A review for Motion planning using Autonomous Mobile Robots

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Abstract: -In today world autonomous mobile robot is of the great importance as it is able to find path on its own. Motion planning is one of the most researched area when we design both the autonomous mobile robots and legged robots. The basic definition of motion planning is to plan a path from the initial desired point to the goal point including the obstacles in the given environment.

Many techniques have been studied by researchers for the past thirty years in the case of mobile robots. This article presents a review to provide solution for motion planning using different nature inspired algorithm. It presents a comparison between the classic approaches and the nature-based approaches used to develop an optimized solution in the area of autonomous mobile robots. Thus, it can be easily implemented in real time obstacle avoidance especially in the uncertain environment. It improves the challenges in navigation also minimizes computation calculations. The performance of the algorithm is better in turns of the path optimization as compared to the other available approaches. The results of this paper will enhance how optimized path planning implemented to achieve real-time intelligent autonomous mobile robots.

Keywords: Autonomous mobile Robots, Working environment, Classic evolutionary Algorithms, Nature Inspired Algorithms, Motion Planning

Introduction: -

During the past decades autonomous mobile robots have been applied different area such as defence, industry and surveillance environments, agriculture, medical field etc. to perform the obligatory works in unmanned areas.

Path planning and motion planning is one of the most fundamental problems that have been resolved. In the recent years, optimization is booming area in research area for providing a solution to real time problems. The demands for solving real time problems has attracted many researches to develop fast, accurate and computationally powerful optimization. Historically problem-solving techniques are classified into two categories: Extract and heuristics methods.

Problems related to NP complete are solved using logical and mathematical programming whereas heuristics methods are superior in solving NP -hard and complex optimization where classical approaches fail.

Generally speaking, path planning is divided into two categories – Global path planning and local path planning.

In case of global path planning all the information regarding the environment should be already provided to the robot before, the robot starts to move on the path given. On the contrary in case of the local, nearly all the information about the environment is not known to the robot.

The robot is totally unaware of its environment before starting its path.

The paper is as follows: Section 2 and Section 3provides a review of global path planning and Section 4 provides a review of local path planning and conclusion

2: Global Path Planning

In the process of the global path planning the following steps have to be followed

Environmental Maps: This is normally used in the case of global path planning. In this case the robot will use a suitable topological model to understand the given space and plan the path accordingly.

Optimization Principles and Path Search Algorithm: -This path search algorithm is adopted to find the optimized path free from collision between the set point and the desired point.

2.1.1 Classical Approaches used in path planning

A: -Cell decomposition Approach: -

The basic idea behind this method is that the given path between the source and the destination can be determined by dividing the free space into smaller regions called cells. The cells are formed inside the robot's workspace. After the decomposition is done, a connectivity is formed according to adjacency relationships between the cells, where the nodes represent the cells in the free space, and the links between the nodes show that the corresponding cells are adjacent to each other. From this a straight-line graph of connectivity is drawn. This corresponds to the continuous path generated by following the adjacent free cells from the start to goal point. These steps are used both in an exact cell decomposition method and an approximate cell decomposition method.

Approximate Cell Decomposition: This is a different approach to the cell decomposition as the recursive method is used to subdivide the cells until one condition arrives when: The cell lies either completely in free space or completely in the region of the obstacle or an arbitrary limit is reached. The cell is divided into four small cells of same shape each time it gets decomposed. After the decomposition free path is visible through the cells. This called the quad tree decomposition method also.

Figure: Cell decomposition method approaches

The Potential Field Approach: -This method involves modelling the robot as a particle moving under the influence of a potential field that is determined by set of obstacles and the target present. This method is actually very efficient as at any moment the motion of the robot is determined by the

Potential field at its location. Thus, the computed information gives the direct correspondence to the robot's motion and no computational power is wasted. This is a very powerful method as it easily gives the presence of the robot.

For example, potential fields are additive, adding a new obstacle is easy because the field for that obstacle can be simply added to the old one.

The Roadmap Approach: - This approach is dependent upon the concepts of workspace space and a continuous path. A set of 1D curves, each used to connect two nodes of different polygonal obstacles present in the free space R. That is, all line segments that connect a edges of one obstacle to a edges of another without entering the interior of polygonal obstacles .This set of paths is called the roadmap. If the continuous path is found in the free space R, the initial start point and the goal point are connected to this path to arrive to a final optimized solution

path. If more than one path is found then its optimized using Dijkstra's shortest path algorithm

There are various types of roadmaps, visibility graph, the Voronoi diagram used in this c. A visibility graph is shown below. The shaded areas represent obstacles. The solid lines are the edges of the graph and connect the vertices of the obstacles. The straight lines connect the beginning and end configurations with the roadmap. An example is a shown below.

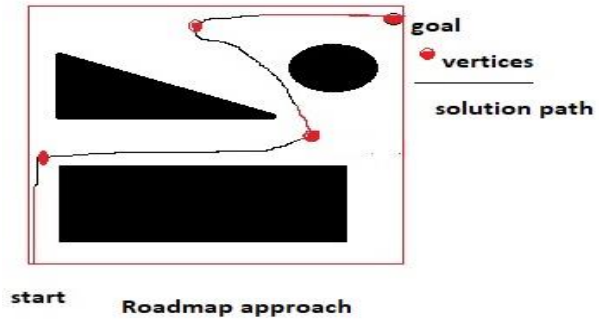

Figure: -Voronoi diagram

Path search algorithms: -The path search algorithms are classified into two categories: - heuristics approaches and the artificial intelligence approach

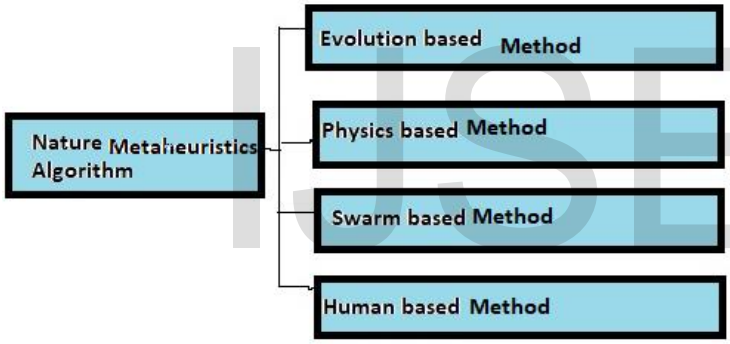

Figure: Classification of Nature inspired metaheuristics Algorithms

In the last few decades nature heuristics algorithms are emerging as a tool and alternative to traditional approaches.

Evolution based searches: These are basically inspired by the nature evolution initially a set of population is considered and then the process is studied based on stochastics eventually

Genetic algorithms Genetic algorithm (GA) is most popular evolution-inspired technique that imitated by the principles of Charles Darwin Theory of survival of the fittest [4]. This method involves the base process of selection, reproduction and crossover.

These three processes are performed by initializing a population basically chromosomes. Then each chromosome are test based on the fitness value related to the problem objective. This fitness value plays the role of the prime function to select the best out of the worst.

These selected chromosomes undergo the process of crossover till the worst combination are converted to the best.

The Genetic Algorithm (GA) begins by initializing population of chromosome. Then based on the fitness value best individual is selected into the mating pool, where they undergo crossover and mutation to produce a new set of solution. The GA plays an important role in generating the guidance plan for the missiles also. A novel methodology based on GA for the military and ocean domain is provided by iyer[] .They used GA to protect and identifying the GA to positioning strategy for underwater sensor network positioning and deployment.

Fuzzy Logic:- this is one of the most used concepts in the field of navigation .The concept was first introduced by Lotif Zadeh in 1965 and was the favourite topic of the researchers. Popularly used in the areas where the degree of uncertainty is high, complexity is more and the nonlinearity is present. Pattern recognition, decision making data classification, machine learning are the various areas in which this technique is highly used. The user trained rules like if then loops are used as sequences which are then converted into rules to their mathematical equivalents. The fuzzy-based strategy was applied for navigation of a humanoid robot in the 2D environment by Rath et al. []. The navigation in a 3D environment is one of the difficult tasks which is addressed using fuzzy logic for path planning of aerial robots, and underwater robots by Abbasi et al.

Artificial Neural Network:

The ANN is used to express the relationship of mapping relationship from the given workspace or perceptual. Artificial neural network is an intelligent system that consists of many simple and highly interconnected processing elements The Neural networks is basically consists large interconnected networks, which are well organized in the different level as input, hidden, output layers. The input layers identify the pattern and they then communicate with the hidden layers and do the actual processing using the weights attached to the networks. Hidden layer along with the output layer then transfers the answer. This ANN layers help in the learning ability and fault tolerance in the filed of autonomous robot navigation.

Firefly algorithm: Yang discovered the Firefly algorithm in 2008.the algorithm was inspired by the flashing behaviour of the fireflies. The principle of the FA algorithm comprises

1.Fireflies are unisexual insects so that one firefly gets attracted to other fireflies regardless of their sex.

2.The attractiveness is directly proportional to the brightness and it decreases as the distance between two insect increases. The fireflies with less brightness move towards the brighter flies, may one or more. In case if there are no brighter flies then these fireflies move randomly

3.The brightness of the files is determined by the objective function.

FA is used as the optimization tool for mobile robot navigation and in almost all the areas of engineering

Bacterial foraging optimization (BFO) algorithm: -Passino in 2002 introduce the new nature-inspired optimization algorithm based on the behaviour of the E. coli and M. Xanthus Bacteria. These Bacteria searches for nutrients by making the use of energy accumulated per unit time. These bacteria travels to the region where there is high amount of nutrients. Based on the level of chemotaxis they radiate certain signals which are used for communication. Chemotaxis, swarming, reproduction, and dispersal are the four main process involved.
BFO is mainly applied to the static environments in the robot navigation.

Ant colony optimization (ACO)

This is a swarm intelligence algorithm developed by Marco Dorigo in 1992 in his Ph.D. thesis []. It is a population-based approach used to solve the combinatorial optimization problem. The

ACO algorithm originated from the behavior of ants and its ability to find the shortest path from their nest to a food source

Conclusion: -

This study on motion planning helps to classify the existing methods into classical and reactive approaches. The main objective is reactive robot perform better than the classical approaches-based robots. They can handle the uncertainty in a better way. They can be preferred for real time navigation applications. There is newly developed algorithm such as BFO, FA, ACO HS, IWO, SFLA are more optimized in complex environment and handles uncertainty well by developing hybrid approaches

According to the literature survey, most of the researchers have applied nature inspired algorithm for mobile robot navigation mostly in the static environments, only few have used the dynamic approaches. Most of the analysis is done on a simulation-based environment rather than using real time robots. The hybridization of these algorithms leads to better choices in the area of innovations

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