

# Modelling Human Evacuation Egress using Simulation Techniques: A Review

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**ABSTRACT:** The simulation of human evacuation egress (EE) behaviour is the process of replicating real-life human movement from a dangerous to a safe place. However, research in human movement during evacuation is less explored using hybrid Social Force (SFS) and Agent-based Model (ABS) for modelling human evacuation behaviours. Therefore, the aim of this research is to investigate the potential simulation techniques such as SFS and ABS. The research methodology for this work encompasses few phases including problem identification, literature review, analysis and presentation of results. The results of reviewing process are the database sources of the studied articles related to the human EE movements and potential simulation techniques that can be used and proposed hybridize of two techniques. Future work proposed a technique of hybrid Social Force and Agent-based which is expected suitable to model human egress evacuation and possible to produce better performance.

**Keywords:** *evacuation and egress; human behaviour; modelling and simulation*

## 1. INTRODUCTION

EE movements in emergency situations is difficult to capture since it often requires exposing real people to the actual, and possibly dangerous scenario. Therefore, M&S is needed to overcome this difficulty. Modelling is a method of solving problems and can be replaced by a simple object which describes the real system with behaviour. The simulation additionally alludes to a large gathering of models and applications to mimic the behaviour of real systems for closer representation. Other than that, the evacuation and egress (EE) movements involve the changes of a person in a place, position or posture relative to some point in the environment and has a same goal of moving or egressing to exit. The other behaviour of human during EE is they are getting panic and move faster than normal. Yet, simulation technique is required to develop a simulation model to represent the human movements during EE. The scope of this work is human EE movements in a closed building, thus the review covers this scope to identify the potential simulation techniques.

Many research works have been done in the evacuation model using few techniques such as SFS and ABS [1]. SFS is a common model in simulation for evacuation and can represent the collective movements of EE. Meanwhile, ABS able to model the autonomous agent and individual movement. However, research in M&S of human evacuation movements is less explored using hybrid SFS and ABS, even though there are few

drawbacks in each single model of SFS or ABS. Thus, the objective of this research work is to investigate the potential simulation techniques or models such as Social Force Model (SFS) and Agent-based Model (ABS) for modelling the human EE movements as realistic as real incidents.

One of the features for modelling EE, is to consider the shortest path rule that found significant to model similar to a real incident which shows the way-finding behaviour of pedestrians to reach the goal/ exit. Thus, ABS is applied this rule in M&S related to human evacuation movements. A well-known model in Modelling and simulation (M&S) of evacuation is SFS which found able to model the queuing process and clogging effects of the humans at the exit. Thus, these behaviours are important to be considered for evacuation M&S. Few works were investigated the human EE movements using the M&S techniques such as [2-5], however there are little works focused on the technique to be hybridized and to compare the hybrid technique with single techniques such as ABS and SFS. Hence, the research gap to be filled is to investigate the performance of the simulation techniques by comparing between single techniques of ABS and SFS with hybrid ABS/SFS.

## 2. METHODOLOGY

This his research was conducted with few phases include problem identification, literature review, analysis and presentation of results (review guidelines). The previous section has described the main problem to be solved which lead to achieving the research objective. The process of the literature review is based on previous studies to attain the broadest variety of related studies from journals and proceeding articles, and websites related to M&S specifically the potential techniques to model the human evacuation movements (comprehensive search from online digital databases) and the most related and recent published year is from 2012 to 2020. The search string is described as follows; "human movement AND/OR behaviour AND evacuation OR egress AND simulation AND/OR model AND/OR AND building OR indoor OR closed area". Selection of papers consisted inclusion and exclusion based on research objectives in order to choose full-text reading. In the process of literature review, the selection of papers consisted inclusion and exclusion based on research objectives in order to choose full-text reading, and written in English only. Then, the screening process included keywords, title and abstract. Number of extracted publications: initial researches are 197 and resulted at 20 primary research works. Furthermore,

analysis is related to existing work on the techniques for modelling human evacuation movements which provide clear depiction on the reviewed techniques.

### 3. RESULTS AND DISCUSSION

The result is related to review analysis of selected primary works. The well-known resources for this work are based on the online digital databases with the percentage of each resource and used for this research work from the total of 20 selected primary works (2012 to 2020) and described as follow; IEEE Explore (25%), SpringerLink (10%), Web of Science (20%), Science Direct (25%), Elsevier (10%) and Google Scholar (10%).

Based on the analysed selected primary works, the summary of features of ABS and SFS has been summarized. It provides a motivation to the researchers to conduct further study which focus on the simulation techniques and the potential single techniques to hybridize for modelling human EE movements. Conclusively, ABS is consisting features of individual agent, intelligent, straightforward and appropriated to model complex human behaviour, with the free movement patterns and interactive behaviour. Then, ABS model systems are made up of autonomous (self-directed) agents who follow a series of predefined rules to achieve their objectives while interacting with each other and environment. ABS able to capture an emergent phenomenon, flexible to use, and to mimic the system in natural ways [6].

SFS technique is a human behaviour model based on social-psychological and physical-forces. It assumes that each human meets the laws of motion as a particle and uses force vectors to describe the real force and intrinsic motivation [7]. Besides, SFS is a high suitability for modelling the aggregate behaviour of the crowd and in the population. Other than that, SFS is better to reflect the pedestrian or human traffic, especially in the evacuation.

As the literature indicates, the choice of the simulation techniques relies on the individual judgment of the techniques' features. ABS has been chosen by 40% studies meanwhile SFS has been chosen by 35% studies from the analysed primary studies in various of evacuation types such as in the building (e.g. shopping mall, office building, and airport) to represent the human EE behaviours or movements.

ABS provided a list of strengths that they are deemed most appropriate for modelling human behaviour and movement. However, ABS cannot model the self-organization agents in EE M&S. Meanwhile, SFS found able to model the human evacuation and egress behaviour however the limitation is SFS did not modelled the individual proactive agent. However, ABS and SFS are not suitable for modelling themselves only, as single technique because of the limitations such as follows. ABS not focusing on egress, which is no clogging effect and force element in EE while, SFS does not focus on the proactive behaviour and individual interactions during EE. Therefore, the hybrid simulation technique is proposed in this work to overcome the discussed problem [8].

### 4. CONCLUSION

Conclusively, throughout literature explorations show that the limitations from both single simulation techniques can be solved by combining or hybridize these two techniques which aim for a closer representation and for gaining better simulation results. However, this work is lack of another few components such as conceptual modelling including the EE factors as the simulation input and performance measurement parameters as simulation output. Thus, these limitations need further explorations as future research work and opportunities for modelling human EE movements.

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### REFERENCES

- [1] K. Ijaz, S. Sohail, and S. Hashish, "A survey of latest approaches for crowd simulation and modeling using hybrid techniques," in *17th UKSIMAMSS International Conference on Modelling and Simulation*, 2015, pp. 111-116.
- [2] A. Adamatzky and G. Sirakoulis, "Building exploration with leeches *Hirudo verbana*," *Biosystems*, vol. 134, pp. 48-55, Aug 2015.
- [3] S. Wu and E. D. Zende, "A conceptual framework to simulate building occupancy using crowd modelling techniques for energy analysis," *International Council For Research And Innovation In Building And Construction*, 2016.
- [4] W. N. A. W. Samsudin and K. H. Ghazali, "Crowd Behavior Monitoring using Self-Adaptive Social Force Model," *Mekatronika*, vol. 1, pp. 64-72, 2019.
- [5] K. R. Roza, J. Arellana, A. Santander-Mercado, and M. Jubiz-Diaz, "Modelling building emergency evacuation plans considering the dynamic behaviour of pedestrians using agent-based simulation," *Safety science*, vol. 113, pp. 276-284, 2019.
- [6] M. A. Majid, K. Z. Zamli, and M. A. I. Fakhreldin, "Modelling a Complex Human Centre Queuing System for Enhancing the Capability of Agent Based Simulation," in *Proceedings of the International Conference on Data Engineering 2015 (DaEng-2015)*, 2019, pp. 383-391.
- [7] S. O'Connor, F. Liarokapis, and C. Jayne, "Perceived Realism of Crowd Behaviour with Social Forces," pp. 494-499, 2015.
- [8] N. A. A. Bakar, M. A. Majid, and K. Adam, "Simulation and Modelling the Human Crowd Evacuation," in *IOP Conference Series: Materials Science and Engineering*, 2019, p. 012038.