. 18, pp. 147-60, Mar 2015.