International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-4, November 2019

Multi Robot Path Planning Based on Cuckoo Search and With PSO Algorithm in the Complex and the Unknown Environment

Shubham Shukla, NK Shukla, Vibhav Kumar Sachan, Sanjeev Sharma

***Abstract:** For an efficient operation of and autonomous robots or agents optimization of the path is an essential feature. In my proposed paper I will discuss about the CS Algorithm its parameter analysis and how it is applied on the mobile robot in an intricate environment with numerous amount of static obstacles. Taking the concept from the flight behavior of the cuckoo this meta-heuristic algorithm is designed.[1] We will show the different parameters of traversing by agents in terms of coverage, time, movement and energy between its targets and obstacles, based on these parameter we can identify the target seeking behavior and obstacle avoidance of the robot, then the comparison will be made between path planning with PSO algorithm and Cuckoo search[2] algorithm depending on various parameter analysis. With the help of both the algorithm which is the Cuckoo Search and PSO algorithm we will try to show how robot avoids the obstacle and proceed towards the target, when the robot reaches its goal we shall be able to justify that it has followed the smooth optimal trajectory within the frame or the desired environment.*

***Keywords:** path planning; cuckoo search; parameter analysis and comparison; optimal trajectory*

I. INTRODUCTION

In many real life applications robotics can be used in the form of hazardous cleanup of the waste [1],in the purpose of rescue and search [2,3], planet exploration and surveillance system[4,5] in the environment of combat[6] delibery of the medical facility [7] when the intricacy of the work increeses it is better to implement multi robot systems.[8]

In the field of autonomous mobile robot path planning and its optimization has turn out to be the most important tool. Amongst many application including military operations, mines excavations, material transportation fall under the category of mobile robot and planning of its path.

Manuscript published on November 30, 2019.
* Correspondence Author
Shubham Shukla*, Department of Electronics and Communications, J.K Institute of Applied Physics, Central University of Allahabad
NK Shukla Department of Electronics and Communications, J.K Institute of Applied Physics, Central University of Allahabad
Vibhav Kumar Sachan, Department of Electronics and Communications KIET Group of Institutions, Ghaziabad
Sanjeev Sharma Department of Computer Science Engineering Indian Institute of Information Technology, Pune

The mobile robot planning of path with the help of natures inspired algorithm are classified into two different categories which is the planning the path globally as well as planning the path locally. When the environment is completely known to the robot and when the path is predefined then this type of path planning fall under the category of global path planning.

Goal seeking is the process for the navigation of the robot from the start to the end point and can able to accomplish the task without making any type of collision[9,10] Since in the case of global path planning there is no certainty of path and hence it lacks robustness.For the optimization problem robot path planning can be taken into consideration[11] NIA can increase the chance if the robotics movement and can also generate diverging path selection.

In [12] a method for mobile path planning is been given with the use of PSO for the danger source environment this method has been implemented here environment is been featured as the horizontal and vertical lines . Multi objective PSO can be used as the solution of length and the degree of path.

In [13], in this paper new process of chaos PSO is been proposed to solve the path planning issues in the complex and in the unknown environment , the method leads to the fast search and proves efficiency to find the path.

In [14] By the use of differential evolution and Q learning robotic path planning can be solved. For global search differential evolution is used and for local search q learning is used. When we take the case of local path planning or reactive approach then in this case the robot traverse totally complex and an unknown environment and sometimes in partially known environment without making any sort of collision with the obstacle present.

Huwedi et al. [15], proposed the GA for finding out the solution of the multiple robots. They used the static environment and the decouple approach. To find the optimal path for the for the robot from its start till end. In the second step to avoid the collision of each robot the strategy been used.

Rashmi at el.[16] proposed the path planning technique using the honey bee mating technique (HBMO). This technique is been used for the local path in the case of the individual robot, here two objective functions were constructed to find the best position of the robot and the other objective is to avoid the collision of the obstacle and other robot.

Several other paper [17,18] proposed the technique of path planning their objective is to find the path planning solution for the shortest and collision free path.

When we consider the parameter analysis of both the path planning techniques then we can draw the conclusion that the local path planning is much more feasible than the global path planning.

For path planning of the mobile robot different types of techniques been used by the researchers to solve the issues related to the path planning of the multi robot. Some of the classical path planning techniques are visibility of graph, Voronoi diagram, grids and artificial potential field. One of the major disadvantage the robots are facing is that they got trapped into the local minima before they even meet their target. Based on the membership function and its rule we can check the dependence of fuzzy logic rules . Based on neural network (NN) navigation techniques of mobile robot approaches has been presented by many researchers (Singh&Parhi,2009; Velagic,Osmic,&Lacevic,2008).

In my article I have worked upon the different parameters of the multi robot path planning by finding out its parameters in the complex environment, I have find out four parameters such as Move, Time, Coverage, and Energy. Depending upon the values of the parameters I have made a comparison with the same parameters associated with PSO. With different sets of environment and there related parameters the efficiency of particular approach can be easily verified.

With the help of simulations on MATLAB 2013 I have formed several maps and also the table related to the values of different parameters for two different optimization algorithm. In the year 2009 and 2010 two prominent researchers Yang and Deb has developed the CS Algorithm which shows the parasitic behavior in laying their eggs in the nest of the neighbor birds. The major advantage one can encounter is that when it is being compared with the Genetic Algorithm (GA) or with PSO it shows less number of parameters which is to be tuned which makes it to be more adaptable for a wider class of optimization to implement. CS algorithm has proved its importance by holding a guaranteed properties of convergence.

The Rest of the paper is organized as follows: In section 2 Cuckoo search algorithm is proposed, In section 3 path planning with help of Cuckoo search is been used, section 4 deals with the proposed CS algorithm and sec 5 about the path planning through CS. Section 6 discuss about the flow diagram of CS algorithm and 7 Discuss about the comparison of the parameters in CS as well as in PSO , sec 8 shows comparison of traversing of robots in the complex environment using two different optimization algorithm Cuckoo Search and PSO. Section 9 Comparison of the parameters in graph obtained by Simulation of four agents 3, 6, 9 12 using Cuckoo Search (C.S) algorithm and PSO for Coverage and Time. Section 10 shows the comparison of the parameters in graph obtained by Simulation of four agents 3, 6, 9 12 using Cuckoo Search (C.S) algorithm and PSO for Move and Energy. Section 11 shows the comparison of the parameters in Table obtained by Simulation of four agents 3, 6, 9 12 using Cuckoo Search (C.S) algorithm and PSO Move and Coverage of a robot. Sec 12 shows the comparison of the parameters in Table obtained by Simulation of four agents 3, 6, 9 12 using Cuckoo Search (C.S) algorithm and PSO Move and Coverage of a robot and sec 13 proposed the conclusion which discuss about that according to parameter analysis in which case the movement time coverage and energy is showing better results.

II. CS ALGORITHM

In operations research, cuckoo search is an optimization algorithm developed by Xin-she Yang and Suash Deb in 2009[19]. Nature has given tremendous capability to Cuckoos in the case of their strategy which is really aggressive and involves the condition in which the female lay their eggs in their neighbor's nest where their eggs hatches out in the form of young cuckoo birds. In few cases when the host bird discovers the reality that the eggs present in their nest are not its own then the Cuckoos either abandon the nest of destroy it.

Cuckoo search (CS) is a nature's inspired algorithm and has been recently developed to provide the solutions of the problems related to optimization based on the levy flight behavior of cuckoo this algorithm is designed. In such type of flight we consider distributed length of a tailed probability distributions where in such a walk the major part of the increment are distributed in accordance with the power law:

$y = \chi^{-\beta}$ (1) [11]

where $1 < \beta < 3$ which is an infinite variance.

In the detailed description of the Cuckoo Search algorithm (CS) (Yang & Deb, 2009) following rules were used.

(1) At one time a cuckoo can lay only one egg and after laying their eggs all the cuckoo will dump their eggs in the nest which is randomly chosen.
(2) The nest which is found to be carrying the high quality eggs will be carried forward to the next generation.
(3) When the Cuckoo bird lay eggs I their fixed nest and has been discovered by the host bird with a probability $p_a \varepsilon [0,1]$.

One of the special feature of the host cuckoo bird is that they can either abandon or throw the eggs by building the new area. This approximation of assumption can be taken as p_a of the nest n and finally the new nest will replace the old one. The value of the objective function is proportional to the quality of the fitness for the maximization of the problem, fitness quality is also associated with the objective function. We have considered each egg to be the solution and when there is a new egg been laid by the cuckoo it has been considered to be the new solution, the comparison is been made between the two solutions with the aim to use a better solution.

Suppose according to the new solution $X^{(t+1)}$, The Cuckoo is been represented by i then the performance of the levy flight is been given by

$$Xi^{(t+1)} = Xi^{(t)} + Xi^{(t)} + \alpha \oplus \text{levy}(\lambda) \qquad (2)$$

According to the scale of the problem the actual step size would be $\alpha > 0$ where

$\alpha = 1$. Equation 2 represents the random walk of the stochastic equation.

The entry wise multiplication sign is been represented by $\oplus$ which is similar in the case of PSO bust as far as the levy flight is concern the random walk is more effective because it traverse the longer area.

III. WITH THE HELP OF CUCKOO SEARCH (C.S) ALGORITHM PROBLEM FORMULATION FOR ROBOT PATH PLANNING.

Based on the levy flight behavior of the cuckoo the path planning for the mobile robot in the local and static environment has been established.

For the robot navigation path planning is one of the fundamental issues in the field of the navigation of the robot. As far as the natures inspired algorithm is concerned the Cuckoo Search has played a crucial role in the evolutionary computation In an unknown environment it becomes the essential feature for the robot to detect the obstacle and avoid it. To solve the path planning problems several meta heuristic algorithms has been taken into aspect but the most popular natures inspired algorithm is the cuckoo search algorithm, at the initial level the navigation problem has been minimized and set according to the position of an obstacle in an unknown environment. While going through the performance the globally best nest (Cuckoo) has been chosen by the agent in every iteration and set the locations in series.

IV. ALGORITHM OF CUCKOO SEARCH

Objective Function $g(k)$, where $k=(k1, k2, \ldots\ldots kd)^T$

Let the starting population of the host nest 'n' $k_i(i=1,2\ldots\ldots n)$

While (t<maximum generation) or (Criteria stop)

Randomly get a cuckoo by the levy flight

If (F_i>F_j) then

Then j is replaced by the new solution

End

In the place of the abandoned worst nest (p_a) new nest are built

Keep the best solutions (or quality solutions with the nest)

Solution will be numbered to find the current best solution

End while

Process the result

End

In case of no detection of an obstacles it will certainly travel towards its destination after that no intelligent computation is required for the detection of the destination.

V. USING THE CUCKOO SEARCH ALGORITHM DEFINING PATH PLANNING

Let the starting point of the robot is 'A' and the global point is considered to be 'B' in an environment. The important aspect which the robot has to keep in its memory that it has to reach its desired target avoiding all the obstacles. With the help of the cuckoo search algorithm the robot can traverse the path avoiding the obstacle in order to find the nest the CS algorithm must be initialized whenever the obstacle falls within the range of the sensor. In the case of CS algorithm the nest heaving eggs of the best quality will lead the new generation, hence the optimized path length of the robot is been compared with the quality of the eggs.

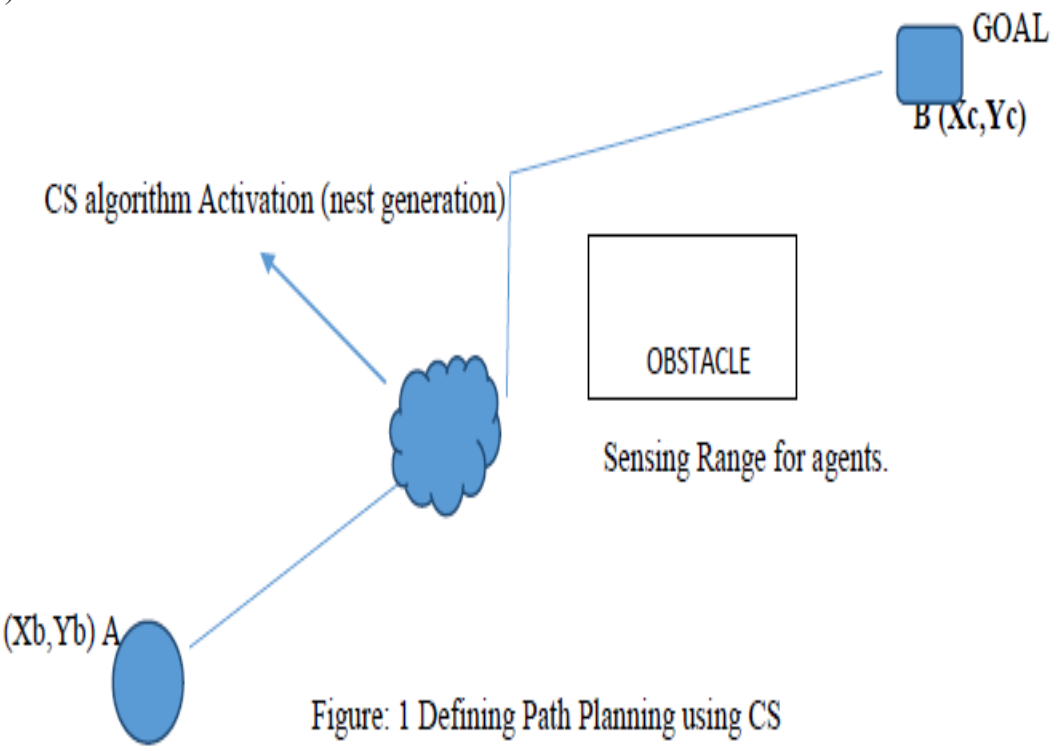
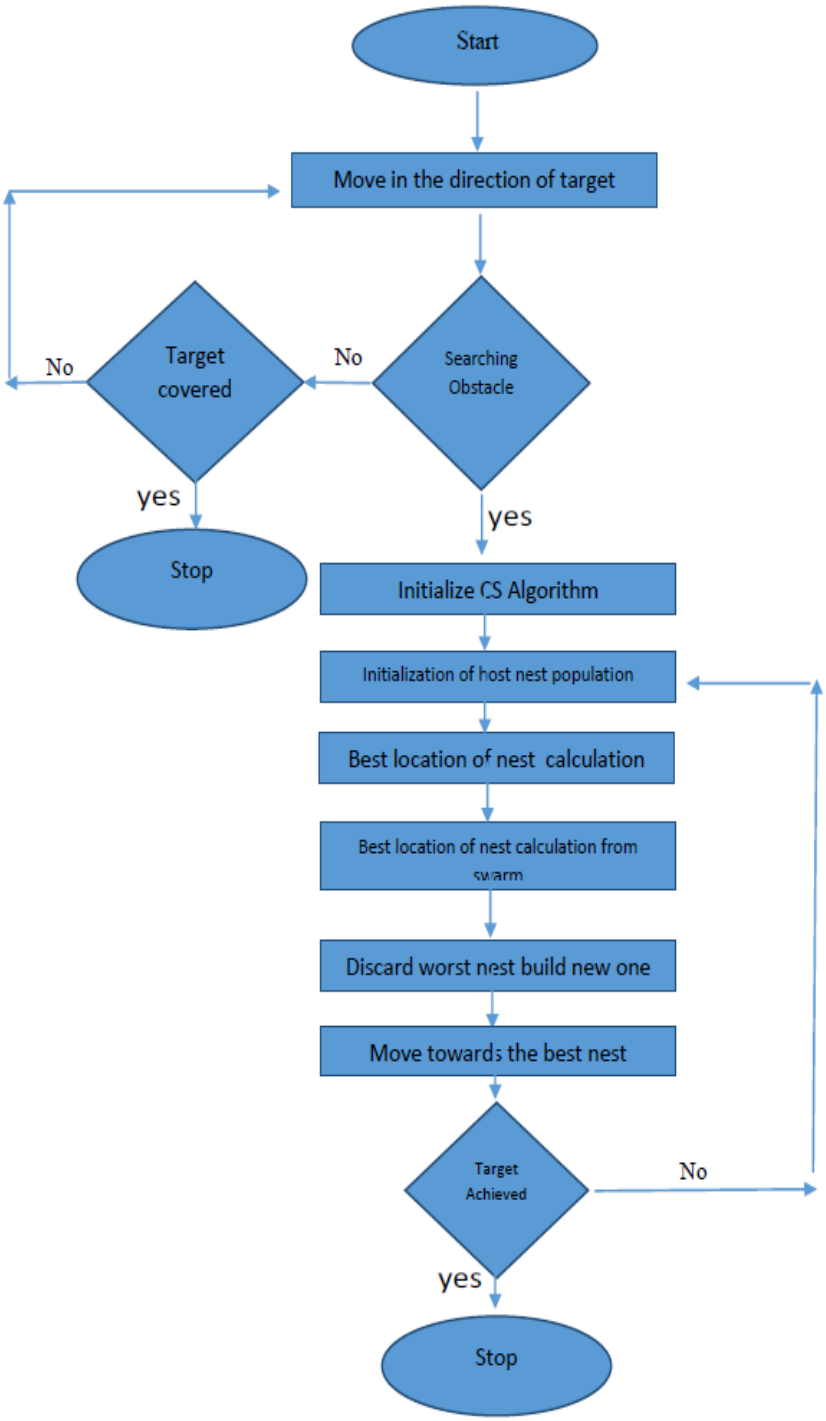


Figure: 1 Defining Path Planning using CS



6. Flow Diagram of the Cuckoo Search Algorithm

7. *Comparison of Parameters for multi robot path planning by Cuckoo Search with PSO algorithm*

In the field of multi robot path planning natures inspired algorithm has played a crucial role and when we talk about natures inspired algorithm then Cuckoo search algorithm turns out to be the most suitable algorithm for robot path planning as compared to the PSO algorithm. In my article I have tried to analyze the different sets of parameters based on path planning by using two different algorithm which is Cuckoo

Search and Particle swarm. The parameters of path planning comprises of movements, time taken, coverage and energy consumed.

Depending on various parameters I have formulated the result using table and maps with the help of which a proper estimation of the path planning can be formulated. We have considered four agents 3, 6, 9 and 12 and taken four different sets of environment. With the help of MATLAB 2013 simulation of an algorithm is been done.

8. *Comparison of traversing of robots in the complex environment using two different optimization algorithm Cuckoo Search and PSO.*

Following are the simulation result of map 1 with four agents 3, 6, 9 12 using Cuckoo Search (C.S) algorithm

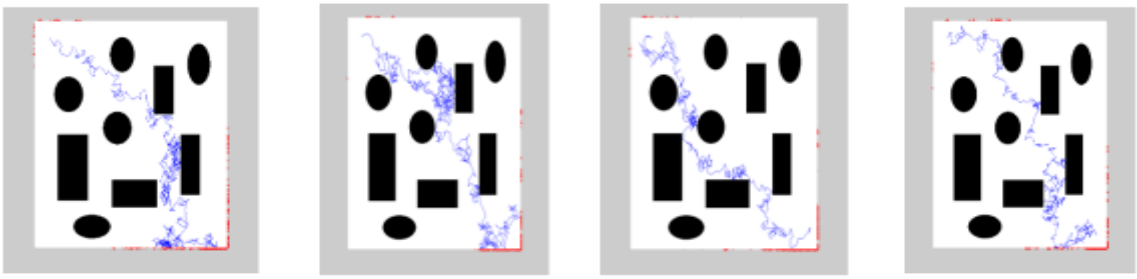


Fig: 3 Map 2 agent 9 Fig: 4 Map 2 agent 12 Fig1: Map 2 agent 3 Fig: 2 Map 2 agent 6

Following are the simulation result of map with four agents 3, 6, 9 12 using Particle Swarm Optimization (PSO) Algorithm

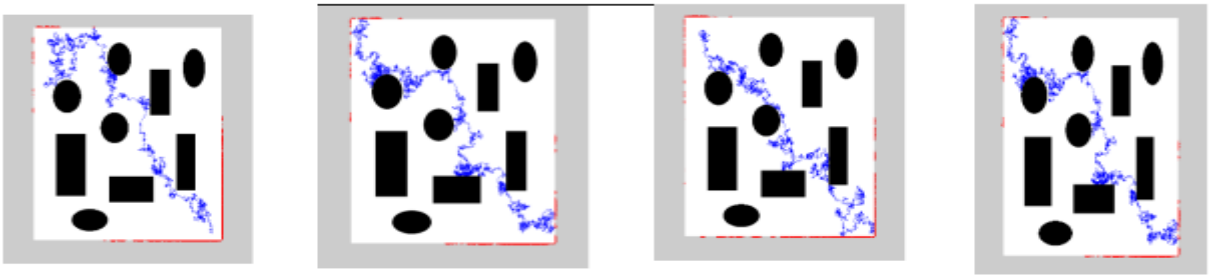
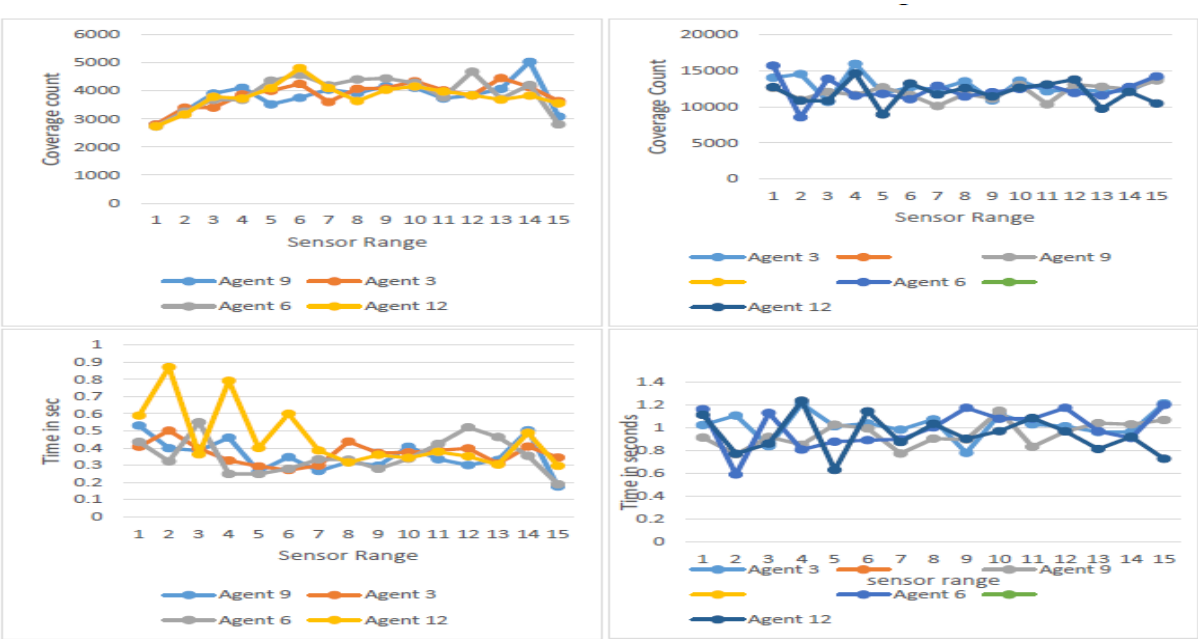


Fig: 1 Map 2 Agent Fig : 2(Map 2 For Agent 6) Fig : 3(Map 2 For Agent 12) Fig :4 (Map 2 For Agent 9

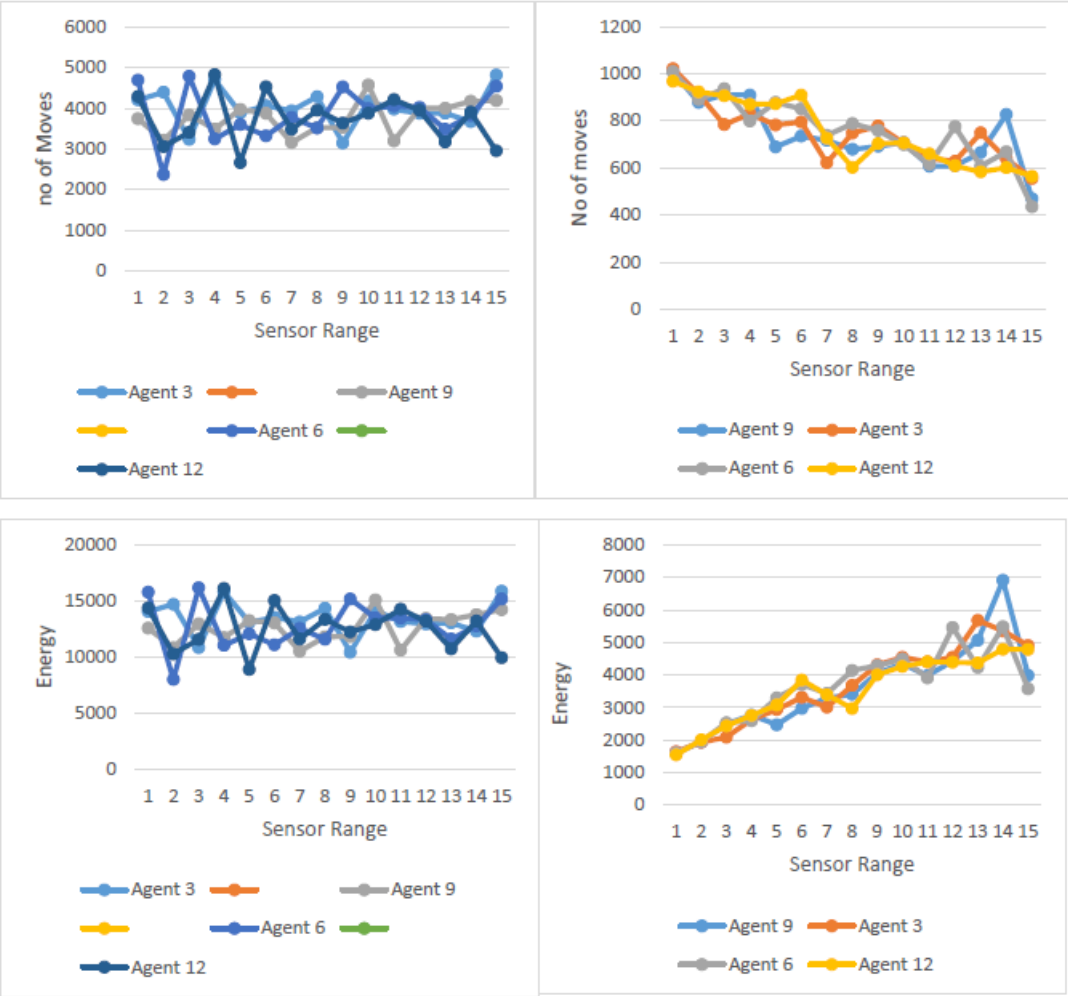
9. *Comparison of the parameters in graph obtained by Simulation of four agents 3, 6, 9 12 using Cuckoo Search (C.S) algorithm and PSO for* ***Coverage and Time.***

Cuckoo Search (C.S) *Particle Swarm Optimization (PSO)*



10. *Comparison of the parameters in graph obtained by Simulation of four agents 3, 6, 9 12 using Cuckoo Search (C.S) algorithm and PSO for* ***Move and Energy.***

Particle Swarm Optimization (PSO) algorithm *Cuckoo Search (C.S)*



11. *Comparison of the parameters in Table obtained by Simulation of four agents 3, 6, 9 12 using Cuckoo Search (C.S) algorithm and PSO* ***Move and Coverage*** *of a robot*

for Cuckoo Search Optimization *for PSO Optimization*

Move				**Move**			
Agent 9	**Agent 3**	**Agent 6**	**Agent 12**	Agent 3	Agent 9	Agent 6	Agent 12
1010	1021	1008	968	4204	3742	4686	4286
878	914	891	923	4391	3213	2372	3057
912	784	936	906	3234	3830	4781	3405
909	830	799	870	4700	3487	3245	4823
689	782	878	872	3883	3969	3598	2663
735	795	851	909	4062	3873	3320	4524
717	622	738	726	3935	3159	3772	3481
679	748	788	602	4281	3520	3511	3949
692	778	759	703	3146	3529	4521	3633
708	705	699	706	4176	4568	3985	3872
607	640	616	660	3975	3196	4053	4211
609	628	775	609	3871	3996	4018	3945

665	749	607	583	3878	3996	3482	3171
827	639	668	601	3668	4170	3820	3903
469	555	435	564	4812	4185	4535	2955
Coverage				**Coverage**			
Agent 9	**Agent 3**	**Agent 6**	**Agent 12**	Agent 3	Agent 9	Agent 6	Agent 12
2803	2804	2734	2740	14047	12635	15727	12753
3278	3406	3265	3163	14556	10984	8552	10847
3909	3408	3686	3793	10688	12076	13898	10837
4115	3874	3684	3726	15973	11665	11531	14629
3523	4004	4367	4097	11829	12725	11811	8940
3757	4252	4572	4817	12725	11636	11073	13255
4046	3604	4200	4103	12411	10120	12936	11709
3917	4079	4412	3640	13555	11782	11430	12621
4176	4091	4447	4039	10897	11145	12041	11446
4113	4347	4286	4160	13653	13046	12485	12673
3731	4022	3772	3978	12159	10360	13039	13120
3843	3839	4686	3845	12373	13100	11925	13802
4073	4459	3719	3688	12164	12801	11577	9738
5039	4139	4212	3832	12178	12441	12772	12075
3088	3640	2810	3557	14034	13673	14240	10475

12. *Comparison of the parameters in Table obtained by Simulation of four agents 3, 6, 9 12 using Cuckoo Search (C.S) algorithm and PSO* ***Time and Energy*** *of a robot*

for Cuckoo Search Optimization *for PSO Optimization*

Time				**Time**			
Agent 3	Agent 9	Agent 6	Agent 12	**Agent 9**	**Agent 3**	**Agent 6**	**Agent 12**
1.0233	0.9143	1.1619	1.113	0.5313	0.4081	0.4361	0.5893
1.1071	0.7681	0.5915	0.7729	0.3993	0.5017	0.3231	0.8717
0.8386	0.9192	1.1295	0.8619	0.3851	0.3967	0.5506	0.3634
1.2097	0.8523	0.8088	1.2368	0.4609	0.3279	0.2497	0.7921
1.0127	1.0267	0.8782	0.631	0.2644	0.2936	0.2493	0.4006
1.0374	0.9941	0.8918	1.1434	0.3476	0.2724	0.2795	0.6003
0.9831	0.7742	0.8992	0.8747	0.2668	0.2982	0.3344	0.3863
1.0736	0.905	1.0033	1.0346	0.3186	0.4384	0.3324	0.3167
0.7802	0.8969	1.1742	0.9039	0.298	0.3717	0.2794	0.3607
1.1182	1.1484	1.0786	0.9701	0.4082	0.3748	0.338	0.3428
1.0292	0.8336	1.0787	1.086	0.335	0.3872	0.4248	0.3784
1.0132	0.9676	1.1742	0.9686	0.3009	0.3985	0.521	0.3523
0.9626	1.0403	0.9687	0.814	0.3309	0.3099	0.4646	0.3039
0.9619	1.0295	0.91	0.9203	0.5036	0.4092	0.355	0.4888

1.2132	1.0677	1.1994	0.7289	0.1763	0.3448	0.1894	0.2965
Energy				**Energy**			
Agent 3	Agent 9	Agent 6	Agent 12	**Agent 9**	**Agent 3**	**Agent 6**	**Agent 12**
14045	12573	15777	14374	1624	1638	1600	1542
14690	10823	7996	10255	1938	1931	1947	2007
10827	12950	16170	11566	2491	2086	2530	2433
15794	11725	11037	16113	2765	2628	2595	2759
13074	13241	12067	8879	2467	2937	3293	3076
13527	13036	11080	15036	2972	3314	3710	3846
13124	10500	12539	11599	3290	3010	3431	3388
14340	11795	11572	13348	3408	3680	4138	2966
10411	11823	15171	12233	4055	4312	4285	4004
14145	15084	13476	12877	4341	4542	4488	4259
13155	10608	13474	14262	3977	4402	3910	4404
12934	13436	13312	13189	4430	4542	5457	4389
13046	13331	11598	10711	5067	5680	4235	4370
12300	13766	12776	13203	6912	5352	5483	4788
15868	14214	15174	9934	3985	4904	3575	4781

VI. CONCLUSION AND FUTURE WORK

This Paper has given the novel methodology for the analysis of parameters involved in multi robot path planning technique with the help of the natures inspired algorithm which includes Particle Swarm optimization and Cuckoo Search , through the series of simulation maps , graphs and tables the proper demonstration of the following algorithm has been done. It has been observed by seeing the graphs driven from the desired parameters that the two algorithm PSO and CS is following the different traversing mechanism in the complex environment, on one hand in the case of Cuckoo search all the robots starts from the same point and meets at the same point after traversing the environment while on the other hand the agents through the PSO optimization technique cannot able to start and meet over the same point. Which concludes that the cuckoo search optimization technique is much more feasible and effective technique as compared to the PSO. Our future work shall focus on the parameter analysis on the hybrid nature of both CS and PSO algorithm. For future work we shall combine both the algorithms PSO and CS together form a hybrid algorithm and analyze the parameters based on traversing of robots also compare the result with PSO and CS separately while doing so we can estimate the efficiency of the algorithm and its suitability to the path planning technique.

REFERENCES

1. Prassler, E., Stroulia, E., Strobel, M.: Office waste cleanup: an application for service robots. In: IEEE International Conference on Robotics and Automation, vol. 3, pp. 1863–1868 (1997)
2. Jennings, J.S., Whelan, G., Evans, W.F.: Cooperative search and rescue with a team of mobile robots. In: 8th International Conference on Advanced Robotics, pp. 193–200 (1997)
3. Davids, A.: Urban search and rescue robots: from tragedy to technology. IEEE Intell. Syst. 17(2), 81–83 (2002)
4. Hougen, D.F., Benjaafar, S., Bonney, J.C., Budenske, J.R., Dvorak, M., Gini, M., French, H., Krantz, D.G., Li, P.Y., Malver, F., Nelson, B., Papanikolopoulos, N., Rybski, P.E., Stoeter, S.A., Voyles, R., Yesin, K.B.: A miniature robotic system for reconnaissance and surveillance. IEEE Int. Conf. Robot. Autom. 1, 501–507 (2000)
5. Chatila, R., Lacroix, S., Simeon, T., Herrb, M.: Planetary exploration by a mobile robot: mission teleprogramming and autonomous navigation. Auton. Robots 2(4), 333–344 (1995)
6. Singer, P.: Military robotics and ethics: a world of killer apps. Nature 477(7365), 399–401 (2011)
7. Dario, P., Guglielmelli, E., Allotta, B., Carrozza, M.C.: Robotics for medical applications. IEEE Robot. Autom. Mag. 3(3), 44–56 (1996)
8. Ahmadi, M., Stone, P.: A multi-robot system for continuous area sweeping tasks. In: IEEE International Conference on Robotics and Automation, pp. 1724–1729. ICRA (2006)
9. Barraquand, J., Bruno, L., Latombe, J.-C.: Numerical potential field techniques for robot path planning. IEEE Trans. Syst. Man Cybern. 22(2), 224–241 (1992)
10. Willms, A.R., Yang, S.X.: An efficient dynamic system for real-time robot-path planning. IEEE Trans. Syst. Man Cybern. Part B: Cybern. 36(4), 755–766 (2006)
11. Bennewitz, M., Burgard, W., Thrun, S.: Finding and optimizing solvable priority schemes for decoupled path planning techniques for teams of mobile robots. Robot. Auton. Syst. 41 (2), 89–99 (2002)
12. Gong, D.W., Zhang, J.H., Zhang, Y.: Multi-objective particle swarm optimization for robot path planning in environment with danger sources. J. Comput. 6(8), 1554–1561 (2011)
13. Hao, W., Qin, S.: Multi-objective path planning for space exploration robot based on chaos immune particle swarm optimization algorithm. In: Deng, H., Miao, D., Lei, J., Wang, F.L. (eds.) AICI 2011, Part II. LNCS, vol. 7003, pp. 42–52. Springer, Heidelberg (2011)
14. Rakshit, P., Banerjee, D., Konar, A., Janarthanan, R.: An adaptive memetic algorithm for multi-robot path-planning. In: Panigrahi, B.K., Das, S., Suganthan, P.N., Nanda, P.K. (eds.) SEMCCO 2012. LNCS, vol. 7677, pp. 248–258. Springer, Heidelberg (2012)684 S. Sharma et al.
15. Ashraf, S., Budabbus, H., S.M.: Finding an optimal path planning for multiple robots using genetic algorithm. In: The 13th International Arab Conference on Information Technology, ACIT (2012)
16. Sahoo, R.R., Rakshit, P., Haidar, M.T., Swarnalipi, S., Balabantaray, B.K., Mohapatra, S.: Navigational path planning of multi-robot using honey bee mating optimization algorithm (HBMO). Int. J. Comput. Appl. 27(11), 0975–8887 (2011)

17. Ismail, A.T., Sheta, A., Al-Weshah, M.: A mobile robot path planning using genetic algorithm in static environment. J. Comput. Sci. 4(4), 341–344 (2008)
18. Ahmed, F., Deb, K.: Multi-objective optimal path planning using elitist non-dominated sorting genetic algorithms. Springer J. Soft Comput. 17(7), 1283–1299 (2013)
19. X.-S. Yang; S. Deb (December 2009). *Cuckoo search via Lévy flights*. World Congress on Nature & Biologically Inspired Computing (NaBIC 2009). IEEE Publications. pp. 210–214.

AUTHOR'S PROFILE

Shubham Shukla is pursuing his PhD from J.K Institute of Applied Physics, University of Allahabad from the Department of Electronics and communication. The area of his research is Robotics. He has completed his M.tech from J.K Institute of Applied Physics, University of Allahabad from the Department of Electronics and communication with the area of communication technology. He has published paper in the journal of Poland WSN and has won the best paper in the IEEE conference held in KIET, Delhi NCR India

Prof N K Shukla is a senior Professor and serving as a Registrar at University of Allahabad, He has completed his Doctorate from J.K Institute of Applied Physics, University of Allahabad from the Department of Electronics and communication. M.Tech from the same institute, he has the vast teaching as well as the administrative experience of more than 25 years, he has guided several PhD students, his area of research is optical fiber, and He has published more than 50 research papers in several reputed Journals and conferences national as well as international.

Prof. (Dr.) Vibhav Kumar Sachan is the Professor & Additional Head of Department of Electronics & Communication Engineering Department at KIET Group of Institutions, Ghaziabad, Uttar Pradesh. He completed his B.Tech. with distinction in 2001, M.Tech. with distinction in 2006 and Ph.D. in 2014. Dr. Sachan started his career as Lecturer of Electronics & Communication Engineering at KIET Group of Institutions, Ghaziabad, Uttar Pradesh in August 2001. During his academic career of 18 years, Dr. Sachan has taught various subjects at UG/PG levels and has authored 16 books, edited 03 conference proceedings and written 06 chapters in different books. He has published 48 papers in reputed International journals, 18 papers in National journals and 37 papers in proceedings of International / National Conferences.

Dr. Sanjeev Sharma is an Assistant Professor in CSE department at IIIT Pune. He has received his Ph.D. in Information Technology from ABV-Indian Institute of Information Technology and management Gwalior M. P., M. Tech. in CSE from ABV- Indian Institute of Information Technology and management Gwalior M. P. He has published several articles in International Journals and Conferences. He has also served as reviewer of papers/articles of many reputed international journals and conferences. His area of research is Soft Computing, Robotics, Biometrics and Nature Inspired Algorithms.