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Approximation Algorithm Approach for Mobile Robot Path Planning

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Abstract—*Navigation plays the principal role when the mobile robot moves in the real world. The real working environment of the mobile robot is unpredictable. So, it is crucial to design a robust algorithm that can handle sudden changes within the environment. This paper incorporates Artificial Bee Colony (ABC) algorithm as a navigation algorithm for mobile robot. The results are compared with Genetic Algorithm (GA), a well-established algorithm for path planning. Results shows that ABC algorithm gives better result than the GA in terms of path length and processing time.*

1. INTRODUCTION

A mobile robot can travel from a pre-defined to unknown or known target location without colliding with any obstacle that arrives. Many algorithms are designed/ modified to perform the task. In the real world, not all obstacles are rigid and considering this knowledge can enable a robot to accomplish navigation tasks. The path planning problem has traditionally received considerable attention in the past and has been well-studied. Path planning is one of the fundamental problems in robotics, and the ability to plan collision-free paths is a precondition for numerous applications of autonomous robots. However it has focused on the problem of planning paths in static environments and with rigid barriers.

Mahjoubi et al. [1] proposed an approach to solve the path planning with dynamic obstacles using evolutionary algorithm (genetic algorithm) where they represented the obstacles in shape of polygon which in turn increased processing speed. Saffari and Mahjoob [2], proposed an approach of, how initial path is commence by a simple rule and then used artificial bee colony algorithm to optimize the initial path. This method is very effective when used in real environments. Wang et al. [3] considered the working environment as set of vertices which leads to decrease in computation time and memory usage. The alternate use of artificial bee colony algorithm for the calculation of paths in a multi-robot environment was proposed by Preetha [4]. A local scheme has been created for assimilate the algorithm of all the robots in the Universe, as per the actual position. As the small robots will have less spacing paths with minimum obstacles. Lei et al. [5] proposed modified genetic algorithm to find feasible paths. As per Ji and Shu [6] applied the improved artificial bee colony algorithm for pronouncing the path for free-flying space robot. Tahan et al. [7] introduced a light fitness function that reduces the computation time which is needed for the calculation and repairing of paths in comparison to other modified GA's. Later on, Tazir et al. [8] presented a global approach which uses genetic algorithm and a local approach that uses dijkstra algorithm to find the sub optimal path when a dynamic obstacle arrives in the global optimal path. Recently, Hitendra et al. [9] proposed an approach to solve scheduling of jobs with deadline. The optimal sequence of jobs is found by using modified genetic algorithm.

The paper is organized as: Section II describes visibility graph and Grids which defines the working environment for the mobile robot. Section III describes ABC algorithm. Section IV describes Genetic Algorithm. Section V shows the simulation result and comparison between ABC and Genetic Algorithm.

2. ENVIRONMENT REPRESENTATION

The robot moves in 2-D space. The 5 uneven shapes and a sizes obstacle constitute the robot's working environment. The obstacles are treated as set of vertices which represent the nodes of the visibility graph. This graph is then made to represent free paths within the environment. Grid based environment is also used, where the orange color grids show the obstacles.

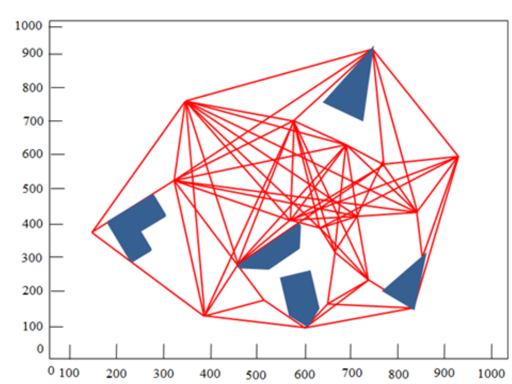

Fig. 1: Visibility graph based environment

Fig. 1 shows the visibility graph environment where the obstacles are shown in blue color patches. Red color lines show the visibility graph lines.

1	11	21	31	41	51	61	71	81	91
2	12	22	32	42	52	62	72	82	92
3	13	23	33	43	53	63	73	83	93
4	14	24	34	44	54	64	74	84	94
5	15	25	35	45	55	65	75	85	95
6	16	26	36	46	56	66	76	86	96
7	17	27	37	47	57	67	77	87	97
8	18	28	38	48	58	68	78	88	98
9	19	29	39	49	59	69	79	89	99
10	20	30	40	50	60	60	80	90	100

Fig. 2: Grid based environment

Fig. 2 Shows the N-type 10x10 grid based environment where orange color grids show the obstacles.

3. PSEUDO CODE OF ABC ALGORITHM:

The following steps are used for ABC algorithm:

1. Set control parameters.
2. Set counter = 0; using (1) assess fitness of possible food sources.

3. Recapitulate Until (counter is not equal to MAXCOUNTER) for each employee bee do
Search the neighborhood of the food source for new solutions using equation (2);

$$m_{ij} = n_{ij} + \psi(nk_j - n_{ij}) \quad (2)$$

where, j is the position of a randomly selected vertex (or grid in case of grid based environment),
φ is a random number such that ψ ϵ[-1,1]
Check if m_{ij} is within the bounds of the monitoring area.
using (1) assess fitness of new food source.
Choose best among old solution and new solution.
4. Compute the probability Probbi of the solution using equation (3)

$$Probbi = \frac{0.9*fitti}{fittbest} + 0.1 \quad (3)$$

5. For each on looker bee do
A random number random ϵ (0, 1) is generated and a food source is chosen depending on the value of Probbi and random;
Check for the latest food source in the nearby the equation(2)
Find out the new solution inner circle of the area

using (1) assess fitness of new food source.
Choose best among old solution and new solution.
6. Save the best solution, till now.
7. Navigate through the test array of food sources
if (test equal to or is greater than max no. of tests for a given food source)
The food source get changed with a randomly generated food source;
Set test = 0.
8. Counter = Counter +1;

4. GENETIC ALGORITHM

In genetic algorithm, the steps are defined in flowchart shown by Fig. 3.

Encoding Scheme: To encode the genes which are present inside the chromosome, an encoding scheme is required.

In this algorithm, value encoding scheme is used.

Evaluation: The fitness of the chromosomes is evaluated using Euclidean's distance formula (1) between the points P_c and P_{c+1}, as the goal is to find the shortest possible path from source to goal location.

$$F=\sum_{c=0}^{n} d\,(P_c, P_{c+1}) \quad (1)$$

Crossover Operation: Using tournament selection parent population of food sources is generated. According to evaluated fitness value select some of the minimal value chromosomes. Regardless of initial population pick two parents for every selected chromosome. Opt for the best out of least value chromosome and the new developed chromosome. To produce two offspring's, perform the hybrid crossover within the parent chromosomes.

Mutation Operation: For mutation operation, choose two minimum fitness value chromosomes and generate new offspring. Evaluate the offspring for the fitness value. If the new offspring has better fitness value then replaces the least fitness value parent chromosome with the new offspring.

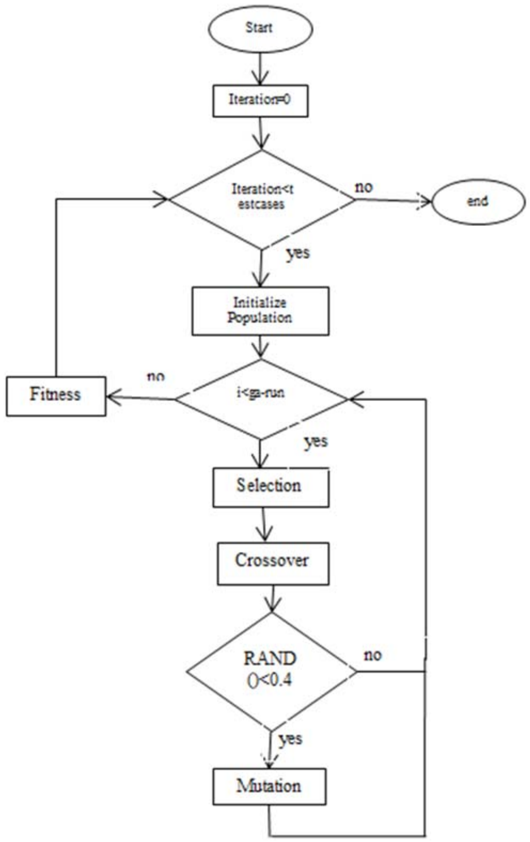

Fig. 3. Flowchart of Genetic Algorithm

5. RESULTS

The algorithms are simulated on Windows 8 using MATLAB R2009a, i5 processor, 2.6 GHz machine. Two different environments are used i.e. visibility graph based and grid based to validate the results.

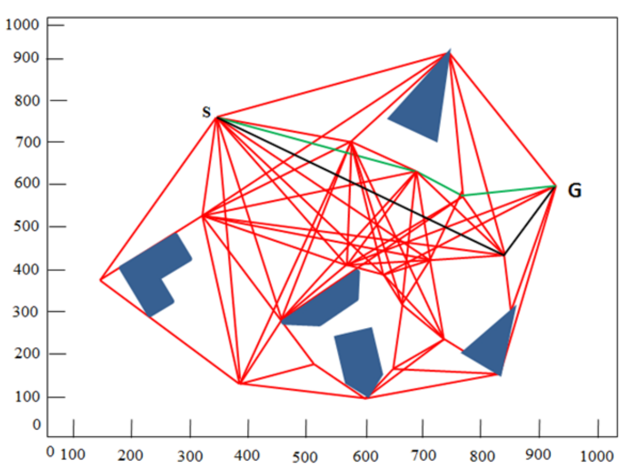

Fig. 4. Result of Visibility Graph

Fig. 4. shows the comparison of ABC and Genetic Algorithms in the visibility graph based environment. The path obtained by applying ABC algorithm is shown by green lines. The path obtained by applying Genetic algorithm is shown by black lines.

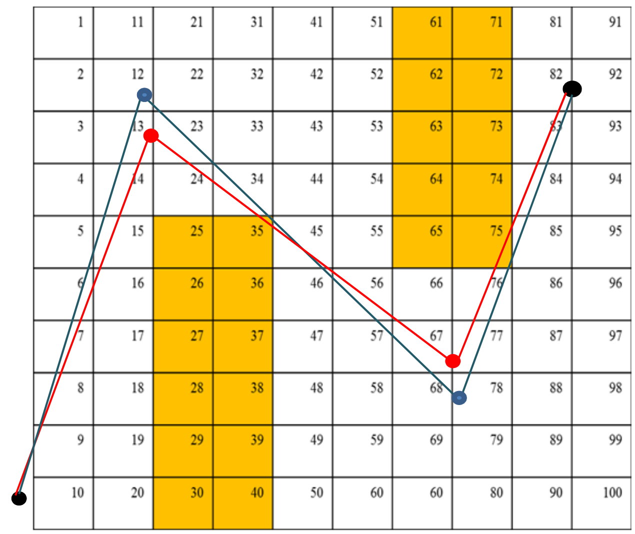

Fig. 5. N-type Environment

Fig. 5 shows the comparison of ABC and Genetic Algorithms in the grid based environment. The path obtained by applying ABC algorithm is shown by red color lines. The path obtained by applying Genetic algorithm is shown by blue color lines.

Table 1: Comparison of Results

Algorithms	**Visibility Graph Based Environment**		**Grid Based Environment**	
	Path Length	Time(sec)	Path Length	Time(sec)
ABC Algorithm	158.670	1.178	157.055	0.961
Genetic Algorithm	160.023	1.865	157.785	1.203

It is clear from the above table that ABC algorithm takes less time of execution and gives shorter path, in both the environments, in comparison to genetic algorithm.

6. CONCLUSION AND FUTURE WORK

The selection and layout of transitional points are the key factors of path planning robot issue of combinative task. Various process and procedures are developed for these factors in which artificial bee colony is one of the comparative techniques to obtain desired optimal solution. ABC algorithm is created to get optimal distance between source and destination as stated in this paper, when we compare to genetic algorithm ABC provides the best result. Visibility graph is used to initialize the food source. In the new era of robotics, an efficient hybrid algorithm will be treated as decision making system.

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