ABSTRACT

Title of Thesis:- Ant Colony Optimization based Adaptive Control System

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In this thesis, Ant Colony Optimization (ACO) Algorithm is applied on Adaptive Control System. Here adaptive control is nothing but intelligent path planning of a mobile robot for given path points using advance ACO by avoiding all static and dynamic obstacles. ACO is another metaheuristic technique, which is based on the natural ant's behavior and widely used to solve complex optimization problem. The path planning of a mobile robot is a big challenge for industrial robots and intelligent path planning of mobile robot increases its adaptableness. The intelligent path planning is a part of robot's adaptive control system where robot will move from source to destination in known, partially known or unknown environment by generating optimized path using soft computing methods and avoiding all static and dynamic obstacles.

The objective of the proposed research work is to apply a feasible, proficient and stable technique for mobile robot path panning, to identify and move on a shortest distance path to reach at target location by avoiding collision with all kinds of obstacles.

The major focus of the research work is:

- To determine suitable objective function and this can be used in algorithm to reduce error. Use of objective function is the mandatory requirement for any soft computing technique as they are inherent. It is used to calculate object strength for any iteration. Therefore to find out the suitable objective function is very critical for any adaptive control system and soft computing techniques
- To validate the effectiveness of Ant Colony Optimization (ACO) Algorithm for path planning of mobile robot with obstacle avoidance and observe its behavior.
- To apply and observe the mobile robot path planning when Teaching Learning Based Optimization (TLBO) Algorithm and Cuckoo Search (CS) is applied. The results of the

TLBO and CS would be observed and analyzed for different parameters.

- To develop hybrid techniques for mobile robot path planning. It is more effective to combine two or more soft computing techniques to achieve better results in comparison to conventional techniques as it has more potential to solve any complex real time problems. Hybrid algorithms work very effectively and efficiently under the dynamic environment conditions and with multiple robots also.
- Validation of newly developed hybrid algorithm for simulation in real kind of environment. The results of new hybrid algorithm should be validated with other hybrid algorithm for its effectiveness.

Basically following four steps are involved in the simulation:

- Storing of actual path points into system: The system will store path points and algorithm will use these points for generating shortest path.
- Generation of Shortest Path: System will generate shortest path using different input parameters by avoiding static dynamics
- Path Navigation, Tracking & Obstacle Avoidance: The robot will navigate shortest path generated by the system and also provide feedback for any dynamic obstacle.
- Re-Generation of Shortest Path: In case robot finds any dynamic obstacle then system will re-generate shortest path.

The results shows that if we increase no. of path points all the algorithms take lot of time to generate shortest path and also fails to generate shortest path accurately and precisely. The analysis further indicates that modified algorithm may give better result comparing to conventional metaheuristic algorithms.

Initially the focus of the research was to modify existing ACO algorithm however results suggested that Modified ACO is not suitable for large number of path points as it converge very slowly. After further research it has been found that integration of two or more metaheuristic algorithm may give better results. The focus of the thesis is majorly on developing advanced hybrid algorithm by integrating two or more metaheuristic algorithms. In recent years, hybridization among various algorithms has been done and is successfully applied in many areas of engineering and science. Over the decades, researchers always verify and recommend which algorithm gives better result in which area and even sometimes it is problem specific. Interest of using hybrid techniques is speedily growing these days, while doing hybridization; output of one technique is treated as input for other technique.

In the proposed hybrid ACO-CS algorithm, behavior of Cuckoo bird is replaced with ants of Ant Colony Optimization algorithm i.e. the search approach of finding best nest in CS is replaced by identified shortest path through ACO. In case of hybrid GA-ACO, output of GA is applied as input to ACO and ACO is utilized as the mutation of GA. Here GA performs selection and crossover process and obtained a single value as solution, which is the optimal value. Further development in the category of hybrid technique is MACO-CS algorithm, which is the major contribution of this thesis and is applied for path planning. It uses the advantages of both algorithms and then combines them accordingly. In ACO, ants follow that path only which is having highest intensity of pheromone deposited but this process is sequential in nature and makes the system slow, so its takes relatively more time to solve combinatorial optimization problems. Therefore CS is used to overcome this drawback, i.e. slow performance of local search in ACO and hence by using CS local search is performed at a much faster rate in comparison to ACO. CS performs better because it has only one parameter to control besides population size.

The integration of Modified ACO with Cuckoo Search resulted a new algorithm named Hybrid Modified ACOCS. In this algorithm Cuckoo Search is applied for local search while Ant Colony Optimization is applied for global search. The comparative study of Hybrid MACOCS has also been done with Hybrid ACO-GA and Hybrid ACO-CS for robot path planning on various environment conditions like distance travelled, time taken and percentage error occurred by the robot for different path points. The comparative study reveals that all the proposed approaches are capable of solving the basic issues of path planning for mobile robots during navigation. However Hybrid MACOCS is able to generate efficient path quickly and with less number of input parameters and convergence is very fast with less percentage of error and generates shortest distance path in adaptive environment.

In future, this study can be extended for considering the velocity with which dynamic obstacle is moving, and produce robust method. Forecasting of probability of collision for robot and obstacle can also be done in advance. Furthermore other types of nature inspired algorithms can be developed or integration among existing algorithms can be applied to such type of path planning problems for optimization parameters. For path planning, multiple robots with multiple targets may be considered in place of single robot with single target.