The Impact of Spatial Layout Design on the Pedestrian Movement during Panic Situation: Pedestrian Survival Prediction

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Abstract. Crowd management has become the global issue due to the fatal incidents happened that involve the high casualties of pedestrians. During panic situation, the survival rate of the pedestrians are depends on the several parameter values that are hard to discover due to the catastrophic case scenarios and almost impossible for the scene to be created due to the human ethical conduct. Hence, with the advance of computation technique and the improvement of Artificial Intelligence (AI) process automation, the panic situations are able to be visualized with the computer simulation. However, based on the previous simulation researches, there are a lot of features that had been found that are able to influence the pedestrian movement and caused the clogging region on the spatial layout. Hence, this research has been conducted to justify and analyze the findings of influential features by simulating the near-realistic pedestrian movement using Cellular Automata (CA) approach to re-enact the real behavioral actions of the pedestrians during panic situation. Based on the near-realistic simulation and the construction of the spatial layout design based on the features that promotes the clogging region experiments, the results had shown that the structural arrangement of a space is the proper solution to increase the pedestrian survival rate and decrease the clogging region. However, the existing structural also can enhance the safety quality of the space by re-arranging the obstacles in the spatial layout. This research had introduced the granularity based approach and proves that the implementation of the fine-grain obstacles' arrangement while accommodating the interior design standard may reduce the time (10 seconds, 0.1%) taken for evacuation process and increase the probability of movement directions for the pedestrians to ensure the balance usage of the egress points.

1. Introduction

The movement of pedestrian has become one of the supreme global issues especially with the regards of human safety that involve with the evacuation process during panic situation. During panic situation, the ordinary movement of the crowd will experience a sudden changes with an abrupt disperse in a vast area for escaping and lifesaving actions. The pedestrians will move within the crowd with heavy stress and panic impact that highly will cause the subconscious actions; yelling, rushing, pushing, shoving especially in front of exit point, crying and etc. The abrupt actions will cause a great anxiety impact and increase the physical collision of the pedestrians and leads to a great number of injuries and casualties. Hence, the crowd management has become the most impactful and valuable supervision and control measure to ensure the safety of the pedestrians in the space and assist the movement process to ease the pedestrians’ activities. The crowd movement management has become
complex and difficult when involving the massive movements due to the high potential of great fatalities incidents and able to leads towards the high number of casualties of the pedestrians [1, 2].

Recently, there are a lot of panic situations happened that caused fatal incidents and promote a great effect on the surroundings and pedestrians such as earthquake, stampede, flood, fire, bombing and etc. [1, 3, 4]. Last 2017, around the globe, there were several fatal incidents had happened such as the entrapment of a family of four in their house in Malaysia that lead towards total death in February 2017, the loss of 72 persons in the great fire of Grenfell Tower in West London in June 2017 and a great tragedy of a religious school that was burned down at dawn that had trapped and killed 25 people in Malaysia in September 2017 [4-7]. Based on these incidents, all of these impactful incidents were happened at the closed area location. The closed area building is the one of the crucial space that has the great influences from the structural, interior arrangement and material of the layout. Hence, to find the reasonable explanation and strategic analysis, the researchers around the globe are searching for the possible features that contribute towards the difficulty of the movement activities for the pedestrians especially in the panic situations and enquiring for the suitable implementation methods for solving, overcome and even predicting the outcome of this crowd management issues [2, 8-12].

Based on the previous research, there are some features that were identified that able to contribute towards the safety breach of the pedestrian in the closed area building during panic situations were identified, such as; 1) The panic attack that stimulate the reflex actions between the pedestrians with the surroundings’ elements, 2) The impenetrable structure and lack of exterior foundation design of the building that will entrap the pedestrians more than assisting the evacuation process, and 3) The complex arrangement of the interior elements that influencing the pedestrians’ movement patterns [10, 13, 14]. However, based on the previous researches, the researchers need to re-enact the panic situation to imitate the realistic incidents for the accurate analysis of the issues and identifying the features involved. However, the type of research that involving the catastrophic and calamitous scenes might need some other alternative methods for conducting the experiments due to the dangerous impact and able to jeopardize the human life such as re-enacting the fire situations and stampede situations. Hence, the Artificial Intelligence (AI) has come in handy for imitating the incidents by simulating the situations using the computation process.

The AI scope of computer science is used to simulate the situations and designing the entities that involve in the situations. The designed entities supposedly will reflex towards the surroundings with the near-realistic characteristics. Based on the previous researches, during panic situation, the pedestrian will experience the behavioral changes based on the type of incident happen as the spontaneous reactions towards their surroundings’ condition [10, 13]. For the real-time re-enact of the movement, computer science researchers had established some great simulation models to re-create the situation to reach the real-time movement of pedestrian that involves with many kind of target objects as the obstacle parameters [10, 15-17]. The simulations of the pedestrian movement and the target situations, especially the panic situations are important in assisting the right authorities and even the building developer and interior designer to manage and also design the standard and safety friendly spatial layout purposely for preventing any unwanted situation (entrapment, stampede and etc.) to be happened, for incident’s response planning and countermeasure, and also for predicting the situation that might be happened in the future. Hence, focusing on the future prediction point of view, this research had established a thorough investigation specifically on the lecture hall of Universiti Sains Malaysia for justifying and finding the impactful features that able to influence the pedestrians’ movement (students’ movement) based on the spatial layout design by simulating the near-realistic pedestrian movement simulation during the panic situation and predicting the pedestrian survival rate as the evaluation and assessment for finding the feasible lecture hall design that is evacuation friendly.

2. Spatial layout design: Impactful features during evacuation
Closed area is the space that always full of crowd especially during event (auditorium, cinema and etc.) or on daily basis (lecture hall, tutorial room, house, office building and etc.). Nowadays, these attraction places were developed and designed to accommodate the crowd by providing the comfortable, pleasant and sheltered places with the existence of fancy and decorative materials such as
chair, table, carpet, and etc. that satisfied the cultural design and esthetical value. However, these convenient elements are significantly might create a difficult situation especially for evacuation process during panic situation. The basic focuses of the closed area development are the structural design and the functional design. The structural design is the external arrangement of the space that shapes the building and act as the bridge entrance between the pedestrians and the functional serves of internal design. There are many types of building design that were developed based on the standard architectural design and customization of the architects that are influence by the cultural and heritage composition. However, the complexity of the structural design and the lack of relevant access of the space will create a great impact and able to jeopardize the safety of the pedestrians especially during panic situation. The issues will be featuring the complex structures that promote the difficulties of the pedestrians’ sense of direction and the number and size of entrances (ingress/egress).

The complex structures issue can be relate to the high rise building and unique customization design that serve the esthetic value more than the standard design. The fire incident at the 24-storey high of Grenfell Tower in West London in 2017 had proved that the high rise building is one of the pedestrian’s “out of actions” situation that had entrapped the pedestrians in the building and burned almost for 60 hours. The fire incidents had cause the life of 72 victims. Besides the building’s storeys counting that affect the pedestrian’s life, the structural design customization of space also plays a great impact such as the fire incidents that had struck the Station Night Club in Rhode Island in 2003 that had cause a great stampede incidents at an egress due to the fire blockage of the other egress and also the religious school tragedy in Malaysia in 2017 that had killed 25 people that were found piling on top of each other at a corner of the room due to the blockage of the only egress of the space. Based on these incidents, the victims of the dreadful incidents were believe to be safe if there are another egress points that serve to accommodate the needs of the pedestrians of that panic situations. Hence, there are previous researches on the computerization of the structural architecture design for constructing a simulation to find the issues that had contributed towards the casualties [2, 10, 13]. These multidisciplinary researches were inspired by the occurrence situations to contribute towards the easiness of evacuation process during panic situation by structuring the spatial design based on the behaviour actions of the pedestrians.

Escaping from a spatial layout had caused a hustle to the pedestrians especially if the egresses available are not afforded to accommodate the needs of a large crowd. The subconscious actions of the pedestrians that are in hurry to get out of the space such as pushing and shoving in front of the egress points had caused the “faster-is-slower” effect [18-20]. The clogging region of the spatial layout can be visualized as per Figure 1(a). Based on Figure 1(a), the clogging region that was developed in front of the egress will serves the hourglass effect (Figure 1(b)) by continuously allowing the maximum number of pedestrians to pass by the egress. The pedestrians will keep on trying to push the other pedestrians in front for escaping the space that create a high physical contact and cause some serious injuries. The injuries will weaken the pedestrians and increase the anxiety that will increase the chances of stampede incident to be happened [2, 21]. Figure 1(c) shows the panic situation with clogging regions that can be represented as an hourglass effect.

![Figure 1](image1.png)

**Figure 1.** (a) The visualization of clogging region in front of egress
**Figure 1.** (b) The hourglass effect at the egress during evacuation that promotes the clogging region
**Figure 1.** (c) The clogging regions formation due to the hourglass effect; egress and narrow walkways

Note: The blue colour rectangles were the walls, the black colour rounds were the obstacles and the red colour rectangles were the egress.

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![Figure 2](image)

**Figure 2.** The column or any static obstacle will be able to control the evacuation process by dividing the clogging region formation and reduce the pressure force on the affected surface

However, the perturbation process for shaping the pedestrian movement is not able to fully solve the clogging region issue but able to assist the pedestrian to move out from the space in a manner order that will decrease the intense situation at the entrance’s bridge and avoid the physical injuries. The research finding by [20] had shown that the outflow at the clogging region will increase for 50% during the division process. This finding is supported by the mathematical formulation (Equation 1) on finding the pressure distribution to the surface area.

\[
\rho = \frac{F}{A}
\]

where the pressure, \( \rho \) is the amount of the force, \( F \) applied to the surface on contact, \( A \). The 50% overflow that was found by [20] was proven by the findings on the reduction of pressure that will cause the enlargement of contacted surface area due to the constant number of pedestrian which had derived as the constant number of force for every time step.

The clogging region also might be happened due to the arrangement of the materials in the spatial layout that serves the functional design purposes. The fancy and decorative materials such as furniture will serve the functionality of the space but also will become the obstacles for the pedestrians to move around the space. The obstacles’ placement will construct a pattern of movement directions based on the pedestrian movement behavior actions in the spatial layout. The interior arrangement will affect the pedestrian movement as the interior materials become the obstacles for the pedestrians on the layout. Based on the previous research, the arrangement of the furniture will be able to influence the pedestrian’s survival rate by shaping the movement pattern for the pedestrians [19, 24]. There are many issues that involving the interior arrangement such as the spacing issue for the walkways to accommodate the needs of the pedestrians. The walkways spacing was recommended \( \geq 1.2 \) meters (m) to meet the standard of interior design paradigm [25, 26]. The spacing issue of the interior materials with the egress points is also able to create a huge impact that act as the obstacles in front of the egress points and will cause great difficulties in evacuation process than serve as an immediate barrier that able to perturb the pedestrians’ movement flow. Figure 3(a) and Figure 3(b) show the recommendation of the materials (furniture and etc.) in a spatial layout for obliging the standard interior design to ease the movement of the pedestrian at the walkways and in front of the egresses (doorways) [25, 26].
Figure 3.(a) Standard spacing for the walkway between walls-walls and walls-obstacles
Figure 3.(b) Standard spacing in front of ingress/ egress between the walls-door-obstacles
Figure 3.(c) The coarse-grain obstacles’ arrangement
Figure 3.(d) The fine-grain obstacles’ arrangement

Hence, based on the standard recommendation on the spacing in the spatial layout in Figure 3(a) and Figure 3(b), it is noticeable that the number of materials (furniture and any materials that occupy space on the floor) also able to contribute towards the massive and complex movement shape of the pedestrians. The complex pedestrians’ movement pattern shows that there are many route changes that caused heavy difficulties in finding the right path to the nearest egress while avoiding any physical collision between the pedestrian-pedestrian and pedestrian-obstacle [23, 24]. Hence, the materials of a spatial layout must be minimized up to the functional needs and the implementation of the granularity scaling is highlighted by this research study for re-arranging the obstacles. The coarse-grain of obstacles (materials) arrangement will increase the functionality needs but might create a low chances for the pedestrians to get easily moving to the nearest egress point during panic situation due to less number of moving paths. While, the fine-grain obstacles might cause the lack of functionality purposes that sometimes may cause the reduction of the materials inside the spatial layout but increase the number of paths for the pedestrians to move to the nearest egress point. Figure 3(c) and Figure 3(d) shows the visualization of the coarse-grain obstacles’ arrangement and fine-grain obstacles’ arrangement.

Based on the features investigated in this research that had contribute towards the difficulties of pedestrians’ movement and promote the clogging region in the spatial layout, this research had selected a lecture hall at Universiti Sains Malaysia to be the structural target for justifying and analyzing the highlight features for contributing towards the crowd management issue especially for pedestrians evacuation process during panic situation.

3. Pedestrians Movement: Cellular Automata (CA) approach for reviving the entities elements

Cellular Automata (CA) is the microstructure’s modeling in representing the finite number of states within finite number of dimension. This discrete model will always change the state based on the defined relative of the elements by generating the new state of the microstructure at the neighboring cells. The new generation of the microstructure will always remain within the homogeneity composition that sometimes will be able to display a uniform pattern for representing the indication of the microstructure within the dimension with the asynchronous state influence from the neighboring cells occupied by the other independent microstructures. The coercion of the microstructure of the CA approach had been adapted by this research for representing movement of the selected entities within the simulation process for representing the near-realistic situation and human behavior actions; the pedestrian movement elements.

3.1. Cellular Automata (CA) based pedestrian movement: Behavior Actions

Pedestrian is the complex entity that has several of probabilities for the neighboring movement based on the various behavioral-based movements that made with the reactions of the pedestrian towards the surroundings. Hence, there are no defined relative of the elements (characteristics) of the movement. However, previous researches has shown that the pedestrian movement as a microstructure entity can
be represent with the interpretation of the CA-based approach for imitating the intelligence of the human’s decision-making especially in deciding the possible route for moving. Furthermore, during panic situation, the pedestrians will make a self-organizing approach for saving their lives during the evacuation process to reach the safe place. Hence, based on the previous findings, this individual management process will be able to adapt into the enforcement of microscopic movement approach.

Figure 4(a), Figure 4(b) and Figure 4(c) shows the pragmatic approach of this research to design the realistic pedestrian movement simulation.

![Figure 4(a)](image1.png)  
![Figure 4(b)](image2.png)  
![Figure 4(c)](image3.png)

**Figure 4.(a) Basic von Neumann movement direction approach**  
**Figure 4.(b) Moore Neighborhood movement direction approach**  
**Figure 4.(c) Transition probabilities of movement transition over a time step**

This approach will highlight the pedestrian’s situation in the 3x3 grid of spatial layout with the middle grid ((i,j) = (0,0)) will be current position of the pedestrian. The movement direction transition based on the von Neumann approach will serve the direction’s probability ((i,j) = (0,1),(0,-1),(1,0),(-1,0)) that shown in Figure 4(a). However, the realistic Moore Neighbourhood approach will be able to serve the more precise direction of the pedestrian movement ((i,j) = (-1,1),(-1,0),(-1,1),(0,1),(0,-1),(1,1)) based on the figure shown in Figure 4(b) that is based on the navigation direction approach shown in Figure 4(c) that appear to be more human-like decision making by highlighting the CA-based microstructure state model approach of the main object to inspect the neighboring cells with the possible characteristics and principles of choosing the next state destination as the new generation of the microstructure (refer Figure 4(c)). The characteristics of human actions will be adapted in the CA-based model approach:

- For every state (time step), a cell only can be occupied by a pedestrian.
- Every pedestrian will continuously moving for every time step based on the neighboring cells’ entities. The movement will be based on the human’s behavioral reaction characteristics.
- Every pedestrian will avoid any collision with the obstacles, fire, walls and other pedestrians.
- Every pedestrian always will find the nearest exit for evacuation process.
- The wall and obstacles will remain permanent at the spot throughout the simulation process.

**4. Experimental setup**

This research simulation will be constructed based on the lecture hall in Universiti Sains Malaysia as target structure of the closed area. To accommodate the CA-based approach on the pedestrians movement, the spatial layout was designed in a grid cells of 40x30 cells (not include the wall of the structure, based on the original blueprint) to represent the 432 square meters (s/m) of area. Figure 5(a) shows the layout grid of the space with the original number of chair (352 chairs) and the best case of having the full lecture students as the pedestrians (352 students). Based on Figure 5(a), the simulations were conducted based on the panic situations that accompanied by the basic setup of pedestrian movement speed during panic situation, 5.0 ms⁻¹ for every time step [18-20]. The experiment will be set based on the panic situation in the lecture hall to justify the features identified by the previous researches and analyze the correlation of the features for the great impact during the panic situation in the lecture hall towards the pedestrians (students) survival rate. The main highlight of this research will be based on the structural enhancement (external arrangement) and the internal enhancement or re-arrangement (internal arrangement) as shown in Figure 5(b) and Figure 5(c). Based on Figure 5(b), the doorways (E6 and E7) were added for analyzing the impact of the structural enhancement towards the pedestrian survival rate in the lecture hall while Figure 5(c) had shown the internal re-arrangement by enhancing the quality of the chairs placement to meet the standard requirement of the interior
design paradigm. A control simulation was made by simulating a panic situation in the lecture hall with the full number of students (352 pedestrians) without having any chair as an obstacle. Through this research, the time (seconds) taken by the 352 pedestrians to evacuate and leave the spatial layout will be recorded and the pedestrian’s flow rate for every doorways were collected for clogging region detection.

![Figure 5(a)](image1.png) The grid layout of lecture hall based on the original blueprint size

![Figure 5(b)](image2.png) The grid layout of lecture hall based on the structural enhancement

![Figure 5(c)](image3.png) The grid layout of lecture hall; the structural enhancement and internal arrangement

5. Result and analysis

The objectives of this research are to find the possible features that heavily impact the survival of the pedestrians which had faced the difficulties of the sudden movement during panic situation while justifying and analyzing the findings based on the targeted structural area, the lecture hall of Universiti Sains Malaysia. The suitable implementation approach was identified by using CA-based movement approach for re-enact the near-realistic pedestrians’ movement. Table 1 show the result of these experiments. Based on Table 1, there are a lot of enhancements and re-arrangements were implemented for analyzing the impact of features involving the functional factors and structural factors. The results of these experiments were controlled by the result of the simulation of original lecture hall that consist of 352 chairs and 352 pedestrians. The 352 pedestrians spent 57.22 seconds of time to evacuate from the lecture hall by using the 5 doorways that originally were built for ingress/egress.

Based on the result in Table 1, the doorway E5 had experienced the major clogging region compares to the other doorways followed by doorway E4. Comparing the E4 and E5 doorways to the E1 and E2 doorways, the E4 and E5 doorways flow rate is not proportional to the other E1 and E2 doorways. Through the observations, this research had found out that the arrangement of the chairs in the lecture hall had controlled the movement direction of the pedestrians and the narrow pathways also had caused a great effect. The lack of other doorways near to the clustered of chairs also had contributed towards the difficulties of the pedestrians evacuation process. Hence, based on these findings, this research had pursued the other experiments on the enhancement and the re-arrangement of the functional and structural design of the lecture hall. The functional and structural arrangements were made based on the features for reducing the clogging region that had been discussed in the previous researches. The simulation were made based on; 1) No chairs (obstacles) in the layout, 2) Reduce the back chair to accommodate the standard walkways’ width to 1.2 m based on the interior design paradigm, 3) Reduce the back chairs and add more chairs at the front for accommodating the number of students to attend a lecture, 4) Re-arrange the chairs to meet the fine-grain arrangement to increase the probability of direction selection, 5) Re-arrange the chair for fine-grain arrangement and reduce the back chairs for the standard walkways width at the back of the lecture hall, 6) Fine-grain
arrangement of chairs, reduce the back chairs and add the front chairs to allow more pedestrians (students) to be seated in the lecture hall.

Table 1. The results on the pedestrian simulation in the lecturer hall for functional factors and structural factors

| Simulation Condition | Number of Pedest. | Number of Chair | Time (s) | E1    | E2    | E3    | E4    | E5    | E6    | E7    |
|----------------------|-------------------|----------------|---------|-------|-------|-------|-------|-------|-------|-------|
| Original lecture hall| 352               | 352            | 57.22   | 0.175 | 0.367 | 1.783 | 1.223 | 2.604 | -     | -     |
| **Funct. Factors**   |                   |                |         |       |       |       |       |       |       |       |
| No chairs            | 352               | -              | 37.43   | 0.508 | 0.721 | 2.137 | 1.924 | 4.114 | -     | -     |
| Reduce back chairs   | 340               | 340            | 57.21   | 0.175 | 0.367 | 1.765 | 1.224 | 2.412 | -     | -     |
| Reduce back chairs, add front chairs | 352 | 352 | 57.20 | 0.280 | 0.472 | 1.766 | 1.224 | 2.413 | -     | -     |
| Fine-grain chairs’ arrangement | 320 | 320 | 48.07 | 0.395 | 0.582 | 1.519 | 1.248 | 2.912 | -     | -     |
| Reduce back chairs, fine-grain chairs’ arrangement | 300 | 300 | 48.04 | 0.396 | 0.583 | 1.520 | 1.249 | 2.498 | -     | -     |
| Reduce back chairs, add front chairs, fine-grain chairs’ arrangement | 320 | 320 | 47.67 | 0.503 | 0.692 | 1.531 | 1.259 | 2.727 | -     | -     |
| **Struct. Factors**  |                   |                |         |       |       |       |       |       |       |       |
| Original lecture hall, add doorways | 352 | 352 | 50.20 | 0.200 | 0.418 | 1.673 | 1.275 | 1.653 | 1.155 | 0.637 |
| No chairs            | 352               | -              | 32.91   | 0.577 | 0.790 | 2.097 | 1.884 | 1.762 | 1.793 | 1.793 |
| Reduce back chairs   | 340               | 340            | 49.20   | 0.203 | 0.427 | 1.748 | 1.301 | 1.586 | 1.057 | 0.590 |
| Reduce back chairs, add front chairs | 352 | 352 | 49.16 | 0.325 | 0.549 | 1.749 | 1.302 | 1.587 | 1.058 | 0.590 |
| Fine-grain chairs’ arrangement | 320 | 320 | 47.18 | 0.403 | 0.593 | 1.526 | 1.102 | 1.251 | 1.102 | 0.805 |
| Reduce back chairs, fine-grain chairs’ arrangement | 300 | 300 | 47.16 | 0.403 | 0.594 | 1.527 | 1.103 | 0.954 | 0.997 | 0.785 |
| Reduce back chairs, add front chairs, fine-grain chairs’ arrangement | 320 | 320 | 46.17 | 0.520 | 0.715 | 1.538 | 1.126 | 1.191 | 1.040 | 0.801 |

Based on the overall result, the addition of the doorways really had given a great impact on the smoothness of the pedestrian movement during evacuation. With the addition of two doorways (E6 and E7), the time taken had been reduced 0.07% with the normal doorways addition and 0.08% with the aid of chairs’ re-arrangement. Hence, based on the result obtained for structural factors in Table 1, the structural enhancements really give a good solution to reduce the clogging region. However, the addition of doorways or any enhancement on the structure of the building is a real hustle when involving the re-construction of the existing building. The simulation of the adequate structural design is important especially during the development and architectural planning process before the actual structure being built. For the existence structure, such as this research target spatial layout, the university’s lecture hall, the functional factors really play a great role on accommodating the students.
while ensuring them to easily moving out from the hall especially during panic situation. Based on Table 1, the reduction and re-arrangement of the chair based on the granularity really affect the number of chairs in the lecture hall. This re-arrangement will reduce the number of the students that are allowed to attend the running lecture in the hall. The reduction chairs at the back of the lecture hall and the additional of chairs to design the walkways up to the interior design standard had shown a good result of maintaining the number of pedestrians, however becomes one of the arrangements that caused the longer time for the pedestrian to evacuate compared to other arrangement. Due to the time constraint, the shortest time need for evacuation was by reducing the chairs at the back and adding at the front while re-arrange the chairs based on the fine-grain design with the number of 320 pedestrians. Based on the overall of Table 1, the re-arrangement based on the granularity fine-grain had shown a good result and reduce the impact of clogging region in the spatial layout. The re-arrangement that had cause the obstacles such as chairs to be scattered around is actually able to assist the pedestrians to create more probability on the movement directions and create more routes for the pedestrians to move on.

6. Conclusion
Panic situation may cause extreme reactions of the pedestrians to save their lives while trying to avoid any physical collision that might harmful. During this situation, there are a lot of factors that had contributed towards the casualties of the pedestrians and also may cause serious injuries. This research has investigated the main reason of the pedestrians' casualties during panic situation. Based on the previous research, main contributor was the clogging region effect that had occurred. The clogging region can be occurred in the spatial layout due to lack of adequate obstacles arrangement and also the inappropriate structural design. Throughout this research, the features that are able to cause the clogging region had been implemented and analyzed. The result had shown that the re-construction of the structural design have a great impact to reduce the clogging region compared to the functional arrangement. However, for the existing building, the re-arrangement of the obstacles had come in handy for assisting the pedestrian to evacuate in a short time. Hence, the granularity approach on the obstacles arrangement for the fine-grain’s chair arrangement in the lecture hall had reduce up to 0.1% (about 10 seconds) of the evacuation time. Even though the number of chairs had decreased, the safety of pedestrians (students) had increase.

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