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Mobile Robot Path Planning by Genetic Algorithm with Safety Parameter

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Abstract:
In the field of robotics, path planning is the key task and to find out shortest possible and collision free path. The project is intended to obtain safe near-optimal path for single and multiple mobile robots in static global environment. The computational mobile robot path planning is done by Genetic algorithm with enhanced fitness function. The fitness function considered safety along with collision free and shortest path. Results obtained for different safety parameter coefficients are compared. It is observed that increase in safety achieves in expense of extra path length. In any application safety is major and prime factor to be considered; in this paper safety parameter is used and shows the effect of safety parameter on optimality and path length.

Keywords: Genetic Algorithm, Mobile robot, Optimization, Path planning, Single Robot.

I. INTRODUCTION

Global mobile robot path planning is trending issue in field of robotics, as the automation is need of future. Robot path planning has application in wide variety areas such as hazards places, manufacturing, material handling etc. A mobile robot must be able to find out optimal or near optimal collision free path to move from one point to another point. The best path is defined to be the path with low cost. Path planning is technique to find a path for mobile object which should be collision free and economical i.e. shortest path. There are several methods to obtain optimal path, these are categorized in two, and first traditional method includes potential field methods [2] and global visibility graph algorithm [3]. Second intelligent planning methods include fuzzy neural networks [4, 5]; ant colony algorithms (ACO) [6], genetic algorithms [7], improved genetic algorithm (IGA) [1], ABC Algorithm [16], Hybrid of GA & PSO [17], improved ABC Algorithm [18]and particles warm optimization algorithms [8]. Each method has its own pros and cons; there is not any method which is perfect, compared different approaches for path panning [15]. Genetic Algorithms (GA) have been established effective for optimization problems. Traditional Genetic algorithm has drawbacks of slow convergence degree, local optimum. This issue is considered while program writing. The main outcome of this paper are first GA with enhanced fitness function to consider different safety requirement, second compared analysis of near optimal and safe-optimal results for single and multiple mobile robot path planning.

II. GENETIC ALGORITHM

The genetic algorithm (GA) is a technique for optimization problems that is based on natural selection. The GA continually modifies a population of individual solutions to get optimized result. At each level, the GA selects individuals at random from the existing population to be parents and uses them to generate the new population for the next generation. Over sequential generations, the population develops toward an optimal solution. Genetic algorithm flow chart shown in,[Figure 1].This is predefined sequence of steps to be followed to solve optimization problems which start with population initialization followed by population selection, crossover, mutation, new population formation, check feasibility by fitness function, check for termination rule, if limiting condition achieved stop the algorithm or repeat the steps again for next iteration till maximum number of generations. GA operators in algorithm are explained in below subsections with an example.

A. INITIAL POPULATION

When GA starts with initial population of paths, created randomly to find an optimal path, the. Each path has the same number of nodes; the number of the node is relative to the problem. If path is consists of n nodes, these points will constitute n-1 line segments, in which the first node represents the source point of the path, and the last node is the destination.

B. SELECTION

This rule selects the individuals, called parents that contribute to the population at the next generation. This chooses parents for the next generation based on their potential from the fitness function. Roulette wheel selection method is used, in which the probability of selecting an individual is proportional to the potential by fitness function.

C. CROSSOVER:

This rule let the parents to associate to form children for the next generation. Conventional crossover methods include two-point crossover and one-point crossover. Andre Neubauer [9] has presented that two-point crossover is better to one-point crossover, so two-point crossover is used in this project. An example of crossover is [Figure 2]

D. MUTATION

This Rule changes individual parents to form children. By slight changes in the population individuals, to creates mutation children. Mutation increases genetic variety and enable the GA to cover a wider space. An example of Mutation is shown in Figure 3.

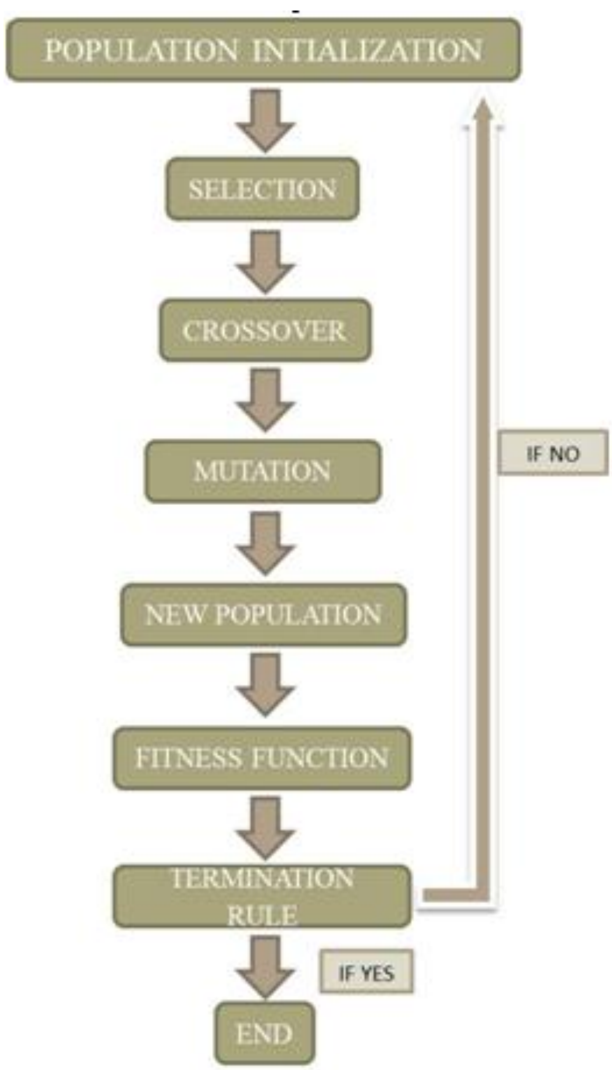


Figure. 1. Genetic algorithm flow diagram

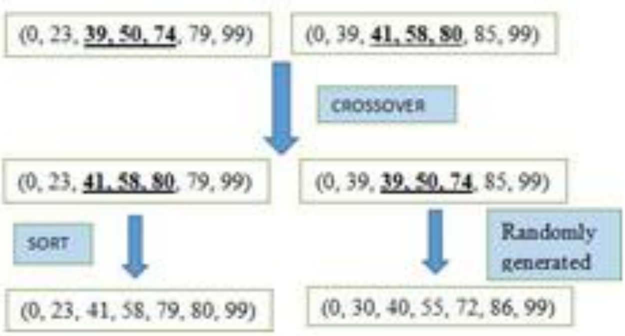


Figure.2. Example of crossover

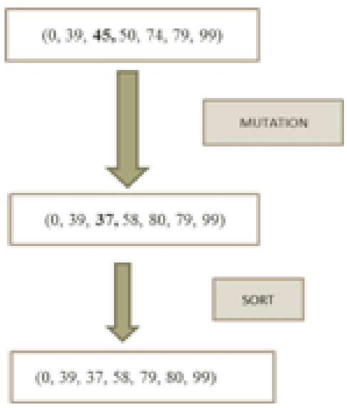


Figure.3. Example of mutation

E. ENVIRONMENT MODELING

A grid-base illustrations is used for the environment work space of robot motion in this paper. There are several static obstacles located in the environment, along with some premises. Assumptions made while modeling the problem are listed as following:

1. 2-Dworkspace, robot's motion is in plane, where obstacle search a factorized by their absolute coordinates and the height of obstacles are ignored.
2. The specific location soft he static obstacle are known.
3. Robot considered as point-sized and occupies only one grid at ataman the size of obstacles scaled according to reflect real environment.
4. Robot(s) stats at time zero from source point with a constant speed.

MATLAB software (version - R2010a) is used for computation of mathematical model.

F. FITNESS FUNCTION

The value of the fitness function should be disproportionate to the endurance ability of the individual. There are two parameters to be considered for a feasible robot path that are path length and safety.

Path length (*l*) is calculated by the eq (1), where n is number of node in path, x_i is X co-ordinate of i^{th} cell and y_i=Y co-ordinate of i^{th} cell.

$$l = \sum_{i=1}^{n-1} \sqrt{(x_{i+1} - x_i)^2 - (y_{i+1} - y_i)^2} \qquad (1)$$

Safety parameter (sp) is calculated by eq (2), where $s(l_i)$ is shortest distance between i^{th} line segment and obstacle.

$$sp = \sum_{i=1}^{n-1} s(l_i) \qquad (2)$$

Objective is to minimize Fitness function (Pathcost) equation number (3), where 'Pathcost' is Total cost for the path, c and d are weight age constant of path length and safety parameter. 'A' is Path segment length outside the obstacles, 'B' is path segment length inside the obstacles and 'P' is high value constant to avoid selection of path containing 'B'.

$$\text{PathCost} = c(A + B * P) + \frac{d}{sp} \qquad (3)$$

Penalty 'P' = 100000, to avoid 'B' in the solution. If present in the solution that's mean path is through the obstacle that is infeasible path.

G. CONVERGENCE RULE

There are two conditions to terminate the algorithm, first is Avg change >= 0.1. And second is maximum number of generations.

H. PARAMETERS

Following parameters are considered while solving the problem:

Number of generation (max) = 50
Population size =50 to 80
Number of solutions = 2 to 8
Penalty P= 100000

III. RESULT

The project consist two parts to demonstrate the result obtained by enhanced fitness function. The first part is simulation for single mobile robot path planning by genetic algorithm with enhanced fitness function and compared with results obtained for different safety coefficient. Second part deals with multiple mobile robots using enhanced fitness function. Simulations are carried out in different square map of size 500 × 500 which reflects the real environment or workspace. The level of complexity is increases in the maps as number of obstacles increased and inter-distance decreased. The obstacles are in black colour and free space is white in colour, where robot is free to move. Robot initiate from the source point denoted as ‘S’ and travel along the path obtained by the algorithm, to destination denoted as ‘D’.

A. SINGLE MOBILE ROBOT PATH PLANNING

Path planning for single robot is done for two situations or map. The mobile robot is initially located at the source point(S) and has to reach destination (D). S and D are defined at initial stage of algorithm, tabled[Table 1]**.** Following the algorithm, path obtained, generation by generation improves but after certain number of generation, for further generations doesn’t improve. That’s why maximum generation is tailored to 30.

Table .1 .Single robot Source and destination

Environment	**Source**	**Destination**
Simple map	410,250	10,100
Complex map	400,250	50,250

Figure 4 and Figure 5 show the obtained optimal path in simple and complex maps for two different set of safety parameters coefficients. For both the maps, later cases with higher coefficient than that for earlier give safe paths with longer path length than earlier one as tabled [Table 2]. Figure4(c) and Figure5(c) show the plot for the fitness function verses generations for simple and complex map respectively. Which shows decreasing trend as objective to minimize fitness function.

Table.2. Single robot Path length for near-optimal and safe-optimal cases

Map	Path length (dimensionless*map size)	
	Near optimal case	Safe optimal case
Simple map	605	703
complex map	743	898

B. MULTIPLE ROBOT PATH PLANNING

In this case there are three mobile robot initially located at source points (S_1, S_2 and S_3) and has to reach destinations (D_1, D_2 and D_3) respectively. There must be no collision between two robots while traveling in the path. A parameter set to avoid collision, based on path length. Source and destination are defined at initial stage of algorithm, tabled [Table 3] Generation by generation paths improve and obtain near optimal paths.

Table .3. Multi Robot Sources and destinations

Robots	**Source**	**Destination**
Robot 1	450,50	50,450
Robot 2	50,50	150,450
Robot 3	50,250	490,200

Figure 6 show the obtained multi robot optimal paths for two different set of safety parameters coefficients. For later case with higher safety coefficient than that for earlier gives safe paths with longer path length than earlier one as tabled [Table4]

Table. 4. Multi robot Path length for near-optimal and safe-optimal cases

Robot	Path length (dimensionless*map size)	
	Near optimal case	Safe optimal case
Robot 1	759	785
Robot 2	495	542
Robot 3	828	930

Figure 6(C) shows the plot for the fitness function verses generations for multi robots. Which shows decreasing trend as objective to minimize fitness function.

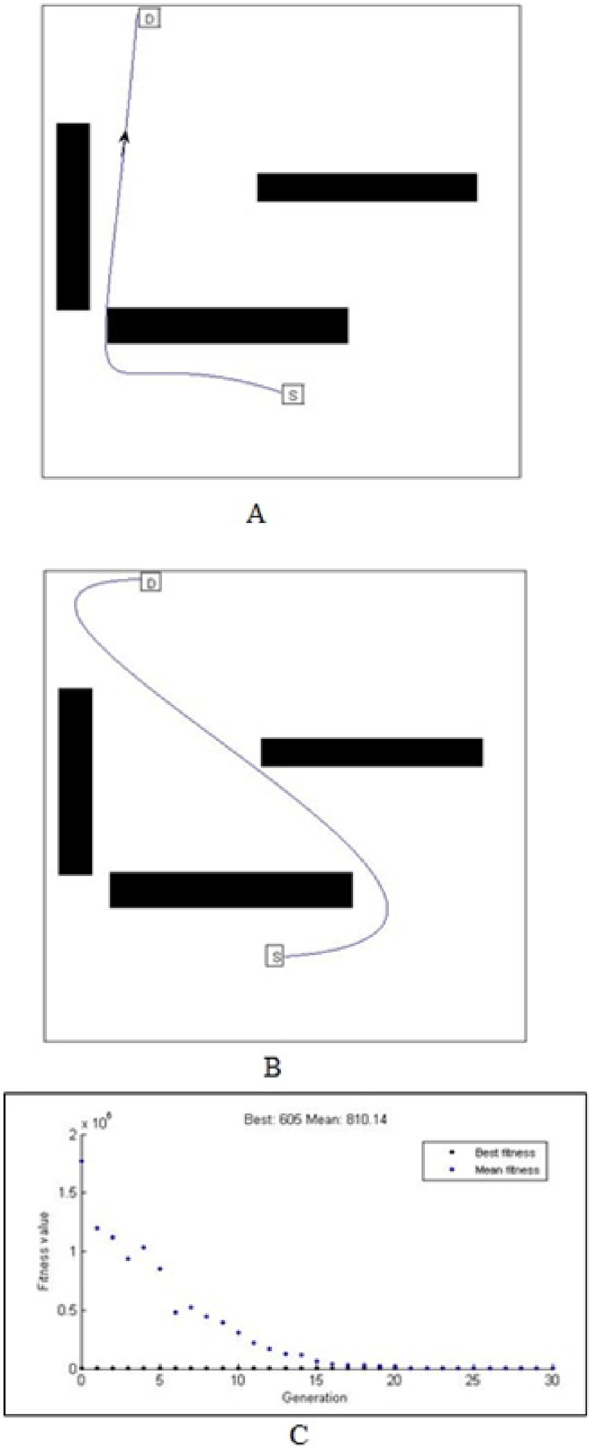
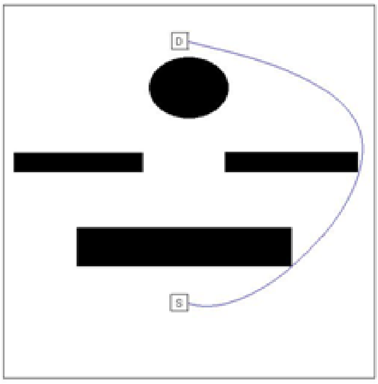
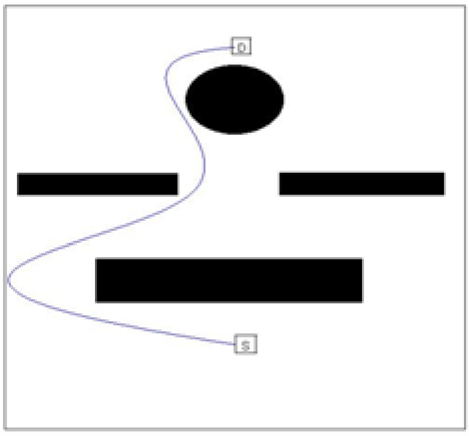


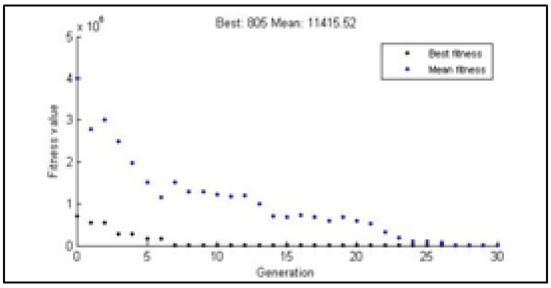
Figure.4. Simple map path planning, (a-near-optimal, b-safe-optimal,c- fitness function)



A

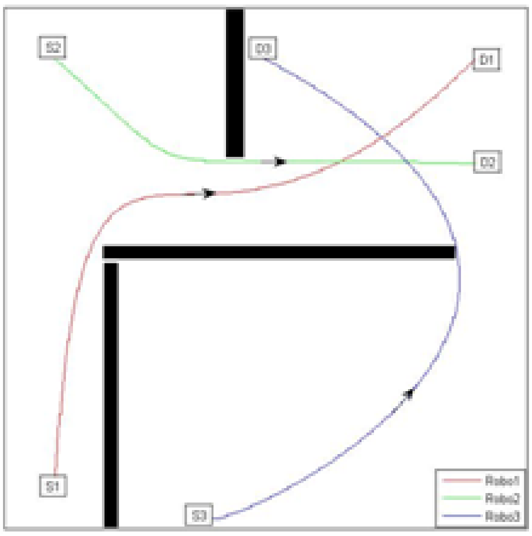


B

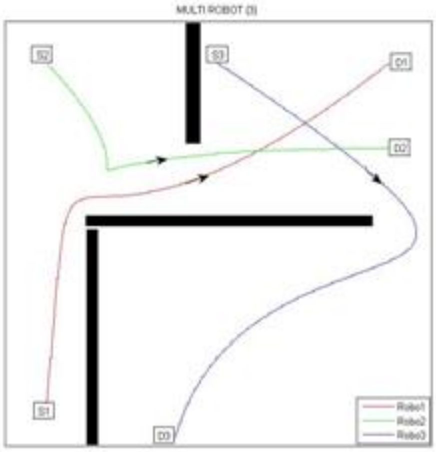


C

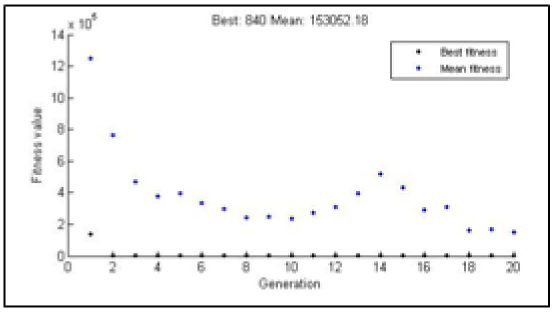
Figure.5. Simple map path planning (a-near-optimal, b-safe-optimal, c- fitness function)



A



B



C

Figure.6. Multiple robot path planning, (a-near-optimal, b-safe-optimal, c- fitness function)

IV. CONCLUSTION

Computational study of Path planning using Genetic Algorithm (GA) is done, and it is capable for finding optimal path without collision. Algorithm is efficiently to guide the mobile robot(s) travelling from the source to destination safely and smoothly with a near-optimal path. Generated optimal result is economical as fitness function included cost of the path with safety and smoothness parameters in consideration. Safe path(s) obtained in expense of extra length of path in addition to optimal path. The mobile robot(s) path planning has been done successfully using Genetic algorithm. It is proven based on the discussed result, the optimum paths produced by the algorithm can move a robot from source to destination without collide with obstacles.

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