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**JIMMA INSTITUTE OF TECHNOLOGY**

**SCHOOL OF COMPUTING AND INFORMATICS**

**DEPARTMENT OF COMPUTER SCIENCE**

**SECTION TWO**

**ARTIFICIAL INTELLIGENCE** **ASSIGNMENT**

**Title: Path planning strategy and navigation of service robot**

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## Introduction

In modern era, to lower the burden of labor on mankind effortlessly, physical tasks are being performed by machines which were considered to be done by human in the past. Nevertheless, there is a need of special thing that machines not only do physical tasks but also can think and make decision like human being. To make things intelligent and to get this target, artificial intelligence knowledge has got important consideration. Path planning has been considered as the most-common problem for robot navigation, robots have to move from starting position to goal position via avoiding obstacles. Robots like micro air vehicle, motion robot, wall-climbing robot and underwater robots have been tested with different algorithms.

Robot navigation is an essential issue in the field of robotics. They are known for them intelligence tendencies. They also cover wide range of applications, such as in transportation, industry, and rescue robots. Path planning is one of the most prominent and essential part of autonomous mobile robot navigation. For the past two decades, researchers are working on path planning problem for which several methods have been developed. Path planning involves the determination of collision-free path from one point to another while minimizing the total cost of the associated path. Depending on the nature of environment, path planning can be divided into static and dynamic environment. If obstacles change their position with respect to time, it is referred as static path planning and if obstacles change their position and orientation with respect to time, then it is referred as dynamic path planning. This knowledge can further be divided into online and offline algorithms. In online path planning, the information about surrounding is obtained from separately attached local sensor installed on robot, then robot construct the map of environment from the information being fed from the locally attached sensors. In offline path

planning, robot has complete information of surrounding environment without the aid of sensors.

Obstacle avoidance and path following are considered as basic problems in mobile robotic system.  
The purpose of navigation is to navigate through cluttered environment in search for optimal path  
from the start position to target position.

## Competencies for Navigation: planning and reacting

In the Artificial Intelligence community planning and reacting are often viewed as contrary approaches or even opposites. In fact, when applied to physical systems such as mobile robots, planning and reacting have a strong complementarity, each being critical to the other’s success. The navigation challenge for a robot involves executing a course of action (or plan) to reach its goal position. During execution, the robot must react to unforeseen events (e.g., obstacles) in such a way as to still reach the goal. Without reacting, the planning effort will not pay off because the robot will never physically reach its goal. Without planning, the reacting effort cannot guide the overall robot behavior to reach a distant goal- again, the robot will never reach its goal.

An information theoretic formulation of the navigation problem will make this complementarity clear. Suppose that a robot *R* at time M*i* has a map and an initial belief state bi. The robot’s goal is to reach a position *p* while satisfying certain some temporal constraints: locg(R)=p;(g≤n). Thus, the robot must be at location *p* at or before timestep *n*. Although the goal of the robot is distinctly physical, the robot can only really sense its belief state, not its physical location, and therefore we map the goal of reaching location *p* to reaching a belief state bg, corresponding to the belief that. With this formulation, a plan *q* is nothing more than one or more trajectory from bi to bg. In other words, plan *q* will cause the robot’s belief state to transition from bi to bg, *if the plan is executed from a world state consistent with both bi and Mi.*In order to reach its goal nonetheless, the robot must incorporate new information gained during plan execution. As time marches forward, the environment changes and the robot’s sensors gather new information. This is precisely where reacting becomes relevant. In the best of cases, reacting will modulate robot behavior locally in order to correct the planned upon trajectory so that the robot still reaches the goal. Of course, at times, unanticipated new information will require changes to the robot’s strategic plans, and so ideally the planner also incorporates new information as that new information is received.

**Robotic Navigation**

Navigation of a robotic system incorporates various techniques and means of gathering information.  
Most notably, any one of many path finding/ path planning algorithms are likely to be used to assists  
in initializing the location of the robot and determining the next move. Navigation in the realm of  
robotics also includes object detection and avoidance. Object avoidance is often referenced when  
discussing Robot human interaction, or HRI. Being able to determine whether an object will interfere  
in the path that the robot is taking is imperative to the safety of the equipment and anyone around, as  
well as for the success of the navigation. Obstacles such as walls are referred to as static obstacles, whereas those that are moving, such as humans on a sidewalk, are considered dynamic obstacles. We  
will discuss techniques for determining and avoiding both classifications of obstacles within this paper.

**Path Planning strategy**

The planning of a path taken by a robot in a closed environment, can be done in various ways.

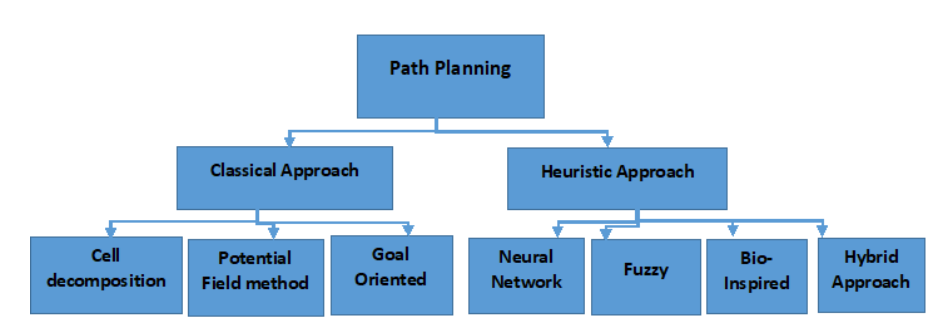
Path planning is an important primitive for autonomous robot to find the optimal path between source and goal. Optimal path is a path that reduces the translation and rotation, while navigating from source to goal. Moreover, the obstacles present in the given environment are being avoided.  
It requires a map of environment and location with respect to map. Path planning mainly based on two techniques:

* Local path planning
* Global path planning

Local navigation is based on high resolution and sensors are used to find ranges. In local method, no prior information is available and also the map of environment is not predefined. It works for the dynamic environment. In global navigation is based on low resolution, where prior information is available  
and map of environment is predefined. It is adequate only for static environment. Both approaches have inefficiencies, so by combining the two to get suitable results. Robot path planning problem can be classified as

(i)Classical approach and

(ii) Heuristic approach. That can further divide into different categories.



1. *Classical Approach*

Classical approaches are used in motion planning and easier to implement. They show better results in cell decomposition, potential field method and goal-oriented method. Classical algorithms require exact information about their working environment. Moreover, sensors are required for real analysis.

The classical method is further sub-divided into: (i) Cell decomposition method (ii) Potential field method and (iii) Goal oriented method.  
 **Cell decomposition method:**

In this method is used to find free space and occupied space between geometric area and the region divided into small region known as cell. The objective of this algorithm is to reach the goal safely. In proposed path planning technique, the robot reaches to goal by avoiding obstacles present in the path. The basic path planning algorithm based on cell decomposition as following steps:  
1. Segregate F into fundamental, related territories called” cells”.  
2. Besides, make sense of which opens cells are adjoining and build up an” accessibility graph”.  
3. Thirdly, find the cells wherein the hidden and target setups untruth and output for a route in the accessibility graph to join the fundamental and target cell.  
4. At last, from the gathering of cells found with a suitable calculation, figure a path inside each cell, for instance, experiencing a progression of divider following developments or by the midpoints of as far as possible and improvements along straight lines. Cell decomposition is categorized as Exact cell Decomposition, if structure of environment has assigned cell border as function and there is lossless decomposition. Approximate cell decomposition, when the border assignment is approximate and there is loss of information. Probabilistic cell decomposition, which is similar to approximate but have no physical meaning.

**Potential field method**

In this method repulsive and attractive forces are assign to target and obstacles. An attractive field is generated which moves inward to goal. In each time stamp a different potential field is generated across the free space. Also, calculate potential field at different position of robot and force induced by the field is also calculated. So, by induced force the robot moves and successfully avoid the obstacles. The obstacles produce repulsive field around it. the force moves the robot away from the obstacles. When obstacle is detected nearby, new approach of potential field repulsion is applied.

Attractive/Repulsive potential field is given by:

U(q) = Uatt(q) + Urep(q)

where U(att) is attractive potential field moves toward target and U(rep) is repulsive potential field to avoid obstacles.

Uatt = 1/2δ.P m.(q; qtarget)

Urep = 1/2α(1/P (q; qobs) – 1/P0)2P n(q; qtarget)

where delta is scaling factor.

**(iii) Goal oriented method:**

In this method, sonar range sensor is used for path planning and robot configuration. Obstacles are avoided while moving toward target. It is based on the method where map of environment is predefined.

## Heuristic approach

Heuristic approach works in the environment, where no prior information about obstacle and environment is available. The nature of obstacles and navigation environment change constantly. These algorithms achieve best optimal solution by bio-inspired algorithms. Different techniques under heuristic approach are neural network, fuzzy logic and various bioinspired algorithms. Hybrid approaches like neural network, fuzzy logic, particle swarm optimization and ant colony method provide smoothness functions.

Heuristic approach is further sub-divided into:

1. **Neural network approach:**  
   This approach is used for path planning and obstacle avoidance. It has number of hidden layers and works in populated environment. It avoids the obstacles present in the path irrespective of their size. A neural network-based model is trained to control the robot navigation in such open environment. And also check the performance of neural network in different environment. Neural network broadly uses to implement motion planning in auto guided robot. Path planning can be done by Principal component analysis (PCA) and multiple perceptron learning (MPL) algorithms. A new technique known as dynamic wave expansion (DWENN) proposed by Lebedev et al. It works in the environment where no prior information is available. The major limitation of NN is that it consumes more time as compare to other techniques. Moreover, it always not provides efficient results.
2. **Fuzzy logic:**  
   Fuzzy logic was proposed by Lotfi zadeh in 1965. The idea behind fuzzy logic is to represent human thinking which is not represented in crisp logic. It is based on IF-THEN fuzzy rules and based on membership functions. For example, to measure the height like very small, short, tall and very tall. To implement this problem is divided into simpler sub-tasks. Fuzzy controllers are used for input output mapping. These controllers are also used for obstacle avoidance
3. **Bio- Inspired algorithms:**  
   Algorithms based on biological behavior are known as bio-mementic approach. The proposed mementic algorithm is based on global path planning. Mementic algorithm is a collaboration of genetic algorithm for path planning and path improvement. The robot has to find next location, to reach the objective irrespective of time and distance travelled. These are further categorized as Genetic algorithms, particle swarm optimization algorithms and Ant colony optimization algorithm. Every one of these aforementioned techniques has its own points of interest and detriments. The problem is examined in both static and dynamic environments. Algorithm is tested in different simulated and real world. It is based on multi- objective of path planning. It is based on Learnable evolutionary algorithm, which determines the correct direction by using machine learning and also, find the fitness function. Various operators are used to find the optimal path, that is length, safety and smoothness. Robot avoid obstacles and also find optimal path by using this algorithm. **(a) Genetic algorithms:** Genetic algorithm is a technique based on natural genetics and is based on operators like crossover, mutation and natural selection. This technique was proposed in 1975 by Professor J.Holland from Michigan University. Hereditary calculation is to copy the possibility of the survival of the fittest, it recreates the methodology saw in a trademark structure where the stronger has ability to survive and endure while the weakest tends to pass on or die. Another population is created by using operators. In each generation of genetic algorithm, path improvement is applied. The smoothness function is calculated through path length and smoothness function. This shows better results as compare to other algorithms [35]. The population is a sequence of strings known as chromosomes. The chromosomes are selected based on fitness function, which define target capacity and pure pursuit issue. The three operator works iteratively until a termination condition is applied. Various methods have been created in path planning, for moving robots around the world. It can also work for multi-robotics system. In [31], the author explains the robot navigation in populated environment. Where both static and dynamic obstacles are present irrespective of their size and shape. **(b) Particle swarm optimization Technique** Particle Swarm Optimization (PSO) is a population-based investigation technique. This technique is widely used in artificial intelligence. The nature of this algorithm is based on movement of flock of birds in search of food. PSO perform arbitrary populace and use target capacity to produce particles. Initially particles are randomly generated to form population. The particles travel in search space and each time update their location. To evaluate the velocity by using fitness function, which is based on real numbers.
4. **Hybrid approach:**  
   It is combination of more than two approaches for better results or to improve the limitations of existing systems. For example, in nature inspired algorithm, genetic algorithms, expert system, fuzzy logic and neural network are combined for better performance. Global path planning and obstacles are avoided successfully. The aim of the proposed work in is to develop a hybrid system by combining neural network, fuzzy logic, genetic algorithm and expert system. The hybrid system was able to deal with vehicle in unknown environment by using hybrid intelligent system. This approach generates a path from source to goal by avoiding obstacles present in the path. It provides better results. Where in hybrid approach is based on global path planning and obstacle avoidance. It uses Distance transformation technique for path planning and Gilebert-Johnson-Keerthi approach for obstacle avoidance. In path planning can be done through hybrid approach by using wireless sensor network. It is based on multi-robotic system. It makes use of known environment map for path planning. In a hybrid approach that particularly deals with navigation of robot in partially unknown environment. Two approaches are combined here. The hybrid approach is combination of trajectory tracking and reactive navigation. Robot navigates in efficient time and has ability to deals with unknown environment. Fuzzy controllers are used for input and output mapping.