Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 133 (2018) 510–517

Procedia Computer Science

www.elsevier.com/locate/procedia

International Conference on Robotics and Smart Manufacturing (RoSMa2018)

Optimal Path Planning of Mobile Robot Using Hybrid Cuckoo Search-Bat Algorithm

MBL Saraswathi[a]* , Gunji Bala Murali[b], BBVL. Deepak[c],

[a,b,c]*National Insitute of Technology, Rourkela,Orissa-769008, India*

Abstract

The mobile robot path planning depends on sensing the data, map building and planning the path according to the prescribed environment. Many researchers have followed different techniques to get the optimal path. In the Earlier days Mathematical model has been developed to get the optimal path but the result obtained was very poor. After that, so many Soft computing techniques have been developed, but the major drawback is that they are more time to find the optimal path. Sometimes these algorithms fall in local optima during execution. This paper Deals with mobile robot path planning using two nature inspired meta-heuristic algorithms namely cuckoo-search and bat algorithm in the unknown or partially known environment. Cuckoo search is based on the parasitic behaviour of the cuckoo, and the bat algorithm is based on the Echolocation behaviour of the bats. The best qualities in the cuckoo-search and the bat algorithm are combined to obtain the optimal path. Proposed method takes less time to reach the target as compared to individual algorithms .The efficiency of this work has been tested in Matlab environment.

Keywords: PathPlanning, Hybrid Cuckoo Search-Bat Algorithm.

* Corresponding author. Tel.: +91 7653885863
E-mail address: saraswathi.lalitha@gmail.com

10.1016/j.procs.2018.07.064

1. Introduction

Robots are becoming a part of everyone daily life.The application of the mobile robots is varying from a simple grass cutting operation to the military applications. The use of the mobile robots is increasing in the automated industrial environment. The interest of research is growing day by day because of various forms. The primary purpose of the mobile robot is to find the optimal path by avoiding the all the obstacles in its path to reach desired destination. Mobile robot path planning involves the perception of the environment and then map building and planning the path according to the prescribed environment.

In the Earlier days, the Mathematical model has been developed to get the optimal path but the result obtained was very poor. After that, so many Soft computing techniques have been developed but the major drawback is that they take more time to find the optimal path, there are classical approaches like potential field method, Voronoi diagram and the cell decomposition method, and they will be struck into the local minima. There are soft computing methods like Fuzzy logic, Neural network, etc. Genetic algorithm(GA), Ant Colony Optimization(ACO),Particle swarm optimization(PSO) , Bat algorithm(BA), Cuckoo-search algorithm(CS) are the metaheuristic algorithms have been developed to reduce the drawbacks of classical approaches as they take more time to calculate the optimal path.

Potential field method gained more attention because of its simplicity, Koren et al. [1] has described in potential field method that robot exert the attractive forces and at the same time the obstacles exert the repulsive effects. The main drawback of the PFM is that they struck in the situations of the local minima considering these drawback he developed velocity force field(VFF) the main purpose of VFF is to avoid the obstacles in real time environment. There are classical approaches like voronai diagram and the cell decomposition method in the voronai diagram is constructed by using the distance between two points and the path obtained by using this process is not the shorter one, in the cell decomposition process the spaces is divided into the number of grids. The accuracy of the process depends up on the size of the grids if the size of the grids is less than the accuracy of the grid is more.Global path planning and the Local path planning are the two methods in path planning if full information about the environment is present then it is global and if no prior information is present then it is known as local path planning.

In the case of local path planning the robot can decide its path by using some external devices like cameras, IR sensors etc., to solve these problems Fuzzy logic [2-4] has applied for path planning. Differernt fuzzy logic techniques were developed .The accuracy for the path planning using fuzzy logic depends on the rules given by the human being.

For mobile robot path planning the most important network is Neural network. The neural network is based on the concept of using the neurons in the human brain, Pratap et al. [5] presented the a multi layered neural network for the path planning in which real world dynamic environment was considered the inputs to the neural network are the front obstacle right obstacle, left obstacle and the output is steering angle, in this by using the sensors object is detected and the path planning is done. But the accuracy depends only on the training state.

N.Sariff et al. [6] has presented the complete review paper on the neural network and the path planning applications of the mobile robots, and he concluded that feed forward back propagation will give more accuracy compared to all the other neural networks.

Genetic algorithm has been proposed Jianping Tu et al. [7] by considering that chromosome has variable length binary string is used and mathematically proven that the obtained path is the most optimal path, but the main draw back of genetic algoritam is that it takes more space in the computer memory.

Deepak et al. [8] Has proposed path planning based on the particle swarm optimization where he developed the fitness function by considering the distance between robot distance to the obstacle distance.

Panigrahi et al. [9] have been developed the cuckoo search by considering the objective function of the each value of the nest for reaching the optimal path by eliminating the obstacles. He has been given an optimal path and he concluded that compared to PSO and GA Cuckoo search is best algorithm. Ghosh et al. [10] proposed path planning for bat algorithm with static obstacles of different shapes and sizes. In the proposed algorithm a fitness function based on the robot distance and the obstacle distance is considered by the combination particle swarm optimization (PSO) and genetic algorithm (GA).

Rather going for single algorithm the hybrid technology will give better result Lim Chee Wang et al. [11] has proposed a hybrid algorithm which combines the potential field method and the distance transform method by using this method the local minima problem is minimized.

Al-Jarrah et al. [12] has presented path planning using neuro fuzzy system where he considered ANFIS system, accuracy and the robustness of the system is more compared to the individual fuzzy and the neural network.

The above-mentioned methods are consuming more time and occupy huge search space during execution of the algorithm. So, by keeping above difficulties in mind, in this paper, a new hybrid cuckoo search and the bat algorithm has been proposed and implanted on different cases studies to check the efficiency of the algorithm.

Abbreviations

GA-Genetic algorithm,ACO- Ant Colony Optimization,PSO-Particle swarm optimization,BA-Bat algorithm,CS-Cuckoo-search algorithm ,PFM-Potential field method,VFF-Velocity force field,ANFIS- Adaptive-network-based fuzzy inference system.

2. Proposed Hybrid cuckoo search bat algorithm for path planning of mobile robot

In this research, optimal path for the mobile robot has been proposed using the hybrid cuckoo bat algorithm. Cuckoo search algorithm is based on the Parasitic behavior of the cuckoo, these cuckoos will hatch the eggs in others nest, and the host birds will hatch the eggs. On the other and, Bat algorithm is based on the echolocation of the bats. Based on the echolocation of the bats they will sense the distance between the obstacles, and they know the difference between the food and the background barriers in some magical way.

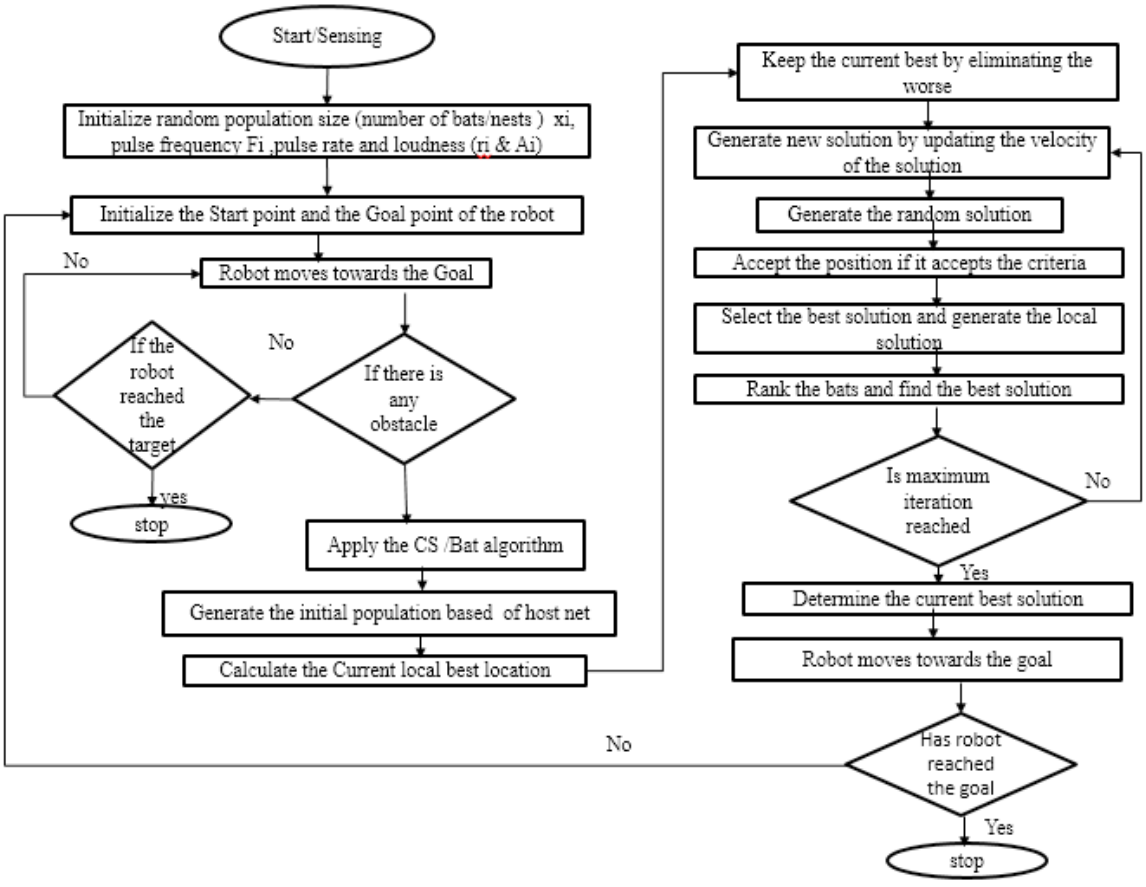

Fig. 1. Flow chart for path planning using hybradized cuckoobat algorithm.

In this cuckoo search and bat algorithm are combined to get the optimal path planning, the best qualities in the bat and cuckoo are combined to get the optimal path of the mobile robot. The detailed flow chart of the developed algorithm is shown in the Figure 1.

In this algorithm instead of applying cuckoo search algorithm or bat algorithm alone, the combination of both algorithms are applied to achieve optimal path of mobile robot. In this algorithm initially, cuckoo search algorithm has been applied to find the local optimal solution. The obtained local optimal solution will be given as the input to the bat algorithm to achieve the global optimal solution. By this, the chances of achieving the global optimal solution will increase compared to the general cuckoo search algorithm and bat algorithm. The proposed algorithm is applied to the mobile robot to find the optimal path in the presence of obstacles in the static environment.

3. Methodology

The proposed algorithm is applied to mobile robot path planning problem and estimated the optimal path of the robot to reach the target point. The detailed pseudocode is shown in the Figure 2 for the hybrid cuckoo search algorithm

```
Define objective function f(x),x=(x1, x2, x3,--------)
Do initialization of a population of n bats /cuckoos in random positions
Initilizations of bat parameters and cuckoo search parameters
for it=1:N
New_Nest=Get_cuckoo(Nest,Bestnest,Lowerbound,Upperbound);          Find the local
  [fnew,Best,Nest,Fitness]=Get_Best_Nest(Nest,New_Nest,fitness);    best with
                N_iteration =N_iterations+n;                       cuckoo search
                New_Nest=Empty_Nests(Nest,Lowerbound,Upperbound,pa);
                [fnew,best,nest,fitness]=get_Best_Nest(nest,New_Nest,fitness);
                N_iter=N_iter+n;
                if fnew<fmin,
               fmin=fnew;
               Bestnet=Best;
          end
end
obtain the local best solution( Lbest )using cuckoosearch algotithm
Q(i)=Qmin+(Qmax-Qmin)*rand
      v(i,:)=v(i,:)+(nest(i,:)*CBEST*Q(i);                         Find the
      s(i,:)=nest(i,:)+v(i,:);                                     global best
      if rand> r(it+1)                                             using bat
     s(i,:)=cbest+0.0001*rand(1,D);
  end
  Fnew=fobj(s(i,:));
if(Fnew<=fitness(i))&(rand<A(it+1))
   nest(i,:)=s(i,:);
  fitness(i)=Fnew;
end
end
```

Fig. 2. Pseudo code for hybrid cuckoo bat algorithm

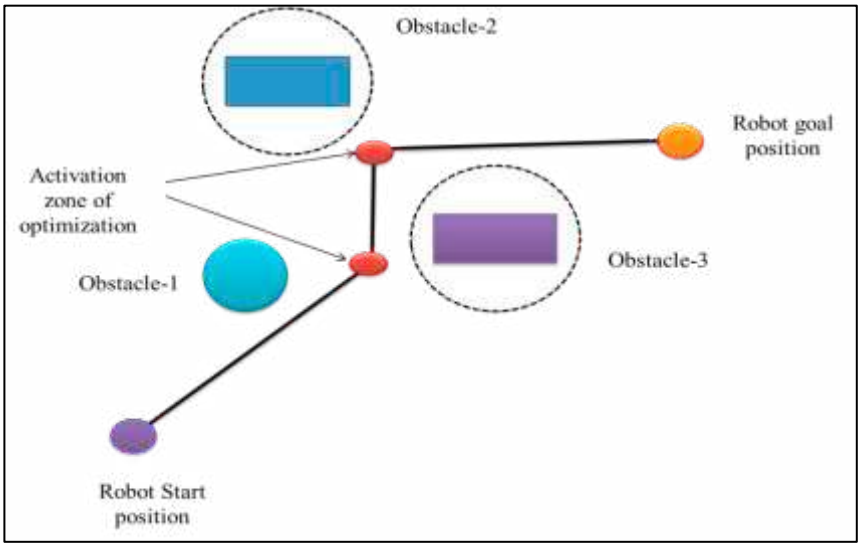

Fig. 3. State of activation of the hybrid cuckoo bat algorithm in the presence of obstacle.

Figure 3 represents the action zone for optimization of the robot path in a sample workspace with different obstacles. By the figure, it is known that at the obstacles position only, optimization algorithm is required. To implement the proposed algorithm and check the optimality of the mobile robot path, two cases studies have been considered.

Before proceeding to the implementation of the algorithm, some of the constraints have to be considered. In this, only circular obstacles have been considered for mobile robot path planning. As we are at the developing stage of the algorithm, only circular obstacles have been considered.

In this, two cases with different circular obstacles have been considered. Figure 4 & Figure 5 represents the sample workspaces for the two cases, which are considered in the Matlab software to obtain the optimal path of the mobile robot.

Case-1:

Workspace

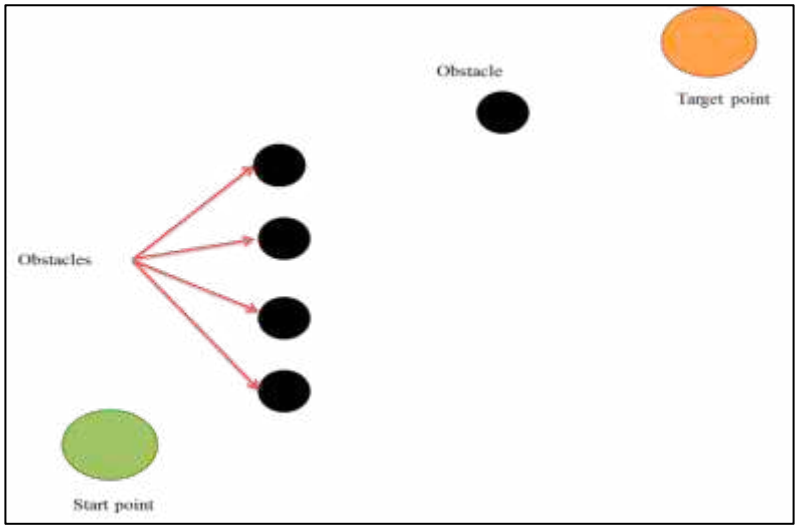

Fig. 4. Represents circular obstacle workspace

In the case-1, the circular obstacles are taken randomly to check the efficiency of the algorithm for mobile robot path planning problem.

Case-2:

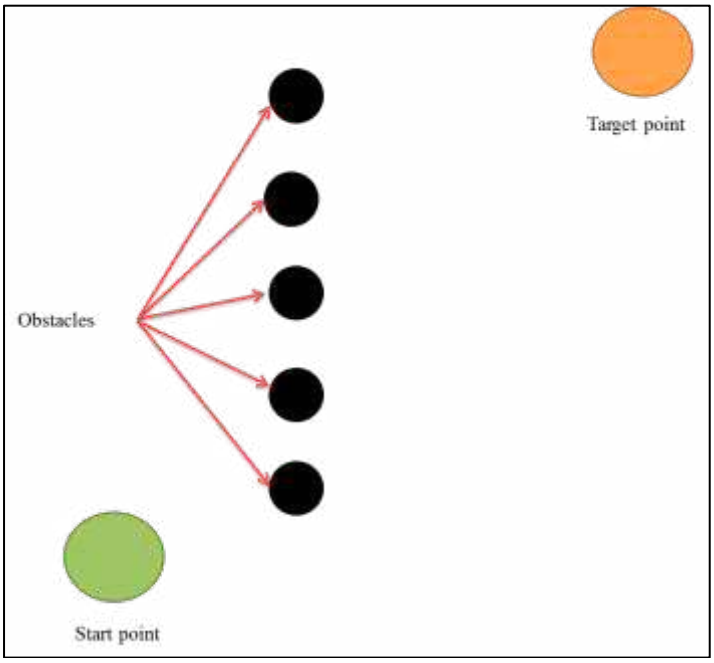

Fig. 5. Represents circular obstacle workspace

In the case-2, the circular obstacles are taken in line to check the efficiency of the algorithm for mobile robot path planning problem.

4. Results

The proposed hybrid cuckoo search bat algorithm is implemented on the mobile robot path planning for optimal path finding between the start and target point. To check the efficiency of the proposed algorithm two case studies discussed in the above section -3 have been considered.

The two cases studies considered in the above section-3 have been implemented in Matlab using a proposed algorithm, and the results of the optimal path for the mobile robot are shown in the Figure 6 & Figure 7.

The proposed algorithm is implemented on the Matlab and run for the 500 iterations. The population size considered for the algorithm is 20, and the number of runs that are executed for the algorithm are 5. The results obtain for the case -1 and case-2 are shown in the Figure 6 & Figure 7.

Case-1:

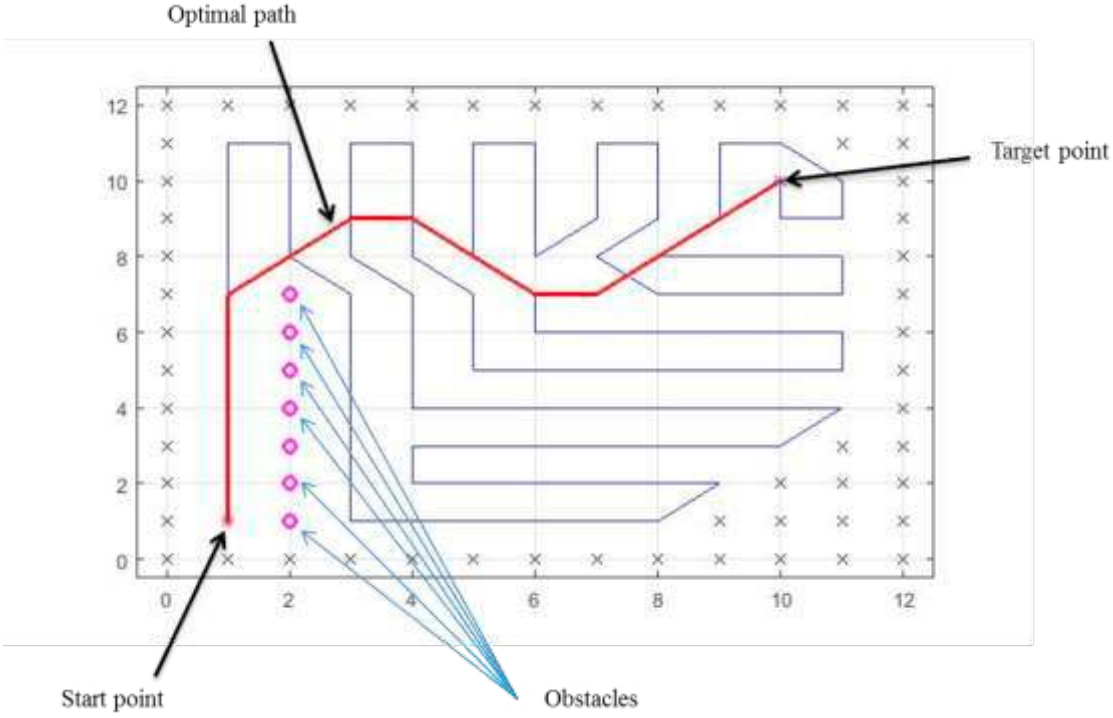

Fig. 6. Represents the optimal path for the mobile robot for case-1

Case-2:

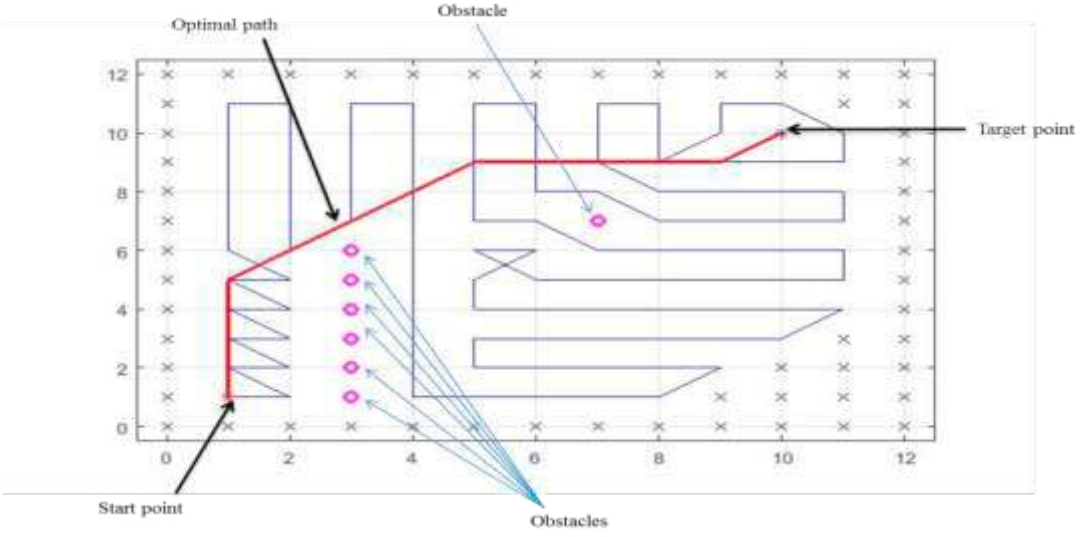

Fig. 7. Represents the optimal path for the mobile robot for case-2

5. Conclusion

In this paper, a new hybrid algorithm name hybrid cuckoo bat algorithm has been implemented on the mobile robot path planning for obtaining the optimal path for the mobile robot. The following conclusions have drawn form the paper is as follows:

1. In this, two sample workspaces with circular obstacles at [(2,1), (2,2), (2,3), (2,4), (2,5), (2,6), (7,7)] & [(2,1), (2,2), (2,3), (2,4), (2,5), (2,6), (2,7)] have been considered to obtain the optimal path for reaching the target point in the Matlab for the mobile robot.
2. The time taken for the first set of circular obstacles to obtain the optimal path is of about '3.04 sec' and the second set of circular obstacles to obtain the optimal path is of about '4.26 sec' respectively, when the algorithm was run for 5oo iteration.

As the future scope the circular obstacles are replaced with the rectangle and combination of the both to check the efficiency of the algorithm.

References

[1]. Y. Koren and J. Borenstein, "Potential field methods and their inherent limitations for mobile robot navigation," Proc. IEEE Int. Conf. Robot. Autom., no. April, pp. 1398–1404, 1991.

[2]. U. Farooq, K. M. Hasan, A. Hanif, M. Amar, and M. U. Asad, "Fuzzy Logic Based Path Tracking Controller for Wheeled Mobile Robots," Int. J. Comput. Electr. Eng., vol. 6, no. 2, pp. 145–150, 2014.

[3]. Y. Liang, L. Xu, R. Wei, and H. Hu, "Adaptive Fuzzy Control for Trajectory Tracking of Mobile Robot," IEEE Int. Conf. Intell. Robot. Syst., pp. 4755–4760, 2010.

[4]. Pandey, R. K. Sonkar, K. K. Pandey, and D. R. Parhi, "Path planning navigation of mobile robot with obstacles avoidance using fuzzy logic controller," 2014 IEEE 8th Int. Conf. Intell. Syst. Control, no. January 2014, pp. 39–41, 2014.

[5]. R. Fierro and F. L. Lewis, "Control of a nonholonomic mobile robot using neural networks.," IEEE Trans. Neural Netw., vol. 9, no. 4, pp. 589–600, 1998.

[6]. N. Sariff and N. Buniyamin, "An overview of autonomous mobile robot path planning algorithms," Res. Dev. 2006. SCOReD 2006. 4th Student Conf., no. June, pp. 183–188, 2006.

[7]. J. Tu and S. X. Yang, "Genetic algorithm based path planning for a mobile robot," Proc. IEEE Int. Conf. Robot. Autom. ICRA '03., vol. 1, no. 0, pp. 1221–1226 vol.1, 2003.

[8]. B. V. L. Deepak, D. R. Parhi, and B. M. V. a. Raju, "Advance Particle Swarm Optimization-Based Navigational Controller For Mobile Robot," Arab. J. Sci. Eng., vol. 39, no. 8, pp. 6477–6487, 2014.

[9]. P. K. Mohanty and D. R. Parhi, "Cuckoo search algorithm for the mobile robot navigation," Swarm, Evol. Memetic Comput., pp. 527–536, 2013.

[10]. S. Ghosh, P. K. Panigrahi, and D. R. Parhi, "Analysis of FPA and BA meta-heuristic controllers for optimal path planning of mobile robot in cluttered environment," IET Sci. Meas. Technol., vol. 11, no. 7, pp. 817–828, 2017.

[11]. L. C. W. L. C. Wang, L. S. Y. L. S. Yong, and M. H. . J. Ang, "Hybrid of global path planning and local navigation implemented on a mobile robot in indoor environment," Proc. IEEE International Symp. Intell. Control, no. February 2002, pp. 821–826, 2002.

[12]. R. Al-Jarrah, A. Shahzad, and H. Roth, "Path planning and motion coordination for a multi-robots system using probabilistic neuro-fuzzy," IFAC-PapersOnLine, vol. 28, no. 10, pp. 46–51, 2015.