# Optimization of A Mobile Robot Path for Obstacle Avoidance Based on Genetic Algorithm

Mohd Zarifitri Kasim Hawari[1], Nur Ilyana Anwar Apandi[1*]

[1]Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka (UTeM), Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

[*]Corresponding author's email: ilyana@utem.edu.my

**ABSTRACT:** A fifth-generation mobile robot is a new type of industrial application that uses an unmanned system. This study focuses on developing a real-time industrial robot system that can work seamlessly with humans. Moreover, there is still some obstacle to cope with the better optimization solution for manufacturing 5G robot. This paper proposed a latency network algorithm for the manufacturing of mobile robots in industry 4.0. The process of the robot path in a complex workspace is proposed, considering the node's collision-free constraint in the moving phase of a robot. An improved genetic algorithm (GA) by restructuring the genes is applied to optimize a mobile robot path. The proposed algorithm is validated on simulations and proven to work effectively in different environments for different percentages of each experiment conduct.

**Keywords:** *Manufacturing Mobile Robot, Industry 4.0, Genetic Algorithm, Path Planning*

## 1. INTRODUCTION

Robotic path planning is a hot topic in robotics these days, particularly in robot navigation, which involves determining a collision-free and optimal path for a mobile robot from beginning to end [1]. The proposed Genetic Algorithm (GA) for path planning effectively optimizes the local and global planners of a robot navigation system [2]. A good algorithm known as the crossover operator in the GA has been implemented to increase the algorithm speed and accuracy [3]. A population comprises the entire set of chromosomes andis estimated based on the fitness function [4-5].

Firstly, to visualise mobile robot environments, a 2D grid-based map is constructed in this study. Next, the GA is applied to the constructed model. The proposed GA is the improvised from paper [2] that uses GA to rearrange the genes for the new population by testing three different environments: irregular, maze and narrow winding environment. The GA was made according to the improvement factors mentioned above in this study. Finally, this paper will analyse the performance and average time of the manufacturing 5G mobile robot based on the percentages differences of obstacles set. Moreover, each set has six additional coordination consist of its existing obstruction.

## 2. METHODOLOGY

Ordered numbered grids define the entire workspace, and the number of grids defines how many cells exist. Cells are defined by $H$, or $H \in [1: h]$, where a total number of cells, $h = 20$. Every cell is either considered to be empty or occupied. Obstacles $O_h$ represents the total percentages of the obstacles implying that the cells occupied are off-limits for travel. Those obstacles are taken from the factory environment. The obstacles boundary is established by their exact boundary plus minimum safety distance. In practice, consideration of a mobile robot's size is 'one while 'moving. Figure 1 shows the flowchart of the GA implemented for path planning.

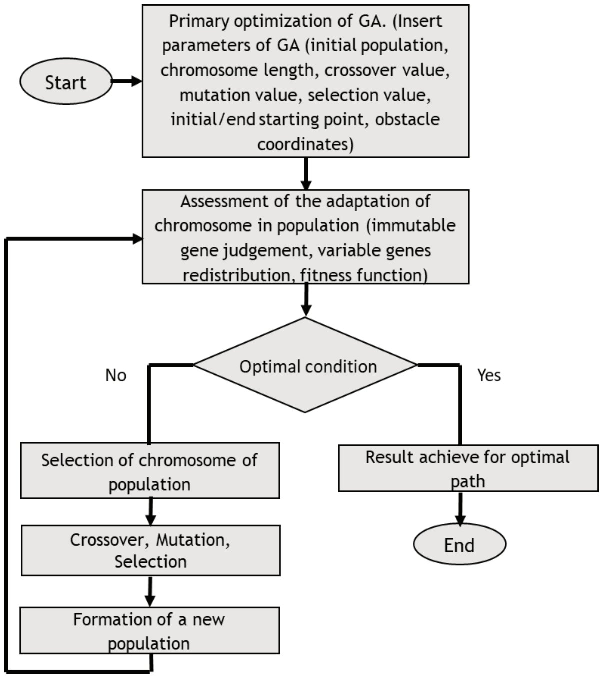


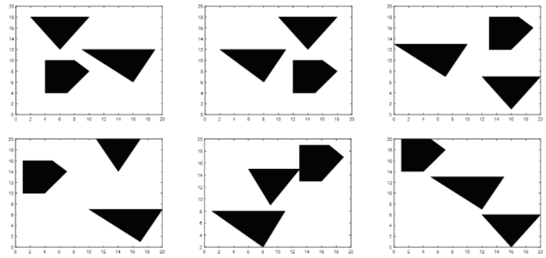

Figure 1 Flow chart of GA for mobile robot planning task

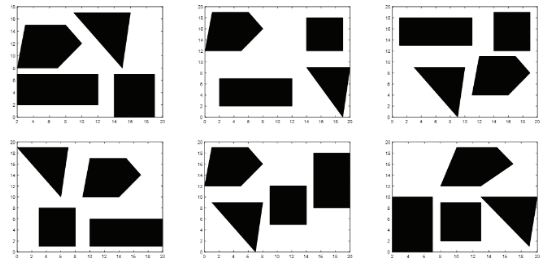
## 3. RESULTS AND DISCUSSION

A simulation was carried out in one environment with various obstacles environment. The shaded part of the initial configuration is made up of a coordination framework and an obstacle field. Table 1 shows the setting parameters of improved GA with obstacles implemented. The values are set considering the actual environment of the industry path. This study conducts three experiments which are using three different obstacles percentages. We proposed six environments for each experiment. For each experiment, the environment is provided with a possible value of obstacle coordination which means the obstacle is semi-dynamic for experiments 1, 2 and 3. We randomly move the position of the obstacle with the aid of the obstacle number provided. Figure 2 shows the six possible environments of the obstacles for each experiment; a. 50% obstacle; b 70% obstacle; c. 90% obstacle.

Table 1. GA parameters setting

| Parameters | Proposed Values |
|---|---|
| Population Size, $\boldsymbol{N_p}$ | 100 |
| Number of Genes | 50 |
| Maximum Number of Generation | 100 |
| Selection Rate, $\boldsymbol{P_s}$ | 0 |
| Crossover Rate, $\boldsymbol{P_c}$ | 0.6 |
| Mutation Rate, $\boldsymbol{P_m}$ | 0.01 |


a. 50%


b. 70%

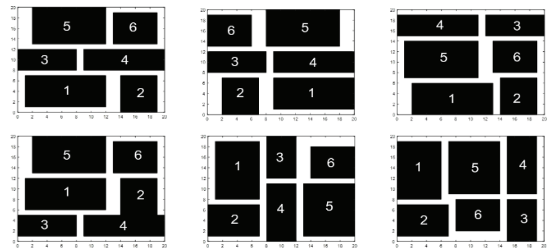
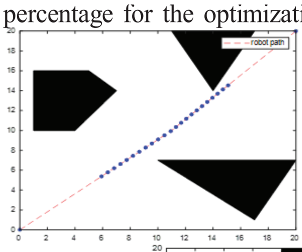
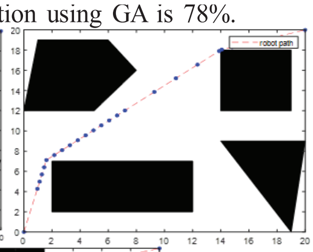

c. 90%

Figure 2 Proposed experiment for the various obstacles

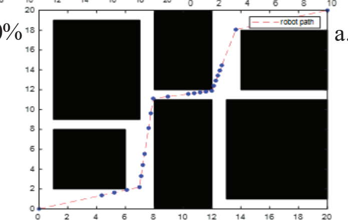
The mobile robot starting position point is at (0,0), and the destination point is at (20,20). The minimum robot path length is shown in Table 2. The robot path represents by the red dashed line in Figure 3, while the blue dots are the coordination's fitness value to avoid the obstacle with GA operation involvement. This shows that GA will optimize the path where the mobile robot is near the obstacle and make sure the path is smooth and shorter for the mobile robot to reach its destination. As we know, the more complex the environment in the area, the longer time for the robot to get through the semi-dynamic obstacle. Thus, the complexity of the environment affects the time it takes for the robot to get through a semi-dynamic obstacle. This study shows that the path planning for mobile robots is consistent when the obstacle is 50% and the overall percentage for the optimization using GA is 78%.



a. 50%



a. 70%



c. 90%

Figure 3 Mobile robot path with various percentages of obstacle

Table 2 Mobile Robot Path Length

| Percentage of Obstacle (%) | 0 | 50 | 70 | 90 |
|---|---|---|---|---|
| Minimum Path Length (m) | 28.30 | 28.32 | 29.91 | 35.33 |

## 4. CONCLUSION

In this paper, obstacle avoidance based on GA is proposed to optimize the mobile robot's path or route. Furthermore, according to the optimal path planning with different percentages of obstacles covered without collision, this improved GA is optimized to reduce the path length after optimization.


## ACKNOWLEDGEMENTS

This work was funded by the Ministry of Higher Education Malaysia under Fundamental Research Grant Scheme (FRGS/2018/FKE-CERIA/F00355) and supported by the Universiti Teknikal Malaysia Melaka.


## REFERENCES


[1] J. Ni,W.Wu, J. Shen, and X. Fan, "An improved VFF approach for robot path planning in unknown and dynamic environments," Mathematical Problems in Engineering, , Jan. 2014.

[2] M. Li, C. Wang, Z. Chen, X. Lu, M. Wu, and P. Hou, "Path planning of mobile robot based on genetic algorithm and gene rearrangement," 2017 Chinese Automation Congress (CAC), Oct. 2017.

[3] Y. Wang, H. Zhou, and Y. Wang, “Mobile robot dynamic path planning based on improved genetic algorithm,” Wireless Communications and Mobile Computing, Aug. 2017.

[4] X. Gong, D. Plets, E. Tanghe, T. De Pessemier, L. Martens, and W. Joseph, "An efficient genetic algorithm for large-scale transmit power control of dense and robust wireless networks in harsh industrial environments," Applied Soft Computing, vol. 65, pp. 243–259, Apr. 2018.

[5] L. M. Schmitt, “Theory of genetic algorithms,” Theoretical Computer Science, vol. 259, no. 1-2, pp. 1–61, May 2001.