Evolution in Electrical and Electronic Engineering Vol. 3 No. 2 (2022) 1-7
© Universiti Tun Hussein Onn Malaysia Publisher's Office

EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Simulation of Crowd Movement during Pandemic Covid-19

Ummu Zahratul Farihah Zakariya[1], **Shamsul Mohamad**[1]*, **Rafizah Mohd Hanifa**[2]

[1]Department of Electronic Engineering Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, MALAYSIA

[3]Department of Information Technology Centre for Diploma Studies,
Universiti Tun Hussein Onn Malaysia, Pagoh Campus, 84600, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/eeee.2022.03.02.001
Received 02 August 2021; Accepted 16 June 2022; Available online 30 October 2022

Abstract: During the COVID-19 outbreak, the spread of the virus has resulted in unprecedented measures restricting activity in many countries, including Malaysia. Many interventions are used to decrease the risk and spread of COVID-19. Most of these interventions are related to social distancing. Social distancing is the new norm to reduce interactions between individuals to slow down the spread of the virus. Using computer software, we can produce simulations that show people's movement in a particular space that considers social distancing. This simulation can help plan people's moves during the covid-19 pandemic with a social distance of 1 meter. Microsoft Visual Studio was used to model the agents and layouts of the mosque, hall and supermarket. The Social Force Model (SFM) was used to produce simulations of crowd movement. SFM describes the agent's motion with the combination of the driving force, another agent's repulsive force and an object's repulsive force. This simulation shows the time and the maximum number of agents in a space considering social distancing. In addition, the simulation results also show the average time the agents take to fill up the areas and the time that agents take to avoid close contact.

Keywords: Crowd Behavior, Social Force Model, Covid-19 Pandemic, Social Distancing

1. Introduction

Crowd simulation simulates the movement of many entities or characters and is used to create virtual scenes for visual media such as movies and video games [1]. It is also used in crisis training [2], architecture [3], and evacuation simulations [4]. The crowd simulation model determines people's desired motion, behavioral crowd, and real situation [5]. Furthermore, with the recent pandemic COVID-19 that has been affected worldwide, this crowd simulation model can be used in our new

*Corresponding author: shamsulm@uthm.edu.my

norms of social distancing, such as in the supermarket, public market areas, mosques or wedding ceremony halls. Simulating crowds at this distance contributes to helping pedestrians to a 1-meter distance from each other. The behavioral timeline can explain movements observed of time taken by the public to fill space. In addition, the social force model is a technique to know the type of character in the crowd simulations.

The user can utilize crowd simulations to figure out how long it will take for everyone to leave the room [6], where the focus is on the evacuation aspect. In a confined space, evacuee simulation is required to verify that the evacuees successfully exit the area and predict the time needed to evacuate, as failing to evacuate can result in death.

Meanwhile, one of the recent crowd simulation technologies that use 3D looks picture gives a clear appearance of the agent action [7]. This project chose an area of a shop lot dormitory as a living space for colleges or any educational institution to apply security measures. Planning and building a better dormitory layout can help ensure that the simulation meets all safety standards and regulations.

2. Methodology

Implementing the social force model in crowd movement simulation during pandemics required a few steps to achieve the objectives. The steps required are divided into simulation components, such as the agent's movement with a distance of 1 meter by using the social force model algorithm, designing the different layouts, and testing and analyzing the output of the other layout, as shown in Figure 1.

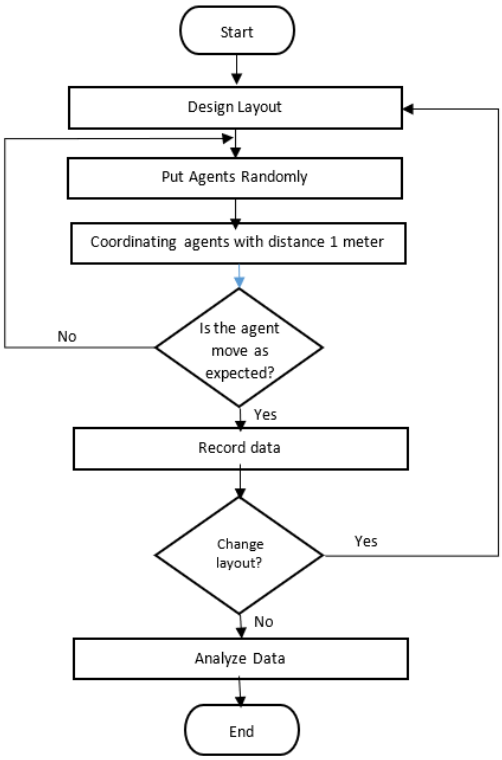
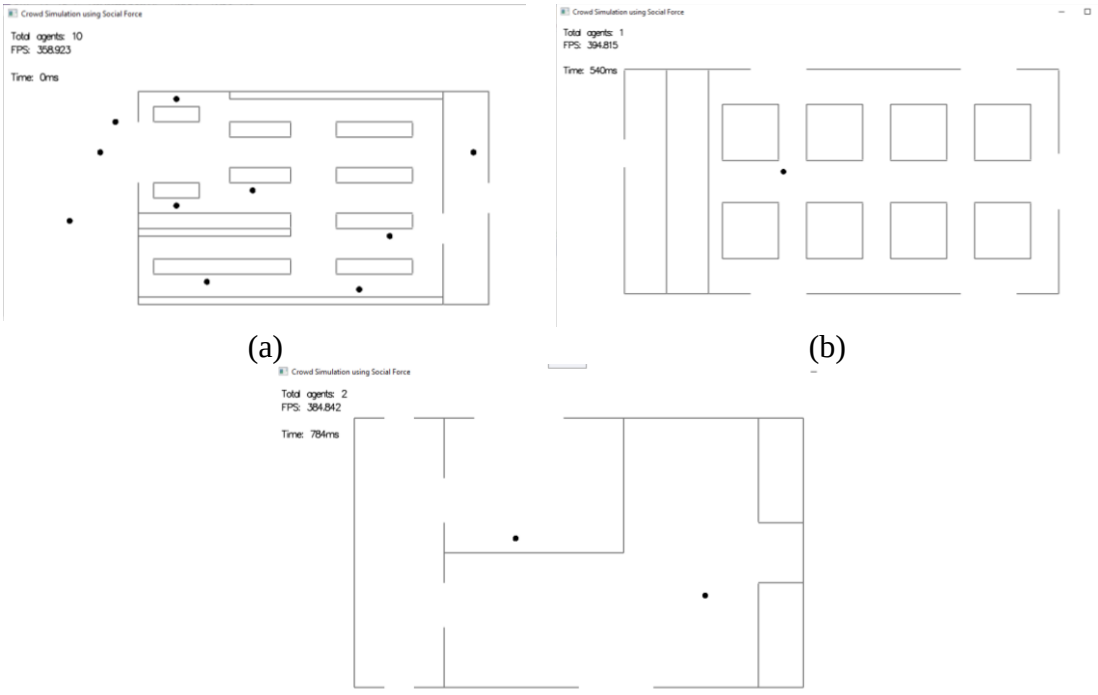


Figure 1: Flowchart of the simulation design process

2.1 Layout

Three different places have been chosen for this project. The places are Speedmart Supermarket in Batu Kurau, Astaka Hall in Batu Kurau and Ar-Rahmaniah Mosque in Simpang 4, Batu Kurau. The layout of the chosen locations is shown in Figure 2.



(a) (b)

(c)

Figure 2: Layout of (a) Speedmart Supermarket, (b) Astaka Hall & (c) Ar-Rahmaniah Mosque

2.2 Social Force Model

The Social Force Model will be used to obtain the result for this process. The simulation used principles of the Social Force Model in each simulation component, such as the agent, surrounding obstacles, and the distance between the agents [8]. The component of f_i^0 refers to the agent's driving force, while component f_i^{wall} refers to the repellent force that exists between agents and obstacles. The last component of f_i^{agent} refers to the sum of repulsive forces between the agent, *i* and other agents, j, and the equation is shown below:

$$f_i = f_i^0 + f_i^{wall} + f_i^{agent}$$

2.3 Software

For this simulation of crowd movement, the software that will be used is Microsoft Visual Studio 2019. Microsoft Visual Studio uses the C++ language and can compute different features of 2D crowd simulation. The libraries used for the simulation in Microsoft Visual Studio are the vecmath package and OpenGL to calculate the Social Force Model's vectors.

3. Results and Discussion

The results and discussion are reported in this section. Through the analysis and discussion, we can conclude the results obtained from the project.

3.1 Simulation Results

The results recorded are from the time agents took to fulfil the spaces with the desired speed by considering the 1-meter distance. Figure 3 shows the result of crowd simulation using Social Force in a Supermarket. Before the simulation start, the agents are placed randomly. The final path of their

movement is set with a distance of 1 meter between each other. Only 20 agents are assigned to fulfil the supermarket spaces at a certain time.

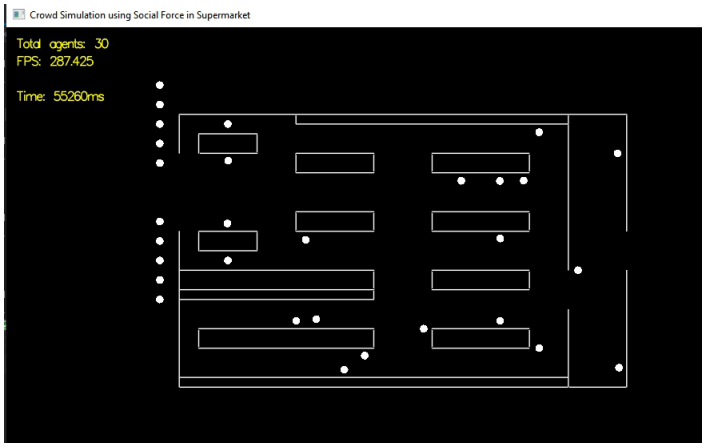


Figure 3: The crowd movement simulation using Social Force in a Supermarket

Figure 4 shows the result of crowd simulation using Social Force in the Wedding Hall. Only 100 agents can fulfil the hall spaces at a particular time

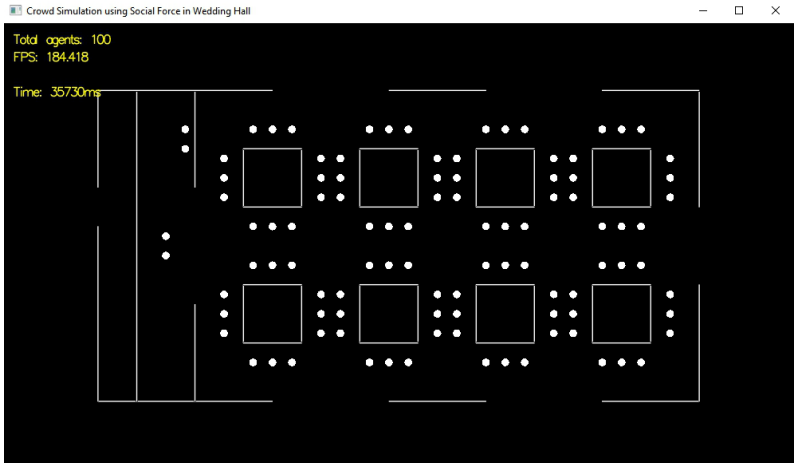


Figure 4: The simulation of the crowd movement using Social Force in Wedding Hall

Figure 5 shows the result of crowd simulation using Social Force in the mosque. The path of every agent has been set up with a distance of 1 meter between each other. Every agent has been put randomly and will move on their way. Only 43 agents can fulfil the mosque spaces at a particular time.

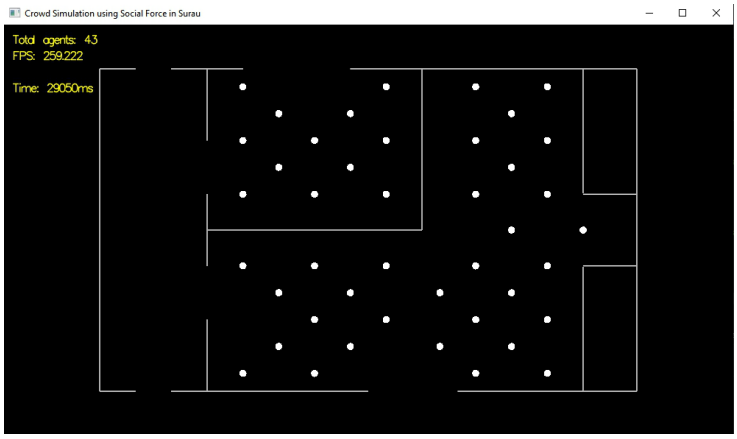


Figure 5: The crowd movement simulation using Social Force in Ar-Rahmaniah Mosque

3.2 Average time

The motion of the agents can be seen from the results. The coordinate of the initial point of every agent has been set with a distance of 1 meter among each other. When the simulation ran, the agents moved to their setting path with desired speed and time. The time taken for the agents to fulfil the spaces is recorded based on the frame per second in the source code. Each layout simulation is run ten times to get the average time required for the agents to fulfil the spaces. Table 1 presents the average time for agents to fill up the three different areas.

Table 1: Average time the agents take to fill up the spaces.

Layouts	Average time (ms)
Speedmart Supermarket	33743.7
Ar-Rahmaniah Mosque	24058.6
Astaka Wedding Hall	31272.5

3.3 Simulation results for different areas

As mentioned earlier, the time taken for the agents to fill up the space is conducted ten times for each area and Figures 6 to 8 show the results in graph form.

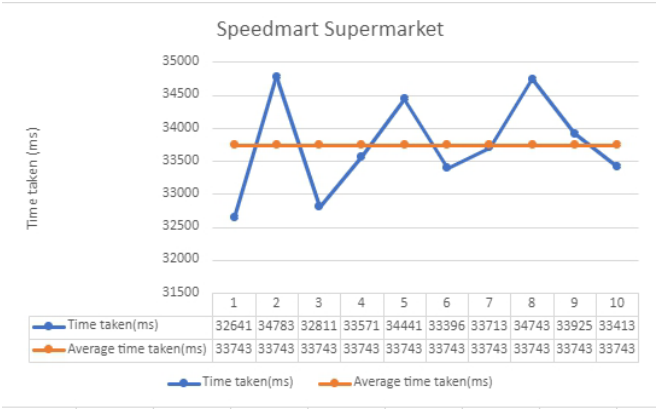


Figure 6: The results of time taken and the average for the agents to fill up the spaces in Speedmart Supermarket.

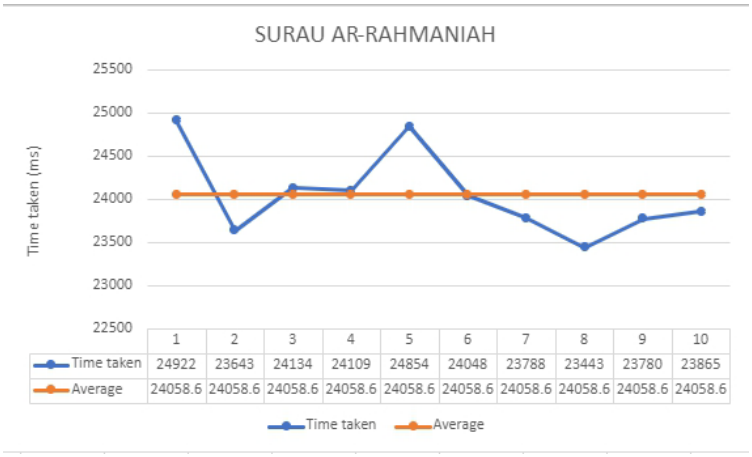


Figure 7: The results of time taken and the average for the agents to fill up the spaces in the Ar-Rahmaniah Mosque.

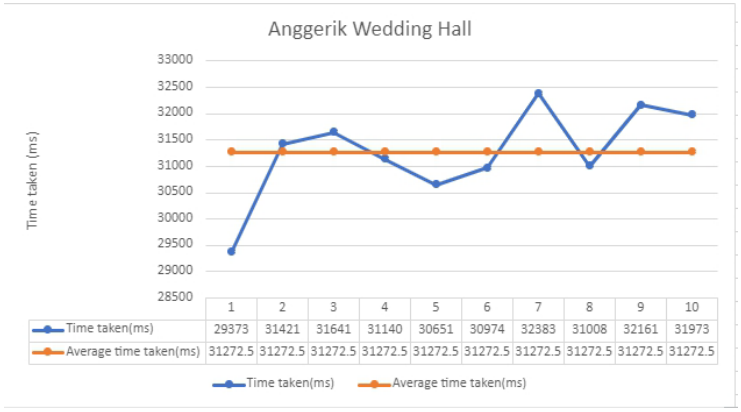


Figure 8: The results of time taken and the average for the agents to fill up the spaces in Astaka Wedding Hall.

3.2 Discussions

This section summarises the findings and contributions made. The results show that the average time the agents take to fill up the area depends on its layout. If the area is wide and simple, the time taken for the agents to fill up the space is much faster than in a small and complex layout, after considering the 1-meter social distancing.

The result casts a new light on the number of agents at the location. For example, Speedmart Supermarket can accommodate only 20 agents at one time, compared to Ar-Rahmaniah Mosque and Astaka Wedding Hall, 43 agents and 100 agents, respectively, to ensure no collision.

One concern about the findings of the simulation result is some agents are colliding with each other to reach their destination. The collision could happen due to the force from outside or the others agents. The duration of close contact may happen from 500ms to 2000ms.

4. Conclusion

The main conclusion that can be drawn is that by using the 2D crowd movement, we could simulate the crowd's activity at different places such as the supermarket, hall, and mosque. These places were chosen as they are involved with social activity in real-life. The simulation is based on the social force model algorithm developed using Microsoft Visual Studio. We have shown that using the algorithm will create a social force between an agent and other agents and obstacles. Due to the force, the agents

will be repelled when they are close. In maintaining the 1-meter social distancing, each agent's path is set to a 2.0 coordinate.

Acknowledgement

This research was supported by Universiti Tun Hussein Onn Malaysia (UTHM) through Tier 1 (vot Q018). Special appreciation to the IoT Laboratory, UTHM, for providing related facilities.

References

[1] Sun, S. (2017). Agent-based crowd simulation modelling for a gaming environment (Doctoral dissertation, University of Windsor (Canada)).

[2] El Talla, S. A., Al Shobaki, M. J., Naser, S. S. A., & Amuna, Y. M. A. (2017). The effectiveness of a training program in increasing crowd funding awareness. International Journal of Advanced Educational Research, 2(1).

[3] Haworth, B., Usman, M., Berseth, G., Khayatkhoei, M., Kapadia, M., & Faloutsos, P. (2016, May). Towards computer assisted crowd aware architectural design. In Proceedings of the 2016 chi conference extended abstracts on human factors in computing systems (pp. 2119-2125).

[4] Mohamad, S., Nasir, F. M., Sunar, M. S., Isa, K., Hanifa, R. M., Shah, S. M.,Ahmad, A. (2018). Intelligent agent simulator in the massive crowd. Indonesian Journal of Electrical Engineering and Computer Science, 11(2), 577–584.

[5] Bavel, J. J. V., Baicker, K., Boggio, P. S., Capraro, V., Cichocka, A., Cikara,Willer, R. (2020, May 1). Using social and behavioural science to support COVID-19 pandemic response. Nature Human Behaviour. Nature Research.

[6] Ismail, F.S., Mohamad, S., Isa, K., Shah, S.M., Hanifa, R.M., Sunar, M.S., & Nasir, F.M. (2018). Simulation of Crowd Evacuation in Laboratory using Social Force Model. *2018 International Symposium on Agent, Multi-Agent Systems and Robotics (ISAMSR)*, 1-6.

[7] Jamaluddin, M.N, Mohamad, S., Sunar, M.S., Isa, K., Hanifa, R.M., Nasir, F.M., Shah, S.M. OpenGL 3D Crowd evacuation simulation at Universiti Tun Hussein Onn Malaysia (UTHM) hostel. Indonesian Journal of Electrical Engineering and Computer Science 16, 1034.

[8] Helbing, D., & Molnár, P. (1995). Social force model for pedestrian dynamics. Physical Review E, 51(5), 4282–4286.