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Path Optimization for Mobile Robot Using Genetic Algorithm

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Abstract – *This study presents the concept of using the Genetic Algorithm approach to resolve the mobile robot path planning problem in a static environment with predictable terrain. We present our initial Idea for using genetic algorithms to assist a controllable mobile robot to hunt out an optimal path between a starting and ending point in an exceedingly grid environment. The two problems that occur in an exceedingly very mobile robot's path planning are finding the shortest path and a collision-free path. These should be achieved during a static environment of obstacles. This work is different from other works within the aspect of stationing the obstacles and running the genetic algorithm with user input iterations. This work ensures that the goal position is the global minimum path of the total potential. During this work, anytime the obstacles keep changing the positions. This work is finished in an environment that's modeled in space-time and collision-free path by a variation of the Genetic algorithm. A genetic algorithm is capable of competing with every other learning algorithm in terms of accuracy and high performance. Because the number of iterations keeps on increasing, the algorithm draws the shortest and collision-free path. When the obstacles, the initial and destination points, so the number of iterations are set the ultimate word result that's the shortest and collision-free path is acquired.*

***Key Words*: Path Planning, Genetic Algorithm, Mobile Robot, Static Environment, Optimization.**

1. INTRODUCTION

Robots are being introduced into practically every sector throughout the planet to attain error-free and optimum results. Every one of the challenges preventing mankind from deploying robots for transportation services is their mobility and navigation, robots, unlike humans, are unable to form optimal path planning without training. This research paper intends to work out the most effective thanks to solving the problem of path navigation.

The goal of robot path planning is to find a path that has a reasonable chance of leading from a starting point to a destination point without colliding with any obstacles. However, this navigation challenge has multiple tough phases that have to be overcome, like obstacle avoidance, location identification, and so on. A reliable and efficient navigation system must be ready to identify the robot's present location, avoid collisions, and determine a path to the destination. As a result, the mobile robot navigation problem could be a complicated challenge, and several other sorts of research are performed, yielding a considerable number of solutions[1][2]. Efficiency, safety, and accuracy are three important considerations when it involves robot navigation challenges. The algorithm's efficiency is regarded as crucial because of one of the primary considerations in locating the destination in a short period. As a result, avoiding superfluous steps or being stuck in local minimum positions by the robot should lead to an honest course.

A perfect approach should also avoid all known barriers. Another key aspect of the algorithm is its safety. Once the optimal collision-free path has been identified, the robot must follow the pre-defined path precisely. The key scope of the path-finding problem is anxious expeditiously and safety considerations. Lots of efforts are made to beat these two critical difficulties[3].

Various conventional methods, like cell decomposition, road maps, and potential fields, are developed to unravel the trail planning problem[4][5]. The bulk of those solutions was built around the concept of spatial arrangement[5]. These approaches demonstrate an absence of adaptation and robustness. To handle the shortcomings of those approaches, researchers investigated a spread of alternatives. For complex and ill-behaved optimization problems, Genetic Algorithms are considered one of the most robust methods available [6].

A Genetic Algorithm could be a prominent approach that seeks the optimum solution from a group of alternatives. Consider through points as genes in an exceeding chromosome, which will provide a variety of various possibilities on a grid map of pathways. During this situation, the trail distances created by each chromosome are considered a fitness measure for that chromosome. An answer path may cross an obstruction in some instances. If the obstruction is formed sort of a rectangle, such random solutions are easily removed by putting in place a straightforward equation between the road formed by two through points and therefore the obstacle. To address the problem of determining robot path planning in a static environment with predictable topography and known obstacles, this paper used the Genetic Algorithm. We presented a simplified fitness function that creates use of the trail length. The proposed study examined the evolutionary process's performance with varying numbers of obstacles at various positions on the terrain. A preliminary test suggests that the proposed method is effective and efficient in dealing with a wide range of tasks in static environments.

2. LITERATURE REVIEW

Table -1: A literature review of the references

S. No	AUTHOR & YEAR	TECHNIQUES/ METHODS	RESULTS	FUTURE SCOPE
1	C. Alexopoulos & P.M. Griffin 1992[7]	V* graph algorithm, E* graph Algorithm	Used two algorithms for mobile robot path planning. In the presence of stationary obstacles, we can compute the shortest time collision-free path for mobile robots.	
2	Margrit Betke& Leonid Gurvits 1997[8]	Navigation of landmarks, map algorithms, localization of mobile robots, robotics, triangulation.	In terms of landmarks, the algorithm is linear. It gives a position estimation that is very close to how the robot is actually positioned. However, there are errors in some of the lengths.	
3	S.S. Ge & Y.J. Cui 2000[4]	GNRON problem, New repulsive potential function, a potential field.	They used the GNRON algorithm in order to ensure the robot would not collide with the goal during its journey using the topic of mobile robot path planning to determine the distance between the robot and the goal.	
4	Yonrong Hu & Simon X. Yang 2004[9]	Genetic algorithm	The genetic algorithm used here uses grids and coordinates to represent the environment when planning a path for a mobile robot. In addition to providing good solutions from infeasible solutions, a genetic algorithm is developed with the use of an efficient method.	when domain knowledge is used in the genetic algorithm, a more viable solution will be given for the initial population of the future study. This is more desirable in the future.
5	Ismail AL-Taharwa, Alaa Shetha & Mohammed Al-Weshah2008[10]	Path planning, genetic algorithm, robotics.	In the case of a mobile robot working in a static environment, the paper describes using a genetic algorithm for path planning and also exposed the performance of evolutionary processes with different sizes of population and different types of tasks in the static environment.	
6	Michael Brand & Xiao-Hua Yu2013[1]	Glow warm swarm optimization, robot path planning, Firefly algorithm.	In both static and dynamic robot parks, firefly algorithm approaches are employed to determine the shortest path in the two-dimensional workspace without colliding with other objects.	The parameters of this algorithm may be further explored in future works, including the minimum number of fireflies needed for real-time implementation.

7	Nadia Adnan Shiltagh & Lana Dalawr Jalal 2013[3]	Global path planning, mobile robots with intelligence, genetic algorithms with modification, optimal path.	Through the application of the Modified Genetic Algorithm (MGA), a path planning algorithm for mobile robots is explored in this study.	
8	Rajat Kumar Panda & B.B. Choudhury 2015[6]	Mobile robot, path planning, Genetic Algorithm	Throughout the paper, we will examine the design of a battery-operated mobile robot and its path planning.	
9	Xuewu Wang, Lika Xue,Yixin Yan & Xing sheng Gu 2017[5]	An ant colony algorithm used in welding robots, co-operative traveling, particle swarm optimization algorithm	In this optimization problem, finding the shortest path length is the objective, while avoiding obstacles is the constraint. After optimization, the shortest collision-free path was obtained. The global welding collision-free path-planning was optimized using the particle swarm optimization algorithm.	
10	ChaymaaLamini, Said Benhlim & Ali Elbekri 2018[11]	Genetic algorithm, path planning, crossover operator, navigation, mobile robot.	This article proposes a fitness function for the genetic algorithm, which minimizes the number of turns required in reaching the goal, which will help optimize the energy consumption of the robot.	
11	HyeokSoo Lee & JongpilJeong 2021[2]	Warehouse environment, Reinforcement learning, mobile robot path- optimization.	This reviewed the use of reinforcement learning as a path optimization technique in a warehouse environment. By avoiding inventory pads, they were able to find the optimal path to the target position.	

Figure -1: Validation of inputs

3. RESEARCH METHODOLOGY

These procedures were taken into consideration when using Genetic Algorithms to resolve the trial planning challenge. These are:

- First, create a grid graph within the search environment(Figure 3). As a result, the robot will travel during a step pattern on the proposed grid, as it would in the real world.

- Second, we want to reset the obstacles within the environment (The obstacles we modify vary from time to time).

Then we would like to specify the starting and ending point for the trail to be drawn by using the parameters start x, start y, end x, end y(start x, start y indicates the place to begin and end x, end y indicates ending point)(Figure 4). The iteration values should be specified only in numbers/digits format. The obstacles are set then comes the initial point and goal point setting. Finally, the iterations and number of runs are set. The setpoints are validated(Figure1). The robot performs the function of finding the path to the goal within the grid environment by employing a genetic algorithm. As a result, after the evaluation draws the best path planning collision-free.

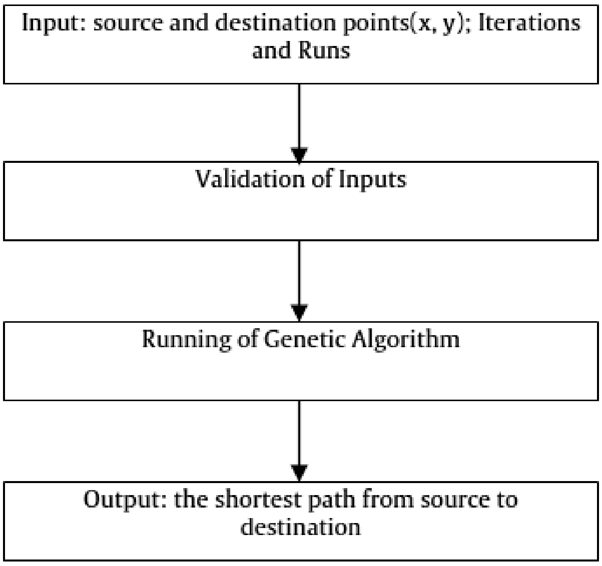

Figure -2: Flowchart for the proposed methodologies

3.1. Genetic algorithm

For a mobile robot, the paper uses a Genetic Algorithm for a global path that guides it to this goal. Using a genetic algorithm, the robot can learn the most effective path to follow in a particular environment. An environment can be a two-dimensional workspace where the target is located, and obstacles must be avoided if the best path is to be found.

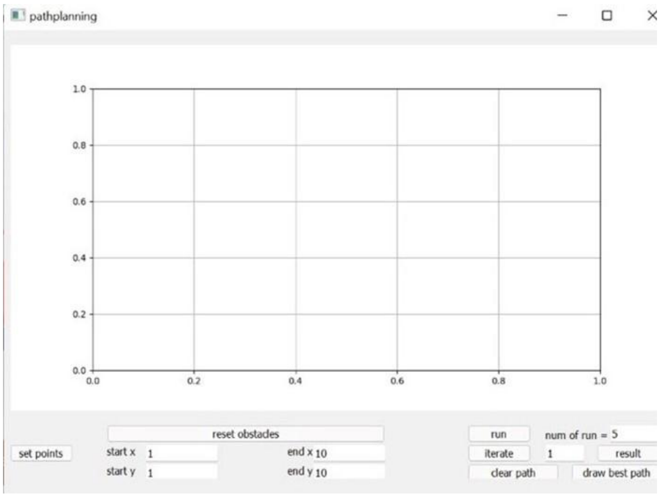

Figure -3: Map for path planning

Generic algorithms maintain a pool of candidates, and the binary strings used to encode each candidate solution are called chromosomes. It has been determined that binary coding is the most effective method. Using the fitness evaluation function, a group of chromosomes is analyzed and ranked as a population. It is crucial to the success of GAs for fitness evaluation to provide information on how good each candidate is. It is common to generate the initial population randomly. Fitness evaluation, selection, and reproduction are the three steps of evolution from one generation to the next

3.2. Path planning

The purpose of mobile robot path planning is to go looking out a path that connects this and target positions. The path should be as short as possible, the smoothness of the path should match the mobile robot's dynamics, and the path should be secure from collisions.

4. RESULTS AND DISCUSSIONS

Created a grid graph within the search environment(Figure 3). As a result, the robot will travel during a step pattern on the proposed grid, even as it might in the real world. In the aspect of stationing the obstacles and running the genetic algorithm with user input iterations, this work is made differently where static obstacles are stationed but reset obstacles(Figure 4) will change the positions of the obstacles. Assures that the goal position is the globally minimum path towards the full potential. During this work, anytime the obstacles keep changing the positions.

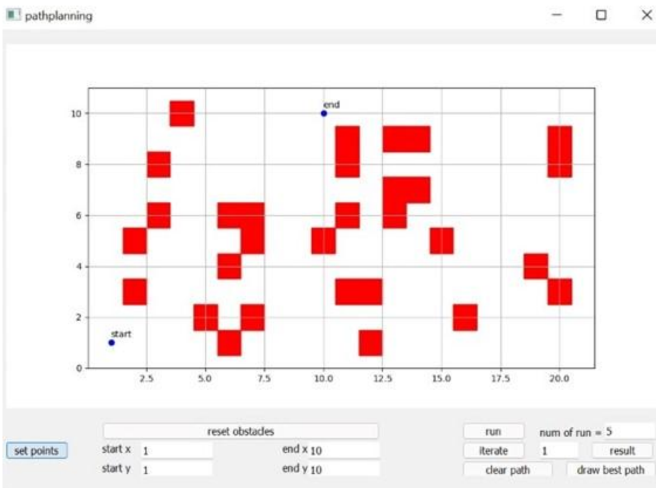

Figure -4: Setting source, obstacles, and destination points

To evaluate the system performance many tests were dispensed by varying the GA's parameters. The simplest performance was achieved with the subsequent parameters starting at (x, y) -> (1,1), ending at (x, y) -> (20, 10)(Figure6), the total number of runs was 1 and the total no of iterations was 500 and (x, y) -> (1,1), ending at (x, y) -> (10, 10)(Figure5), the total number of runs was 5 and the total no of iterations was 500. Overall, the simplest path was not to guide the robot in several ways, starting at different initial locations & with distinct goal points. To induce the most effective shortest path and therefore the collision-free path the iterations should be more. Figure 5 and Figure 6 are two cases. Figure 5 is a scenario where the goal point is among the obstacles and therefore the path drawn between the actual points. Secondly, Figure 6 is a scenario where the goal point is after the ending of obstacles i.e., the place to begin the x-axis, y-axis, and ending point of the x-axis, y-axis, and therefore the path drawn between these points. As may be verified by Figure 5 and Figure 6, the robot tends to maneuver towards the placement of the goal, traveling consistently with a minimum distance direction between the starting and also arrival positions.

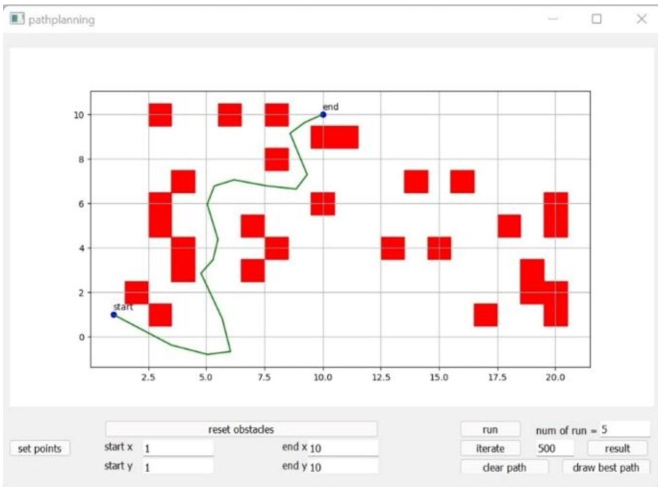

Figure -5: Path planning for scenario 1

Figure -6: Path planning for scenario 2

5. CONCLUSION

The results obtained showed that the utilization of the Genetic Algorithm for the mobile robot produced extremely smooth path planning. The robot usually travels and successfully finds the varied goal points from distinct starting points and environments and at the identical time avoids obstacles. Because the number of iterations increases, the robot will take you to the shortest distance, by reducing the number of turns in its path to realizing the goal. The results prove that the proposed Genetic algorithm method finds the optimal path. The typical no of run values and also the common iteration numbers of the proposed method are more optimal compared to other methods. To induce accurate results while setting the points on the x-axis and y-axis true during this work is handled in such the simplest way that non-numerical characters cannot be taken as input if do that the system warns the user saying that this can't be given as an input to line initial and goal points, This handling of non-numerical characters is additionally through with other input values. The algorithm during this work doesn't use information about the motion of the mobile robot: the history of position estimates, the commands that make the robot move, and also the uncertainties in these commands. The Genetic Algorithms complexity is O(g(nm + nm + n)) with g the number of generations, n the population size(obstacles), and m the scale of the mutants(possible ways). Hence, the complexity of the genetic algorithm in this work is on the order of O(gnm)). Future research can undergo the performance of Genetic algorithms in a dynamic environment. Another future direction is to test the effectiveness of Genetic Algorithms with physical robots during a real-world application. This work has limitations, where the points given are static and obstacles, are generated randomly by the program so in future scope we are able to manually or use a cursor to pick the points and shapes of the obstacles on the map.

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