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OPTIMIZATION AND ARTIFICIAL INTELLIGENCE TECHNIQUE FOR EVACUATION PREPAREDNESS IN HIGH RISE BUILDINGS

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Abstract

The critical tasks during evacuation process is how to find the right ways in order to escape from the danger place to a safe place. In process of finding the right ways, most of the evacuees are panicked. Subsequently, make the process more difficult. With that occurrence, the main objectives of this research study are to identify the suitable shortest path algorithm for evacuation in high rise building, and then design and develop an evacuation route via shortest path algorithm in order to obtain an exit route to evacuate by using Optimization and Artificial Intelligence Technique. The objectives that involved are to help the evacuees to find the best routes during evacuation process. Six phases of methods are raised to accomplish the objectives by utilizing the Dijkstra and Ant Colony Optimization Algorithm. The first step is started from the original building layout. Then transform the layout into 2D layout plan. After that, import the matrix data to generate graph theory. Next step is utilizing the both approaches to achieve the shortest path. The preliminary result has shown positive result which can deliver the shortest path to help evacuees.

Index Terms—Ant Colony Optimization, Dijkstra's Algorithm, Evacuation, Shortest Path

1. Introduction

Evacuation is a process of moving people from danger place to safe place during an emergency. Unexpected event occurs such as natural disaster may cause an emergency situation which brings damage and losses. Though, evacuation planning needs to be prepare to maximize the evacuation effectiveness [1] and also minimize the property losses [2].

The main problems in evacuation process are the difficulties to find the right route in order to escape towards safe place [3] and the behaviour of evacuees during the evacuation especially in indoor place such as high rise building [4]. Moreover, the building itself become more complex with the high population density [5] effect the time of evacuation [6].

An evacuation planning is needed to carry out, in order to improve the efficiency of evacuation process. During emergency situation, evacuees mostly panicked hard to make a decision to find the best path to escape especially the evacuation take place in the closed building. Moreover, the building tend to be complex in structure and design subsequently effect the process of finding the best path and trigger various behaviour of evacuees during the critical situation [7]. Planning the evacuation is important requirement to evacuate people safely when emergency occurs [8] and the planning can ensure the evacuation process done quickly and carefully [9].

A good evacuation management is able to catch the attention of evacuees in guiding them toward exit route quickly and help them make a good decision. Hence, this research design and develop the evacuation preparedness model via shortest path algorithm and Artificial Intelligence Technique on exit route selection to evacuate.

This research is expecting to produce independent evacuation preparedness algorithm for exit route and also guide evacuees escape safely from the building. The evacuee especially those who are unfamiliar with the building can find the best path by following the guide provided and make the evacuation process more efficient by reducing the evacuation distance and time with the improvement of evacuees' behaviour.

The contribution of this research study are guide evacuees to find the best path easy and smooth in a safest way and in consequences reduce the fatalities and injuries of evacuees during the evacuation.

2. Research Methodology

This research methodology utilise Dijkstra's Algorithm and Ant Colony Optimization in finding the best path in the evacuation process in a high rise building.

Dijkstra's Algorithm efficient in generating the shortest path for selection of route and claim to be the best techniques in solving the simple shortest path problem by providing the shortest path from any evacuation node [10] [11]. This algorithm also able to provide safe evacuation plan [12] [13] [14] and solve single sources shortest path problem in a graph search algorithm [15] [16] to find the shortest distance between a node and all other nodes and suit the target of Dijkstra's Algorithm target
[17] [18].

The other technique is Ant Colony Optimization (ACO) Algorithm which is the Artificial Intelligence technique. This algorithm is proved to be the alternative for Dijkstra's Algorithm in solving the problem of finding the shortest path. The ACO algorithm is represents the way of real ants optimize their route while searching for a food. Ants are able to find the shortest pathways from their nest to food place by exchanging information among them via pheromones [19]. Based on the presence and concentration of pheromones, the ants guide their direction and tend to move to high concentration of pheromones to find the optimal path while looking the food [20]. In adapting the ants with the evacuation process, the food is representing the exit node while the ant nest represents the current location of the evacuees.

This implementation of Dijkstra's Algorithm and Ant Colony Optimization involves 6 steps as shown in figure below (Fig 1. Implementation of Dijkstra's Algorithm and Ant Colony Optimization Steps)

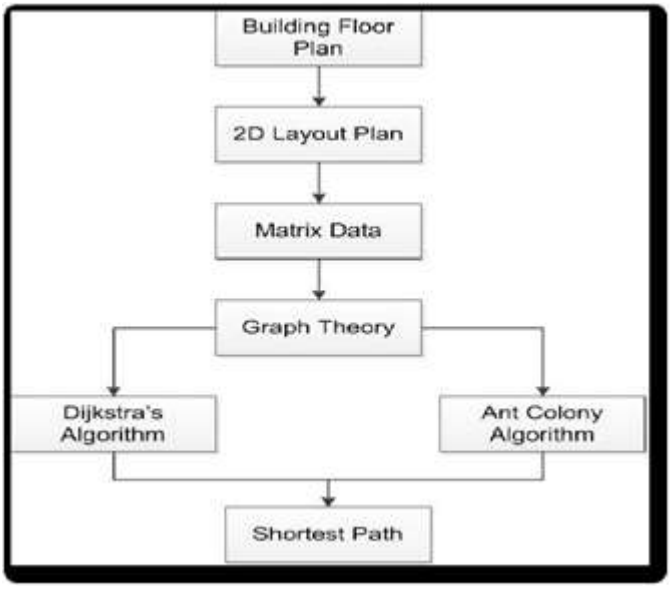

Fig 1. Implementation of Dijkstra's Algorithm and Ant Colony Optimization Steps

Fig 1. The first step is derived from building floor layout. Then convert into 2D floor layout in order to design the evacuation preparedness model by setting up each door in the floor as a node. The distance from each node are also obtain from the 2D layout plan and are collected into a matrix table as a matrix data format to generate the graph theory. Finally, utilize the two selected algorithm.

3. Result and Discussion

Simulation program using MATLAB has been built to find the shortest path using Dijkstra's Algorithm and Ant Colony Optimization. Dijkstra's Algorithm calculate the shortest path using the given distance based on the real building layout, the total distance is from the source node to destination node [21]. Meanwhile, the Ant Colony Optimization obtains the shortest path from the coordinate of each node in the building layout. From the coordinate of node, the ACO calculate the total distance which is the shortest. The result are compared and proved to be the same, it is means that ACO algorithm can be the alternative technique of Dijkstra's Algorithm in finding the shortest path for evacuation.

According to the 2D layout plan Fig 2 below, there are a few nodes for door and staircase. Through the simulation model, the shortest path is obtained between nodes 38 to 47.

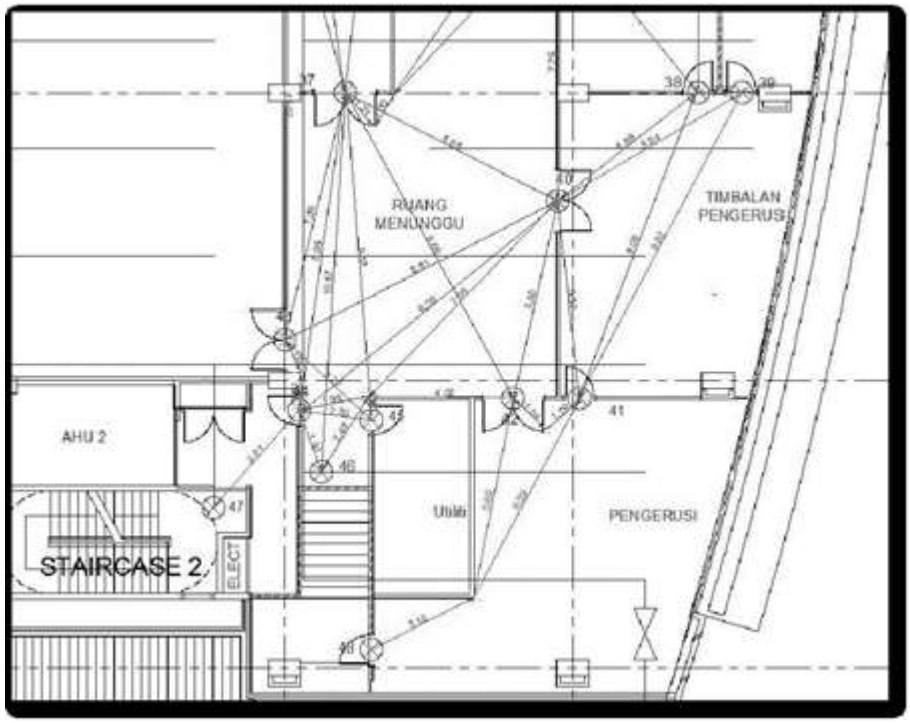

Fig 2 2D Layout Plan with nodes and path between nodes along with distance.

The first calculation is based on Dijkstra's Algorithm (DA), the starting step is to collect the number of nodes in the 2D layout plan above into the matrix table. The matrix table as shown in Table 1 consist of the node and the weight or the distance between the connected nodes.

Table 1 Matrix Table

	38	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**
38	0	0	4.86	9.09	0	0	0	0	0	0
39	1.22	0	5.94	9.62	0	0	0	0	0	0
40	4.86	0	0	5.52	5.65	8.51	9.26	0	0	0
41	9.09	0	5.52	0	2.53	0	0	0	0	0
42	0	0	5.65	2.53	0	0	6.01	0	0	0
43	0	0	8.51	0	0	0	2.07	0	0	0
44	0	0	9.26	0	6.01	2.07	0	0	0	3.61
45	0	0	8.55	0	5.01	3.27	2.03	0	0	0
46	0	0	0	0	0	0	1.83	0	0	0
47	0	0	0	0	0	0	0	0	0	0

Based on this matrix table, the calculation is done by the Dijkstra's Algorithm to obtain the shortest path between the nodes 38 to 47. However, before the calculation is performed the matrix table are read as sparse format and the node are renamed start from one in ascending order. The sparse format is in Table 2 as follow.

Table 2 sparse format

Node	Distance
(2,1)	1.2200
(3,1)	4.8600
(4,1)	9.0900
(1,3)	4.8600
(2,3)	5.9400
(4,3)	5.5200
(5,3)	5.6500

Node	Distance
(5,4)	2.5300
(3,5)	5.6500
(4,5)	2.5300
(7,5)	6.0100
(8,5)	5.0100
(3,6)	8.5100
(7,6)	2.0700

(6,3)	8.5100
(7,3)	9.2600
(8,3)	8.5500
(1,4)	9.0900
(2,4)	9.6200
(3,4)	5.5200

(8,6)	3.2700
(3,7)	9.2600
(5,7)	6.0100
(6,7)	2.0700
(8,7)	2.0300
(9,7)	1.8300
(7,10)	3.6100

There are 10 nodes and 27 edges created based on the data imported. The calculated shortest path is between the nodes 1 to node 10 in the simulation model as the nodes are renamed. (as shown in Table 3)

Table 3 Rename node DA

2D Layout Plan	DA
38	1
39	2
40	3
41	4
42	5
43	6

44	7
45	8
46	9
47	10

The result obtain by DA is shown in the graph (as shown in Fig 3)

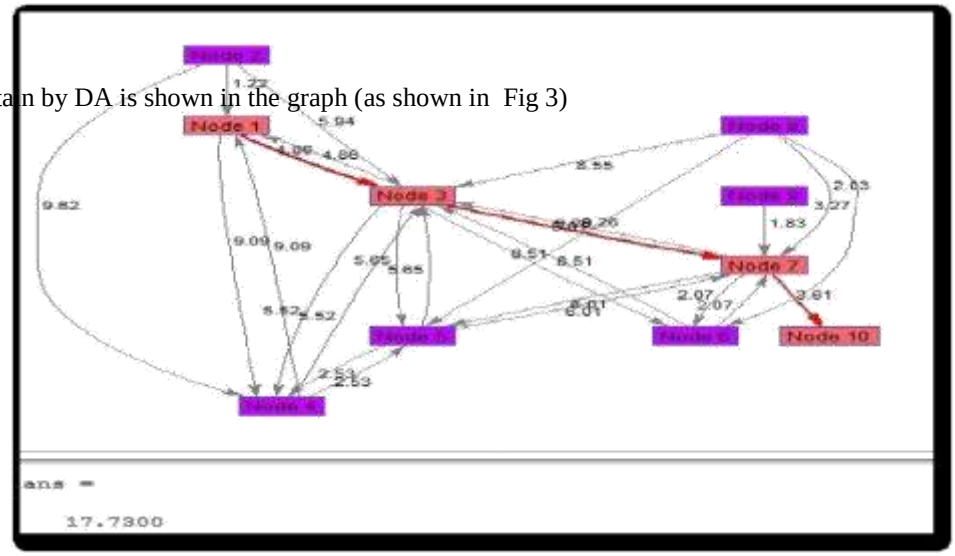

Fig 3 Result DA in graph theory

The path taken is through node 1> 3> 7> 10 with total distance is 17.73 meter. This result is compared with the result of the other technique which is Artificial Intelligence technique, Ant Colony Optimization (ACO). The result of shortest path using ACO can be referred in Fig 4 below.

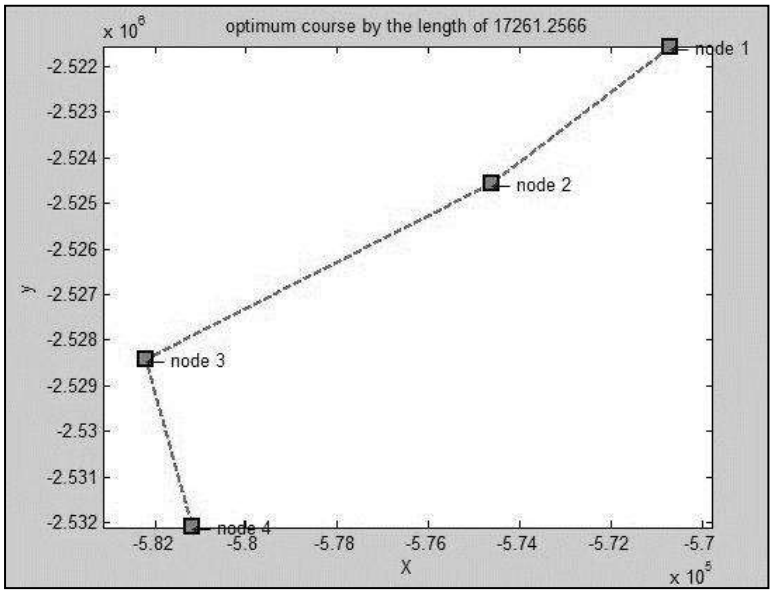

Fig 4 Result of Ant Colony Optimization

The result shows that the total distance is 17.26 in meter. The difference is due to the way of calculation between DA and ACO. ACO use coordinate of the node to calculate the shortest path based on the 2D layout plan (Fig 2). Furthermore, the node are also different as the ACO rename the node into new node (Table 4)

Table 4. Rename node ACO

2D Layout Plan	DA	ACO
38	1	1
40	3	2
44	7	3
47	10	4

The total of shortest distance and the direction of path are same with the result of Dijkstra's algorithm. The differences of the number of nodes can be summarized in the Table 4. From the result that has been obtain, we can prove that Ant Colony Optimization can be the alternative substitute of Dijkstra's Algorithm in finding the shortest path.

4. Conclusion

In this paper, finding the shortest path using Dijkstra's Algorithm and Ant Colony Optimization Algorithm were discussed by using evacuation preparedness simulation model via MATLAB program. To obtain the result, six steps of method had been applied. The first step is converting original building layout into 2D layout plan, second is designing the 2D layout plan of building followed collecting the matrix data to generate graph theory. Then, calculate the shortest path using the two selected techniques which is Dijkstra's Algorithm and Ant Colony Optimization Algorithm. For future improvements is to obtain the safest path using Ant Colony Optimization.

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