Literature Review on Path planning in Dynamic Environment

[1]Bhushan Mahajan, [2]Punam Marbate

[1] Department of Computer Science and Engineering
G.H.Raisoni College of Engineering, Nagpur

[2] Department of Computer Science and Engineering
G.H.Raisoni College of Engineering, Nagpur

Abstract

Path planning is the key task in the field of Robotics. The modelling environment and algorithm to find shortest, collision free path are the basic issues in the path planning problem of the robot motion planning. This paper presents a literature review of different path planning techniques in static as well as dynamic environment. Planning a path in static environment is easy as compared to dynamic environment where the obstacles are moving. There is a need to develop such an effective technique for path planning in dynamic environment. Also a comparative study of different path planning techniques is provided in the paper. Paper mainly focuses on different path planning techniques according to parameters used in method for finding shortest path.

Keywords: *Voronoi Diagram, Dynamic path planning*

1. Introduction

Mobile robots are expected to work in many places such as factories, offices and so on. Now a days, autonomous mobile robots used in the environment where many human beings are working, cooperating with robots. In these environments, the collision-free path planning is one of the major problems to realize autonomous mobile robots. Since there are many stationary/moving obstacles in these environments, autonomous mobile robots should plan their own path that can avoid not only stationary obstacles but also moving ones such as human workers and other robots.

There are various methods available for path planning in the field of robotics, but planning or Finding a path which is collision free, shortest and optimal is recent requirement for a robot or in the field of robotics. Much of the work has been discovered for generating path in static environment where the obstacle in the environment are stationary But According to Today's scenario it should be clear that a robot has to find path up to target efficiently when there are moving obstacles present in the environment.

Fig 1. Represents the classification of the techniques for path planning in robotics. The Robot motion planning is basically divided into two main categories i.e. Path planning in Static environment and Path planning in Dynamic environment. In our literature review, main focuses is on path planning in Static and Dynamic Environment using Graph based modelling. The Several methods used for motion planning in dynamic environment are Artificial potential Field approach, methods based on fuzzy logic, biologically inspired methods, and a graph theoretic approach. The graph theoretic approaches used for both static as well as dynamic environment.

The Graph based representation of the robot working environment is one of the earliest and powerful attempts for creating maps of agents world for the purpose of safe path planning. The graph representation is basically used to connect all the available free spaces of the given field (places that are obstacle free) via a connected set/network of lines. so as to provide a path for robot for performing safe ,target oriented, collision free motion. Such a network is used for motion planning in robotics. The available free spaces are generally considered as vertices of graph whose edges are in fact a network of connected lines. Graph based representation is then used to find shortest, obstacle free path from robot's current location up to target point. Some of the limitations that are due to graph based representation are

- Time complexity in creation of graph as there is increment in robot's field of operation.
- Vulnerability against uncertainty introduced by the application of moving/movable objects.

From research point of view in the dynamic environment where the obstacles are moving leads to new aspect of the path planning problems.

1.1 Path Planning Algorithm

Various approaches, algorithm have been proposed for path planning are according to environment, type of sensor, robot capabilities and etc, these approaches are gradually toward better performance in term of time, distance, cost and complexity.

It is prerequisite that a successful algorithm needs to be convergent. That is, it needs to find a path to the goal if such a path exists. If no such path exists, it must stop and inform the user that the target is unreachable. If an algorithm is convergent, it is then assessed on the following attributes:

- **Path Length:** The distance of the path from start to finish. This should be as short as possible.
- **Computation time:** The algorithm's total execution time excluding time spent driving. This should be as short as possible and is driven by the following sub attributes.
- **Number of calls to the math-library:** A factor which affects computation time is the number of calls to the math library.
- **Computation time per metre travelled:** Algorithms which have a short path length carry this advantage into computation time calculations. Calculating computation time per metre travelled removes this advantage.
- **Rotation:** The amount of turning which is performed along the path from start to finish. This should be as low as possible.
- **Inherent rotation:** Some rotation is hardware dependant and this is filtered out in this measurement.
- **Robustness:** The algorithm's ability to tolerate PSD error, linear driving error and rotational driving error. This should be as high as possible.
- **Memory requirements:** The amount of global memory reserved by the algorithm. This should be as low as possible.
- **Simplicity:** This is measured by the lines of code required for implementation. This should be as low as possible.

Mobile robot path planning has a few main properties according to type of environment, algorithm and completeness. The properties are whether it is static or dynamic, local or global and complete or heuristic. The static path planning refers to environment which contains no moving objects or obstacles other than a navigating robot and dynamic path planning refers to environment which contains dynamic moving and changing object such as moving obstacle. Meanwhile the local and global path planning depend on algorithm where the information about the environment is a priori or not to the algorithm. If the path planning is a global, information about the environment already known based of map, cells, grid or etc and if the path planning is a local, the robot has no information about the environment and robot has to sense the environment before decides to move for obstacle avoidance and generate trajectory planning toward target.

In this paper, we will discuss the different methods available for path planning in the static as well as dynamic environment which uses the geometrical structure for modelling environment i.e.voronoi diagram. Section 2 defines the path planning methods for static environment which effectively uses voronoi diagram with combination of other techniques. Section 3 describes different methods used for path planning in dynamic environment using voronoi diagram. Section 4 gives the comparative study of different method used for Path planning in static as well as dynamic environment. Finally, Section 5 provides concluding remark that why there is need of new technique for path planning in dynamic environment.

2. Path Planning in Static Environment

Path planning in static environment is moving a robot from start to goal position where the obstacles are stationary. In static environment, mobile robots reach to the destination by sensing the obstacles coming across, to get an optimal solution with minimum cost. Following are few methods for static path planning.

One of the method was Mobile Robot Navigation using Voronoi Diagram and Fast Marching [2] does path planning in two steps. First it creates voronoi diagram by extracting safest areas in the environment and second step is the Fast Marching method that applied on Voronoi diagram. Here it uses parameter for path planning as Senser frequency. Path planning in Robot Navigation using Tube Skeletons structure and Fast Marching[3].Basically, it is a new sensor based non-holonomic Path Planner which consist of the global motion planning and local obstacle avoidance capabilities. In the first step the safest areas in the environment are modelled by means of a tube skeleton similar to a Voronoi diagram but with tubular shape. In the second step Fast Marching Method is applied to the tube skeleton extracted areas in order to obtain the best path in terms of smoothness and safety.This method uses sensor frequency, Non-homonymic constraint on robots for path planning.

Path Planning based on Voronoi Diagrams and Genetic algorithms[4] method was proposed for static path planning.In this method, the path planning is based on Voronoi diagrams, where obstacles in the environment are considered as the generating points of the diagram and the environment is static, and a genetic algorithm is used to find a path without collisions from the robot source to target position.It uses Fitness function which consider the length, safety and smoothness of the path for path planning.

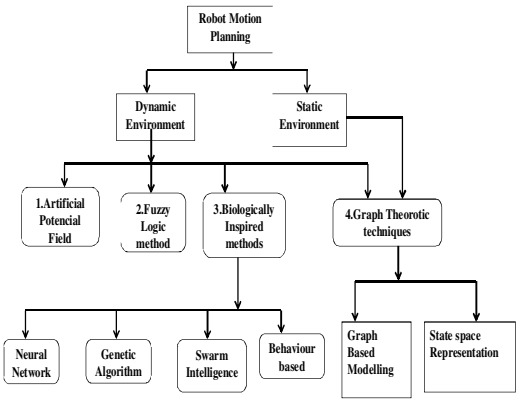

Fig 1.Classification of Path Planning Techniques

3. Path Planning in Dynamic Environment

A lots of work exist on path planning in Dynamic Environment with Moving obstacles Depending upon availability of information about the moving obstacles. The path Planning Algorithms are divided into two main categories. In First category, the information about the movement of obstacle are known in prior to the robot. So, path planned in this category must be safest path which can be obtained by avoiding collision. In the second category, movement of obstacles are unknown to robot,so a strong method should be there for optimal path planning.Here are some path planning techniques in dynamic environment listed below. One of the method was Path Planning for Unmanned Vehicles using Ant Colony Optimization with Dynamic Voronoi Diagram[5] uses Dynamic voronoi diagram for modelling dynamic environment and then Ant colony optimization is applied on obstacle geometry described by the above obtained Voronoi diagram for finding shortest path between source and destination. The combination of Voronoi and ACO approach is expected to provide semi-optimal paths adaptively to a dynamically changing environment. Here Ant strategy used in Ant colony optimization, transition probability from Voronoi vertexes , pheromone intensity of each Voronoi edge.

Roadmap-Based Path Planning Using the Voronoi Diagram using parameter Clearance-Based Shortest Path[6] was proposed by Priyadarshi Bhattacharya and Marina L. Gavrilova which creates a roadmap from the Voronoi Diagram and path planning is based on roadmaps. Optimal path is obtained from different paths using minimum clearance criteria. a minimum clearance value is initially set by user.Here it finds the quality path based on clearance from obstacles, overall length and smoothness

One more method was proposed which uses Probabilistic roadmaps (PRM) method[7] for path planning which is sample based approach, that finds the optimal path by modelling the environment which created through the valid set of positions. It present a sampling-based technique that allows generalizing the problem to an arbitrary partitioning of the environment, then shows how PRMs can exploit this method using Voronoi diagrams. In this method Probability values assigned to each partition and to the edges connecting partitions in the voronoi diagram. Amit Kumar Pandey and Rachid Alami [8] proposed Path Planning method in Human-Centered Dynamic Environment where it uses voronoi diagram for analysis of local clearance and environment structure. This method treats human from the obstacles. the robot constructs different sets of regions around human and iteratively converges to a set of points (milestones), using social conventions, human proximity guidelines and clearance constraints to generate and modify its path smoothly.here Milestone which consist of current position of the robot, predicted position and orientation of the human , immediate next milestone in the robot's current path, the minimum lengths of *Interesting Boundary Lines(IBLs)* on left and right sides of human predicted position.

One more method [9] Multi-agent Navigation Graph (MaNG) data structure using voronoi diagram for Path Planning proposed for multiple robots where it uses a new data structure, *Multi-agent Navigation Graph* (MaNG), which is constructed from the first- and second-order Voronoi diagrams.MaNG perform route planning and proximity computations for each agent in real time dynamically. Potential field is computed for a small number of groups of agents moving with common goals.

4. Comparison Between Path Planning Techniques

We have discussed different path planning algorithm in static and dynamic environment. Following table shows the effectiveness between those methods according to their features. Depending on the recent requirements methods get modified day by day as per the changing environment, different parameters regarding to mobile robot. According to results stated in the above methods their effectiveness in terms of percentage given in the following table. This percentage shows how much the proposed method efficient in finding path in terms of time.

S. N.	Name of Technique	Environment	Features	Effective-ness in path planning
1.	Path Planning for Mobile Robot Navigation using Voronoi Diagram and Fast Marching	Static	obtained trajectories are smooth and safe	50%

2.	Robot Navigation using Tube Skeletons and Fast Marching	Static	non-holonomic restrictions, such as steering angle limits, can easily incorporate inalgorithm and still generates smooth trajectories	60%
3.	Real Path Planning based on Genetic Algorithm and Voronoi Diagrams	Static	Increases Efficiency & computational Time decreases	70%
4.	Path Planning for Unmanned Vehicles using Ant Colony Optimization on a Dynamic Voronoi Diagram	Dynamic	ACO exhibits attractive adaptability and robustness to dynamically changing environments	65%
5.	Roadmap-Based Path Planning Using the Voronoi Diagram for a Clearance-Based Shortest Path	Dynamic	Due to Clearence from obstacle method is more effective in terms of speed quality	85%
6.	A Sampling-Based Approach to Probabilistic for Path Planning	Dynamic	online and robust to the number of timesteps between updates and the capabilities of the evader	60%
7.	Path Planning in Human-Centered Dynamic Environment	Dynamic	Flexible & differently identifies obstacle from any any individual	55%

5. Conclusion

In this paper, we have presented a review on different path planning algorithms in static as well as dynamic environment. As it is observed from the review that planning path in dynamic environment is tricky as compared to static since movement of obstacles is not known in prior. From the above Study we concluded that still there are various methods available for planning path in different environment but there is need to develop a new technique that will results into formation of more optimal path in Dynamically changing environment. We are planning to find such an effective method for path planning in dynamic environment with effective use of graphical based representation such as Voronoi diagram. Voronoi diagram is a strong geometrical structure for representing or modelling any environment and with this we can easily generate paths.

References

[1] Soheil Keshmiri, Shahram Payandeh, “Mobile Robotic Agents’ Motion Planning in Dynamic Environment: a Catalogue”, report presented in Experimental Robotics Laboratory, School of Engineering Science, Simon Fraser University,April 2009.

[2] Santiago Garrido, Luis Moreno, Mohamed Abderrahim, Fernando Martin, “Path Planning for Mobile Robot Navigation using Voronoi Diagram and Fast Marching”, in International Conference on Intelligent Robots and Systems Beijing, China , 2006.

[3] Santiago Garrido, Luis Moreno, M. Abderrahim and D. Blanco, “Robot Navigation using Tube Skeletons and Fast Marching”,Advanced Robotics,ICAR 2009.

[4] Facundo Benavides, Gonzalo Tejera ,Martín Pedemonte , Serrana Casella, “Real Path Planning based on Genetic Algorithm and Voronoi Diagrams”, Robotics Symposium, 2011 IEEE.

[5] Yaohang Li, Tao Dong, Marwan Bikdash, Yong Duan Song,” Path Planning for Unmanned Vehicles using Ant Colony Optimization on a Dynamic Voronoi Diagram”, in International Conference on Artificial Intelligence, ICAI , Las Vegas, Nevada, USA 2005.

[6] Priyadarshi Bhattacharya and Marina L. Gavrilova,” Roadmap-Based Path Planning Using the Voronoi Diagram for a Clearance-Based Shortest Path”, IEEE Robotics & Automation Magazine ,JUNE 2008.

[7] Priyadarshi Bhattacharya and Marina L. Gavrilova,”Voronoi diagram in optimal path planning”, 4th International Symposium on Voronoi Diagrams in Science and Engineering (ISVD 2007),IEEE 2007.

[8] Aditya Mahadevan and Nancy M. Amato,” A Sampling-Based Approach to Probabilistic Pursuit Evasion”, IEEE International Conference on Robotics and Automation RiverCentre, Saint Paul, Minnesota, USA,2012.

[9] Amit Kumar Pandey,Rachid Alami,” A Framework towards a Socially Aware Mobile Robot Motion in Human-Centered Dynamic Environment”, The 2010 IEEE/RSJ International Conference on Intelligent Robots and Systems October 18-22, 2010, Taipei, Taiwan.

[10] Sriramula, Narasimha Rao, and Md Murtuza Ahmed Khan. "Throughput Maximization Using Portfolio Selection and Jamming-Aware Routing Algorithm." International Journal of Computer Science 1.

[11] Avneesh Sud, Erik Andersen, Sean Curtis,Ming Lin ,Dinesh Manocha, “Real-time Path Planning for Virtual Agents in Dynamic Environments”, IEEE Virtual Reality Conference, , Charlotte, North Carolina, USA,2007.

[12] Ms.Punam T. Marbate, received BE(2009) degree from Nagpur university, Ramdeobaba kamala Nehru engineering college,Nagpur.Currently pursuing M-Tech from G.H.Raisoni College of engineering , An autonomous institute affiliated to Nagpur University.One year teaching Experience in K. D. K. polytechnic Nagpur.Member of CSI society.