APPLICATION OF ROBOTIC PATH PLANNING FOR FIREFIGHTING ROBOTS

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ABSTRACT

Path planning is one of the challenging topics of robotics. The problem is to obtain path from source to destination of an autonomous mobile robot in a moving space with dynamic obstacles. The mobile robot has to reach the target position by avoiding collision with obstacles by finding optimum collision free path from source to destination point. Meta-heuristics designates a computational method that optimizes a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. Various meta-heuristic techniques are Ant Colony Optimization, Genetic Algorithm etc. In this paper Genetic Algorithm is utilized for solving Path Planning Problem in dynamic environment. Here also the concept of Multiple Robot is generated and various application areas for the algorithm are discussed. The application area chosen here out of those areas is Fire Fighting robots. Simulation is done using MATLAB.

I. GENETIC ALGORITHM

A genetic algorithm is a search technique that is used to find an approximate or exact solution of optimization problems [1]. Genetic Algorithms are a particular class of evolutionary Algorithm that are inspired by Evolutionary biology like mutation, crossover, selection etc. The genetic algorithm has 3 main steps: natural selection, crossover, and mutation. Natural Selection: At each generation or iteration the chromosomes are updated using their fitness value. If a chromosome has more fitness value than other chromosome than that chromosome win the competition and has the higher probability to appear in the next generation. Crossover: It is defined as the exchange of bits between the parents (chromosome) to generate new offspring. A group of chromosomes usually undergoes crossover at each generation. It is controlled by P_c crossover rate. It is for diversity in the population. Mutation: It is defined as the random change of one or more bits in each chromosome. It is controlled by P_m mutation rate.

II. PROBLEM DESCRIPTION

Suppose we have a moving space for robot of 200X200. The left bottom corner is the source while the right top corner is destination. Inside the moving space there are 20 randomly generated variable size rectangular obstacles therefore the position of obstacles is not known to the robot.The goal is to determine a shortest path from source to destination by avoiding obstacles in the optimal time.

III. PROPOSED SOLUTION

3.1 Where The Algorithm Is Utilized:

Initially the robot started from source and follows the minimal path from source towards the destination which is the minimum path which is found by calculating the slope. While moving on the path if an obstacle arises in between then robot takes 3 steps back and then use genetic algorithm [2]to determine the next path.

3.2 Algorithm:

1. Generate a population of 20 points (chromosomes) randomly near the current position. Each chromosome is represented by (x, y).
2. Calculate the fitness value of each chromosome by applying fitness function. Before applying the fitness function chromosomes are checked for not to come inside the obstacle.
3. Fitness function used here is to calculate the distance of the chromosomes to the destination. For the chromosome that comes inside the obstacle this distance is given a very large value. So that these points are not feasible for selection.

   $$dist(i) = \sqrt{(x_i - x_2)^2 + (y_i - y_2)^2}$$
4. Among these candidate chromosomes the chromosome having fitness value less than the distance of the collision point and the destination are feasible candidates.
5. Among these chromosomes the one having minimum value is selected as best solution for current iteration.
6. After that crossover and mutation are applied to the current population to generate a new population for next iteration.In GA Mutation is controlled by a parameter pm called the mutation probability. For Mutation this parameter pm is set to a value. For every chromosome in the population a random number is generated if it is less than the pm than mutation is applied to it. Like mutation crossover is also controlled by a parameter pc called crossover probability. For Crossover another parameter pc is set to a value. Here again a random number is generated for every chromosome if it is greater than pc than crossover is applied.
7. Steps 2 to 6 are repeated till the maximum number of iterations reached. The chromosome having the minimum value among all the solutions of various iterations is the solution of the algorithm.

Robot proceeds toward the destination point using this solution and if any other obstacle arise in between then this process is repeated again.

IV. STEP BY STEP IMPLEMENTATION OF ALGORITHM

Step1. Robot move one step ahead

Firstly problem space is generated and robot starts moving. Until robot collides with an obstacle it takes one step ahead by calculating the theta value and updating the coordinates for next step.

Step3. Collision with obstacle

If on taking next step robot collide with an obstacle it take three steps back and then apply Genetic Algorithm there. Here the three backward steps are denoted by red dots.

Step 4. Genetic Algorithm

Here a population of 20 random chromosomes (points) is generated near the current position. Then the fitness value of each chromosome is calculated. Fitness value here is the distance of chromosome from the destination. For the points that come inside the obstacle this distance is set to a very large value. Here in this diagram the

population of chromosomes is represented by blue dots and then among these chromosomes the fittest one is denoted by green dot.

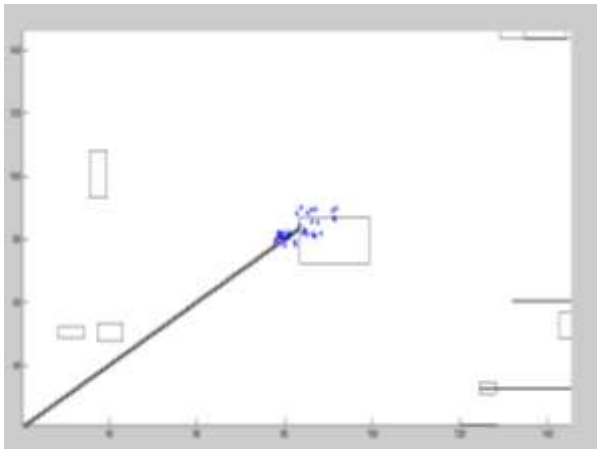

Figure 1 Robot Follow Directional Path Until Collide With An Obstacle

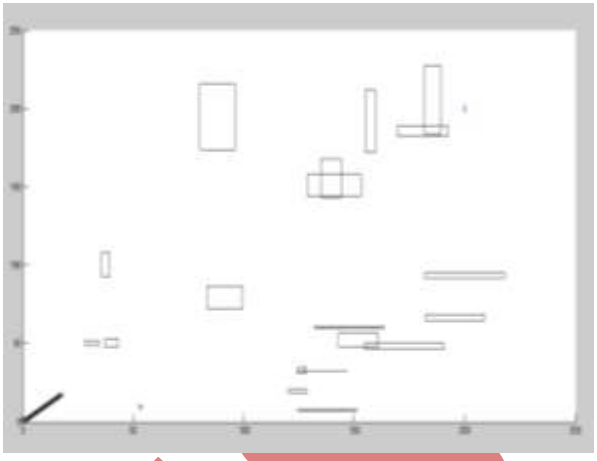

Figure 2 Robot Take Three Steps Back

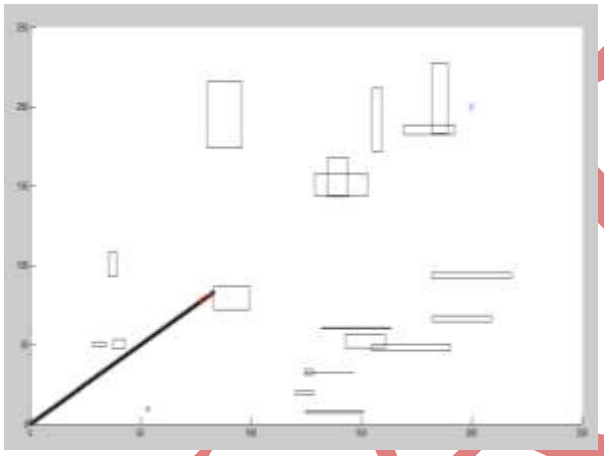

Figure 3 Robot Get New Point Then The Robot Move Forward By Following This Fittest

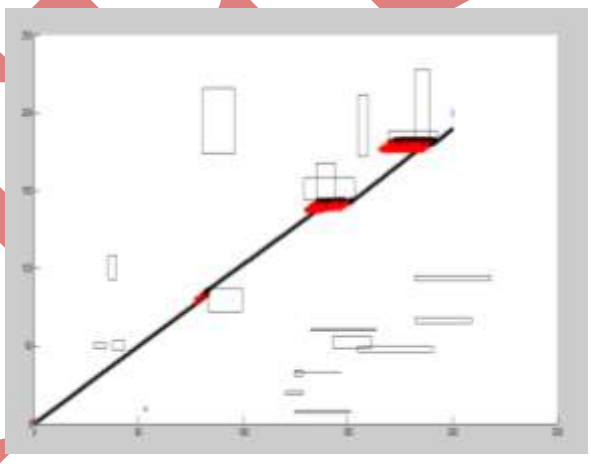

Figure 4 Output Of Applying Complete Genetic Chromosome Algorithm

V. APPLICATION OF PROPOSED ALGORITHM (MULTI ROBOT CONCEPT)

As technology improves the need of mobile robots increases in various application areas [3]. These areas include brain surgery, mountain climbing, firefighting[4], industrial use etc. Robots can explore environments that are harmful to humans like volcanoes or deepness of ocean. In manufacturing industries like car industries robotic arms are used to perform multiple tasks that comprise car manufacturing process. Tasks include welding, cutting, lifting, sorting and bending etc. In military airborne robot drones are used for surveillance in today's modern army. In future automated aircrafts and vehicles couldbe used to carry fuel or clear minefields. In agriculture also automated harvesters are generated to cut and gather crops. Path planning for a number of Applications can be performed by using this algorithm. Various Application Areas include Brain surgery, Firefighting, Gaming, Mountain Climbing Robots, Military problems for reaching a target etc. Here the application Area chosen is Firefighting robots for this a Problem space is to be created. Which consist of source position of robot and a destination position where the fire alarm is rang due to fire. The robot has to move from source to destination to extinguish the fire and to avoid the obstacles in between them. A new problem space is

generated which consist of circular and rectangular shaped obstacles.An Application of above algorithm is made for firefighting robot. A new concept of multiple robots is applied using the same genetic algorithm. Here the destination is the fire prone area. And there are 3 sources from where 3 three robots move towards the fire prone area. When the fire is on at the destination a fire alarm rings. After that the three firefighting robots move towards that place by avoiding the obstacles in between.

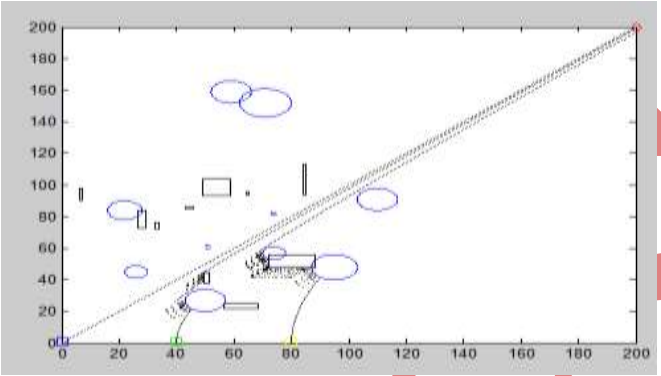

Figure 6multiple Robot Concept For Application In Firefighting.

Table 1 Cpu Time(Sec) Calculated For Multiple Robots.

Parameters	Values
No_iterations	10
Time taken by robot 1	11.9
Time taken by robot 2	16.6
Time taken by robot 3	16.9

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