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Development of Crowd Simulation to Encourage Social Distancing During Convocation Ceremony

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Abstract: The movement behaviour of the people is constantly being studied to understand and maintain human safety. During Covid19, many activities had to be carried out with physical distancing, including convocation ceremonies. Therefore, this study is to develop a simulation of crowd movement during convocation ceremonies using the Social Force Model by emphasizing the aspect of physical distancing. The results of this simulation can compare the time required to fill the hall by arranging the movement of graduates or randomly. As a result, the organized movement of graduates can be faster and comply with standard operating procedures (SOPs) set by the government, while random methods cause congestion in an area and disrupt the movement of other graduates.

Keywords: Crowd Behavior, Social Force Model, Convocation Ceremony, Covid19

1. Introduction

In this era of the pandemic Covid-19, many activities have been affected and cannot be done in physically. It included the education system which has affected the flow and the timetable of the class. Many activities in the education system cannot be done, for example, face-to-face classes, laboratories [1] and everything must go in the online system including activities that cause crowds such as convocation. Many graduated students are going through their convocation online and just certain student can get their certificate face to face with the standard operating procedure [2]. In 2020, campus closures overturned students' lives, driving them to the conclusion their last year essentially. Seniors this year confront a closely resembling destiny since the widespread proceeds to halt numerous understudies from getting a charge out of the ordinary campus which is the graduation day. Every activity must be done in a standard operating system to make sure there have social distancing, no crowd in a crowded place and a correlation. Therefore, the social force model can be implanted in this system of convocation day during the pandemic.

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Collective conduct of numerous people could be a commonplace investigation subject in complex frameworks, and it is extraordinary hypothetical and down to earth intriguing. One of the major approaches to ponder such a framework is utilizing computer recreation to explore how collective conduct on a plainly visible scale rises from a person's intuition. This approach of displaying complex frameworks is as a rule called agent-based demonstrating or agent-based reenactment, and it has been broadly utilized in numerous diverse disciplines, counting humanism, financial matters, atomic science and so forward.

A well-known model to simulate complex dynamics of the pedestrian crowd is called the social-force model. Very interestingly, certain psychological factors are abstracted in model parameters such as "desired velocity" and "social force." Social Force Model is a control system that operates by managing the physical movement of crowds by keeping a proper distance from each other [3]-[6]. Application of this model is created by individual movement force by self-driving motion and challenges come from surrounding individuals and facilities for example static and walking people, walls, and many others. It will show that this model is capable to avoid the obstacle by describing the surroundings and self-organization to collect the effects of the movement of the surrounding very realistically. This Social Force Model will be applied to visual studio simulation. The simulation will show the movement in a massive crowd situation.

Modeling could be a way to create a virtual representation of a real-world system that has software and hardware. If the software components of this model are driven by mathematical relationships, it can simulate this virtual representation under a large range of conditions to work out how it behaves. Modeling and simulation are especially valuable for testing conditions that may be difficult to reproduce with hardware prototypes alone, especially within the early phase of the design process when hardware might not be available. Iterating between modeling and simulation can improve the standard of the system design early, thereby reducing the number of errors found later within the design process.

2. Materials and Methods

In approaching this study, the researcher should choose the correct methodology for this project. Implementing the social force model in the simulation of crowd movement during a pandemic required a few steps to ensure that the objectives are achieved.

2.1 Design Process

The design process may be a series of steps that must follow to return up with an answer to an issue. Persistently the answer involves designing a product sort of a machine or coding system that meets certain criteria and accomplishes a particular task. This process is different from the Steps of the methodology, which can be more accustomed to. If the project involves making observations and doing experiments, it should probably follow the methodology. If the project involves designing, building, and testing something, it should probably follow the planning process.

2.1.1 Simulation Design Process

The flowchart starts with designing a layout of the Dewan Sultan Ibrahim (DSI) with the exact size. It also includes the furniture that will be used for the convocation ceremony. Besides, the entrance and the exit door are using the main door of DSI. Then, can start to design the movement of the crowds. Then the design of the layout and furniture are coded into the software simulation

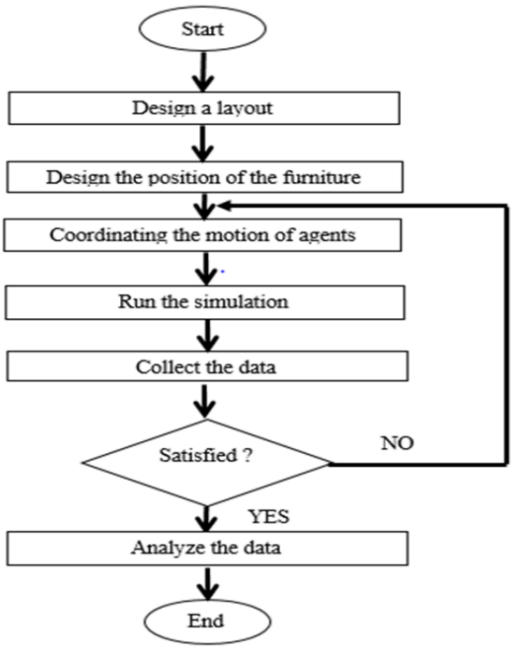

Figure 1: Flowchart of the simulation design process

The flowchart in Figure 1 is about how the process to design the simulation. It starts with the design of the layout based on the actual layout to get the real situation and size of the place. It included the object or furniture that has been used in this simulation. Then, start to coordinate the position of the starting agent to the targeted place. All the point of the movement has been set in the simulation. After that, start the simulation and collect the data based on the result and make an analysis of the movement of the crowd.

2.1.2 Agent Design Process

The coordinating the movement of the agents is based on the process of the convocation ceremony which is the entrance of the graduated student and others. Every process is made in a different process in the simulation and all the data will be recorded. A process flow of the Convocation ceremony process is shown in Figure 2.

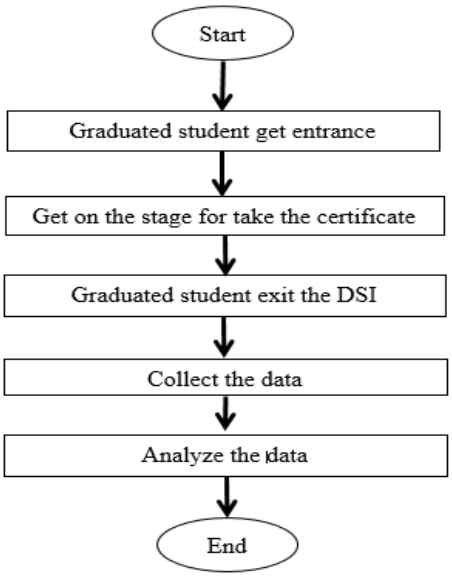

Figure 2: Process flow of the Convocation ceremony process

For the agent, design is based on the real event of the convocation day which starts with the student getting entrance to the hall. After that, the student will get on the stage to get their scroll and the event finish with all the students left in the hall. This process is used to get the actual time taken for the event in real-time. How much time is taken in one session within the desired distance is considered.

2.2 Social Force Model

For obtaining the result for this process, the Social Force Model is used. The simulation will use the principles of the Social Force Model in each of the simulation components like the agent, surrounding obstacles, and therefore the distance between the agents. The model is abstracted as "desired velocity" and "social force", but the concepts don't seem to be physical entities because they describe people's opinions or special features of the human mind. In short, society's collective behavior has been long investigated in psychology and social sciences, and there are many valuable theories and discoveries. As a key model for studying pedestrians' dynamics, the social force model must understand the psychological theory.

2.3 Equations

Below are the proposed principles of Social Force Model including the simulation component like agents, surrounding obstacles and also the interaction force of pedestrians consists of social force that characterizes the social-psychological tendency of two pedestrians to remain off from one another.

$$f_{ij}^{soc} = A_i \exp\left[\frac{(r_{ij} - d_{ij})}{B_i}\right] n_{ij} \quad \text{or}$$

$$f_{ij}^{soc} = \left(\lambda_i + (1-\lambda_i)\frac{1+\cos\varphi_{ij}}{2}\right) A_i \exp\left[\frac{(r_{ij} - d_{ij})}{B_i}\right] n_{ij}$$

Eq. 1

$$\underbrace{\overrightarrow{F_\alpha}(t)}_{\text{Total Effect}} = \underbrace{\overrightarrow{F_\alpha^0}(\overrightarrow{v_\alpha}, v_\alpha^0 \vec{e}_\alpha)}_{\text{Effect of Pedestrian Desire}} + \underbrace{\sum_\beta \overrightarrow{F_{\alpha\beta}}(\vec{e}_\alpha, \overrightarrow{r_\alpha} - \overrightarrow{r_\beta})}_{\text{Repulsive of Pedestrian } \beta} + \underbrace{\sum_B \overrightarrow{F_{\alpha\beta}}(\vec{e}_\alpha, \overrightarrow{r_\alpha} - \overrightarrow{r_\beta}^\alpha)}_{\text{Repulsive of Border}} + \underbrace{\sum_i \overrightarrow{F_{\alpha i}}(\vec{e}_\alpha, \overrightarrow{r_\alpha} - \overrightarrow{r_i}, t)}_{\text{Attractive Effective}}$$

Eq. 2

Based on the formula above, it shows the process of social force model that been used in this simulation where how the agent interacts with the other agent and also how they interact if there is an obstacle on the way to their plac f_{ij}^{soc} is social force where interaction with the crowd moving and they're psychological social with two others pedestrian.

This social force model is based on the situation of the people in the real world in the simulation. Therefore, the total effect shown above is included the movement of that agents. Their effect can be seen with the investigation of the movement of the crowd, the obstacle that has in their way and also how they interact with the obstacle and other agents.

2.4 Layout

In a nutshell, layout design refers to the arrangement of visual elements within a grid so as to convey a selected message. The latter a part of this definition is essential. If a layout doesn't read well to the viewer, the planning is ineffective, regardless of how trendy it's. Grids are useful in layout design because they assist structure and organizing content. Although grids are invisible within the user-facing design, it's easy to inform at a look whether a layout follows a grid system.

This research focuses on the demonstration of the crowd simulation during the convocation ceremony that occurred at Dewan Sultan Ibrahim (DSI) of Universiti Tun Hussein Onn Malaysia (UTHM). Figure 3 shows the real picture in front of the hall of Dewan Sultan Ibrahim (DSI) of Universiti Tun Hussein Onn Malaysia (UTHM). The real 2D layout of the chosen places is shown in Figure 4.

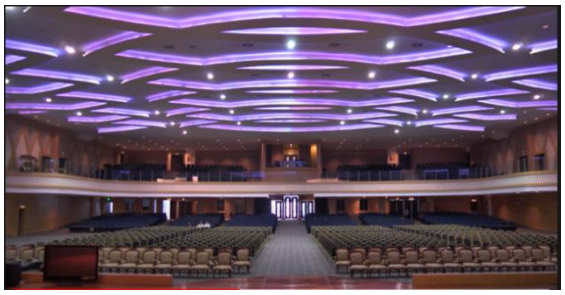

Figure 3: Dewan Sultan Ibrahim

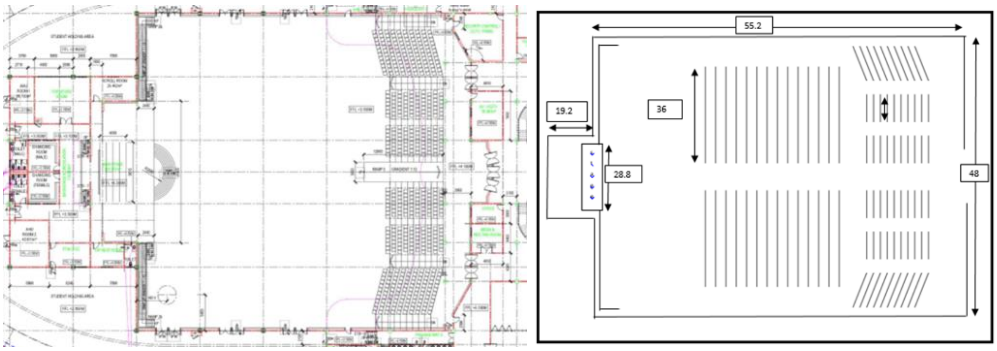

Figure 4: 2D layout

Figure 4 shows a 2D architectural plan. It is the layout of a property or space from above. It'll often show the walls and room layout, plus fixed installations like windows, doors, and stairs additionally as furniture. 2D means the ground plan may be a "flat" drawing, without perspective or depth. The measurement of the design layout area is a centimeter. The Dewan Sultan Ibrahim hall layouts are measured by the area of the grid. With an approximation of 1 grid ≈ 9.6 m. The measurement of the layout is done to help with drawing the layout in Microsoft Visual. The size of the Dewan Sultan Ibrahim hall would then be scaled accordingly to ensure that the layout fits within the GUI window.

2.5 Microsoft Visual Studio 2019

The Microsoft Visual Studio use the C++ language and may compute different feature of 2D crowd simulation. This simulation requires two libraries, which are that the C++ Port of the vecmath package and therefore the Open Graphics Library (OpenGL). The OpenGL is for the graphic of the simulation and also the vecmath package is for the computational calculation of the vectors for the Social Force Model.

3. Results and Discussion

This section will explain the result, analysis and discussion of the project.

3.1 Results

As it can see in the result of the simulation. There are the agents that are moving from the outside of the hall and move through the runway and go to the desired place that is targeted. It was moving by applying a social distancing 1 meter.

Figure 5 shows the actual layout of the simulation in the software that has been used. This layout is based on the actual layout of the Dewan Sultan Ibrahim UTHM. There is some area that is used for this simulation such as the chair at the middle of the dewan and also the stage of the dewan.

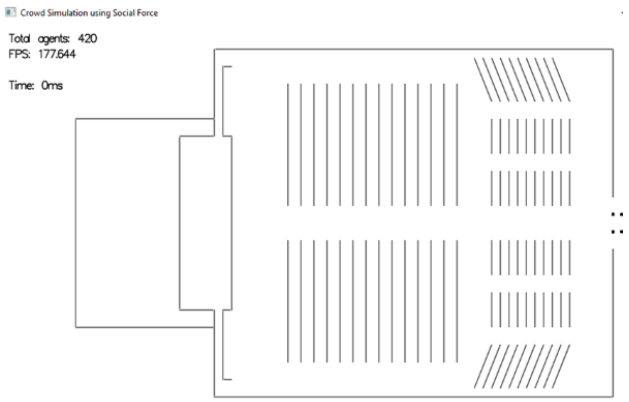

Figure 5 Layout of the hall at DSI in simulation

While Figure 6 show some of the source code that have been used in this simulation. This source code is for the obstacle or object that been used such as furniture, stage, chair and door. The source code of the agents also is important to show how the crowd is moving in that situation.

```
void createAgents() {
    int i;

    for (i = 0; i < 15; i++)
    {
        Agent* agent;
        // upper agent
        // loop 1
        agent = new Agent;
        agent->setPosition(15.0 + 0.5 * i, 0.5); // Step 2: Set init
        agent->setPath(8, 0.5, 0.5);// Step 3: Set target position(s
        agent->setPath(-4, 0.5, 0.5);// Step 3: Set target position(
        agent->setPath(-3.78, 8.0 - 0.5 * i, 0.0);// Step 4: Set tar
        socialForce->addAgent(agent); // Step 6: Add agent to SFM
        // loop 2
        agent = new Agent;
        agent->setPosition(22.5 + 0.5 * i, 0.5); // Step 2: Set init
        agent->setPath(8, 0.5, 0.5);// Step 3: Set target position(s
        agent->setPath(-3.25, 0.5, 0.5);// Step 3: Set target positi
        agent->setPath(-3.03, 8.0 - 0.5 * i, 0.0);// Step 3: Set tar
        socialForce->addAgent(agent); // Step 4: Add agent to SFM
```

```
Wall* wall;
// Upper stage Wall
wall = new Wall(-16.0, 6.0, -8.0, 6.0); // Step 1: Create wall
socialForce->addWall(wall); // Step 2: Add wall to SFM
// vertical hall Wall
//left
wall = new Wall(-8.0, 5.0, -8.0, 10.0); // Step 1: Create wall
socialForce->addWall(wall); // Step 2: Add wall to SFM
//upper hall Wall
wall = new Wall(-8.0, 10.0, 15.0, 10.0); // Step 1: Create wal
socialForce->addWall(wall); // Step 2: Add wall to SFM Wall
//vertical hall Wall
//right
wall = new Wall(15.0, 10.0, 15.0, 1.5); // Step 1: Create wall
socialForce->addWall(wall);
```

```
// chair middle upper // chair middle below
int v;

for (v = 0; v < 14; v++)
{
    wall = new Wall(6.0 - 0.75 * v, 1.0, 6.0 - 0.75 * v, 8.0);
    socialForce->addWall(wall);

    wall = new Wall(6.0 - 0.75 * v, -1.0, 6.0 - 0.75 * v, -8.0);
    socialForce->addWall(wall);
}
```

Figure 6 Source Code of agents, walls and furniture

Figure 7 shows that the crowd of the agent is moved in the hall in the proper way. Which is there is already set up the set point with the specific speed for agagentso move and get to their place. While

result show in figure 8 is the agent are moved randomly where the set point is set up randomly and the agent are moving based on the situation to get to their place.

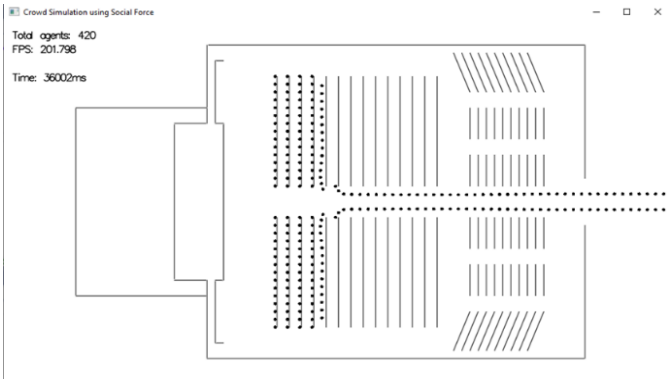

Figure 7 Simulation of the setting point

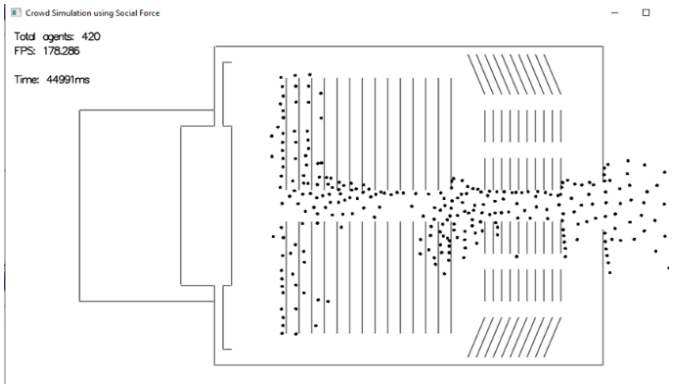

Figure 8 Simulation of the random point

3.2 Discussions

The result of the movement of the crowd agent from the outside hall to the targeted place on the layout in a simulation has shown in the result above. As it can see that the flow of the agent during entrance into the hall is with the social distancing for both situations. The speed of the agent on both situation which is a setting point and randomly is set based on the maximum speed a human can run which the range of human speed is about 1.29 ms to 1.5 ms with both the standard deviation of about 0.19. So in this simulation, the speed that has been used is 1.5 ms and it is based on the situation. If it is a crowd and the movement becomes slow because it has to make the distance between each of the agents.

3.3 Analysis

In this study, the simulation for entering the hall for the convocation ceremony has been tested and analyzed three times to get the time that have be taken for the session. This test is only for entering the hall for 420 students.

Table 1: The time taken for entering the hall

Test	Setting (ms)	Random (ms)
Take 1	78858	293433
Take 2	78294	271200
Take 3	78591	294723
Average	*78581*	*286452*

For these three takes of the simulation, the setting simulation shows that the average time taken is 78581 ms. The time taken is shorter because it moves based on the coordinate that has been set. While for the random movement of the agent, the average time taken is more than 300000 ms to take the agent to get to their place. It is because the movement of the agent is disturbing by the other agent and the obstacle that have in the simulation. The agent has to go through the checkpoint before getting to the place that has been set. At the time the agent moved. There is another agent that avoids another agent to move. Therefore, it will take time to arrive at the setting point.

Based on both simulations that have done, it can be analyzed that is the agent is set with the coordinate to their place. It will be more controlled and the time taken will be shortened than if the agent is set with the random move. Furthermore, if the agent moves randomly. The agent will attract other agents to go to the place that is set and will it will take more time the agent to arrive at their place.

4. Conclusion

This project is to investigate the movement of the crowd to encourage social distancing during the convocation ceremony because as we know that the world has been afflicted with the disease of Covid-19. So, all the activities especially the big event like convocation day will be through with the standard operating procedure for example wearing a mask in a crowded place and applying a social distancing with people around.

Due to that, this project will develop a crowd simulation to encourage social distancing and can be applied on the event day of convocation. Furthermore, this project is focus on the flow of the event which is the entrance of the graduated student until the finish and the student left the hall.

The movement of the agent including the speed with the social distancing effect the time of the event in one session. Then, the movement of the agent has to analyze with the velocity, speed and others to encourage the social distancing. Other than that, this project has demonstrated the usage of the software platform for crowd simulation. This enables researchers to simulate a crowd movement to be applied in real life.

Acknowledgement

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