# Simulation and Modelling the Human Crowd Evacuation



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# Simulation and Modelling the Human Crowd Evacuation

**Noor Akma Abu Bakar[1], Mazlina Abdul Majid[1] and Khalid Adam[2]**

[1]Faculty of Computer Systems & Software Engineering, Universiti Malaysia Pahang
[2]Faculty of Electric and Electronic Engineering, Universiti Malaysia Pahang

E-mail: noorakma215@gmail.com

**Abstract**. The operational research (OR) become one of emerging areas and significance and its relevance to be used in the simulation and modelling. To simulating and modelling the crowd evacuation, the most important elements to have in a realistic model is the appropriate simulation technique. To simulate the evacuee's movement in crowd is still in research and challenge because of the emergence and become a complex task and dangerous for the real and actual case. The computational simulation technique is required in order to model the crowd evacuation as one part of OR and become a solution to represent the fire crowd evacuation in the closed space e.g. Building relates to human movement and its states. The theories and concept of computational method allows for creating, analysing and experimentation. The techniques; Agent-Based Simulation (ABS), Social Force Model (SFM) and the hybrid SFM/ABS has been proposed for this research work. SFM is the well-known and popular technique for crowd evacuation while ABS is best-known, intelligent and appropriate to imitate the human movement. This paper provides a review of this research work from an OR perspective and the outcomes of a review of the computational simulation techniques literature are presented, using a proposed conceptual model will be valuable for future researchers, and modellers alike.

## 1. Introduction

For a several decades, the investigation of simulation and modelling has been extensively conducted in numerous areas such as in traffic flow, entertainment, crowd management, industrial operations, human actions and behaviour and other related applications [1-4]. Generally, the real system of the phenomenon or scenario will be imitated, and no real simulation needed for a computational simulation model[1]. The basic guidelines and general principles required for developing and designing the simulation model. The general idea of a simulation model is a tool to represent the real system or actual scenario. The prediction and decision making also one important element in the simulation model [1]. Throughout literature review, several organization such as the industries, academicians, and investigators researched about the human behaviour and movement as well [2].

Simulation model is used as a support tool for prediction and decision-making of the effects of any changes or optimizing the technique in terms of time, cost, effort, and identity safety. In order to produce a model and the results, the simulation models are being tested as the simulation modelling implements and experimental test [3-5]. The, computational simulation models able to obtain more understanding in a current system through the testing scenario (what-if scenario) using specific software tools. Hence, the simulations model processes have become a useful tool to overcome the issues especially in the modelling the human movement in the crowd evacuation such as building on fire [6]. The organization of this paper which is describes the significance for this study. The research

work is organized as follows. Section 2 examines the related work of the research. Section 3 presents the methodology. Section 4 describes the discussion of the crowd evacuation model. Finally, Section 5 is about the discussion and conclusion for this paper.

## 2. Related Works

The crowd evacuation happens because of the scenarios like accident, tsunami, earth quake, congestion, clogging, egress behaviour, panic escaping, effects of obstacles, jamming, and fire [5, 7]. Thus, the need of simulation model is to define, comprehend and forecast the movement in group of crowd evacuation. The literature analysis describes that several methods have been used to simulating and modelling the human crowd evacuation in the building. This is related to the most popular OR techniques such as Discrete-event Simulation (DES) and Agent-based Simulation (ABS) [8] and the existing crowd evacuation simulation techniques such as Social Force Model (SFM), Cellular Automata (CA), Lattice Gas (LG) and etc. Furthermore, for the future work, we will come out with the significant attribute factors and performance measurement parameters which are important for this research work in order to have a closer representation simulation models on the fire crowd evacuation. The crowd can be defined as follow; when the group of objects such as people, vehicle and so on and the objects interact each other [9]. The movement state changed from normal to emergency with fast speed compared to normal [10]. Hence the crowd evacuation is the process of egress which happens in the crowd with one goal which is egress to the exit or to the safe places.

### *2.1. Simulation Techniques*

The case study for this research work is the crowd evacuation for fire in the building and related to the human movement. Thus, this section discusses the appropriate techniques for the simulation models. This is the first phase for this research work which is to study and identify the simulation techniques. Notably, the simulations enable to predict pedestrian flows are important for the evaluation of architectural designs and operational plans [11]. The simulation techniques significant for this research work in order to modelling the crowd evacuation for building on fire of the pedestrian movement can be simplified as follows; The three simulation techniques have been proposed for modelling the crowd evacuation of fire emergency scenario which are SFM, ABS and hybrid SFM/ABS. Then, the paper will discuss the significance and motivation of these three techniques. The first one is, the three techniques are already chosen because of the other techniques such as Cellular Automata (CA) & Lattice Gas (LG) is not appropriate to use which make pedestrian walk at or within a fixed node or grid. This approach does not allow everyone to move around in an unrestricted manner (not realistic) [12, 13]. SFM and ABS have been chosen because they can deal with individual behaviour to cater the issues on crowd evacuation with the pedestrian movement. The simulation techniques are as follows; Agent-Based Simulation - A newer simulation approach, namely as Agent Based Simulation (ABS), emerged later in the 1990s [12,13] compared to other techniques. ABS able to model the human behaviour and movement without queue and it is claimed that with realistic and suitable for modelling the pedestrian traffic flow [4, 14]. Social Force Model - The most popular simulation technique in crowd evacuation is Social Force Model and simplified as SFM. SFM is a behaviour modelling method which developed with Molnar and Vicsek. The subject is the human pedestrian and the movement in the crowd. The social force motivates the pedestrian for motion planning in crowd. Human behaviour modelling refers to computer-based which imitate either the behaviour of a single person or the collective actions of a team. SFM is continuous in time, space and appropriate for pedestrian dynamic. Proposed Human Crowd Evacuation Model - The critical review from our research work on the literature, it can be summarized as follows; the selection of the simulation method relies on the experience on the simulation techniques and individual assessment of the modeller. Other than that, the question arises as when and what issues SFM can be chosen and how about the ABS and when it should be preferred? ABS has been chosen by and SFM has been chosen by in several simulation models of crowd evacuation in the building e.g. shopping mall, office building, and airport, then at the railway and subway station, road and tunnel evacuation, event

disaster evacuation (e.g. flood, tsunami, earthquake), and the vehicle evacuation (e.g. flight, bus and ship).

## 3. Methodology

In this section, it describes the flow of methodology of this research work. Firstly, the case study description and secondly is data collection on the crowd evacuation, and the computation simulation techniques. The final one is the designing the model for the fire crowd evacuation. The details of the processes are as follows; Search strategy; throughout this process, the term 'crowd evacuation' 'crowd modelling' 'evacuation model' 'simulation model' denotes as the keywords in this paper. In any literature review, the choice of papers and the related inclusion/exclusion criteria with the goal to minimize this by requiring that every paper selected for full-text reading. It is mainly emphasizing on the conclusions of previous studies and the predominant thrust in narrative literature reviews. In this data collection phase also include the process of identifying the significant elements for the crowd evacuation simulation model together fit with the proposed computation simulation techniques. Then, designing the conceptual model for the crowd evacuation model. The last phase it the results of the simulations.

## 4. Simulation Model

It is important to realize that a crowd evacuation simulation model consists of the crowd evacuees' modules. The modules consist of general movement in the crowd evacuation of the pedestrian (human). Other than that, the significant element for the model required the movements of the people for egress and the evacuation route plan. The theory on the influence of the social force from SFM model is needed for the crowd evacuation model; humans are communicating and interacting to each other during the evacuation process. The models contain simulation technique and each model also has this movement state of evacuees. The basic state should have for each evacuee is from normal can be idled or evacuated if the fire alarm triggered. The idle state from evacuation will be happen while waiting for route searching. The conceptual model for the fire crowd evacuation in the building can be reviewed as in figure 1. The models with three different techniques which are SFM, ABS and hybrid model developed to simulate the case study. Each simulation model required the important elements which obtained from the literature review. The model should have attributes factor, the constant variables and the performance measurement parameters (PMP). These elements will be described further in the next publication as one of our future works. Important to realized that each simulation technique for a model contain the rules based on the specified technique such as SFM, ABS and hybrid model.

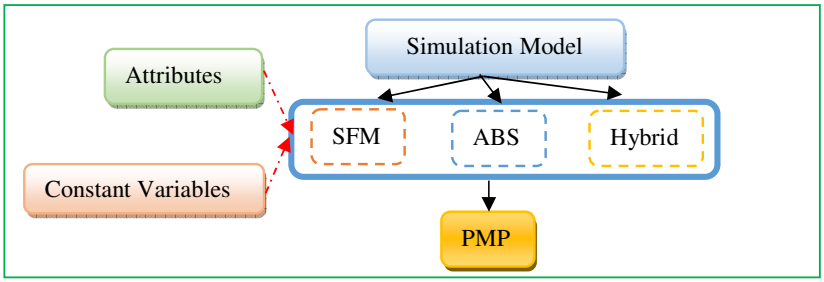


**Figure1.** The conceptual model for fire crowd evacuation.

## 5. Conclusions

The conceptual model relates to the OR element which is simulation and modelling for the described case study. In order to have the simulation model for replicating the real system, the simulation techniques required; SFM, ABS and hybrid model. These models needed the attributes as the factors before the simulation will be ran together with the constant variables to obtain the simulation results. The results will be analysed using statistical analysis based on the performance measurement parameters (PMP). The expected result shows that the hybrid model obtains the better result compared to the other two traditional and single simulation technique (SFM and ABS). As conclusion, this research work focuses on the simulation model for modelling the case study to evaluate the performance of the simulation techniques. The simulation techniques have been proposed as SFM, ABS and hybrid model. Throughout the literature, SFM and ABS are the most frequently chosen by the researchers. In addition, the literature indicated that hybrid model with the better ways, powerful, popular choice, and flexibility as expressed by [2] for the better result. The investigation on the performance of each simulation technique is based on the attribute factors and the output for the simulation model is the performance measurement parameters (PMP). The future works will reveal the specific attributes, constant variables and PMP with the simulation and statistical results. This will proof that hybrid model is the better way for modelling the real system which is will be collected through the simulation results.

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