1 Introduction

While performing navigational tasks, robotic systems, such as AVs, make use of capabilities that involve modeling the environment and localizing the system's position within the environment, controlling motion, detecting and avoiding obstacles, and moving within dynamic contexts ranging from simple to highly complicated environments. One of the main problems of navigation is path planning

Path planning has attracted attention since the 1970s, and, in the years since, it has been used to solve problems across fields from simple spatial route planning to the selection of an appropriate action sequence that is required to reach a certain goal.Path planning can be used in fully known or partially known environments, as well as in entirely unknown environments where information is received from system-mounted sensors and update environmental maps to inform the desired motion of the robot

Path planning algorithms generally try to obtain the best path or at least an admissible approximation to it. The best path here refers to the optimal one,that optimal path will be decided based on a constraints and conditions, for example, considering the shortest path between end points or the minimum time to travel without any collisions. Sometimes constraints and goals are mixed, for example seeking to minimize energy consumption without causing the travel time to exceed some threshold value

Path planning algorithms are differentiated based upon available environmental knowledge so in order to simplify the path planning problem and ensure that the robot runs/moves smoothly while avoiding obstacles in a cluttered environment, the configuration space must be matched with the algorithm being used and selecting the most appropriate approach can be a challenging task

2 Path Planning Algorithms

planning algorithms is selected according to the available information in the current state and used criteria such as the shortest distance measures to the target point using Euclidean distance computation.some of the notable algorithms are Dijkstra's and A* for finding efficient routes in weighted graphs, RRT and PRM for complex spaces, and local navigation techniques like the Velocity Obstacle and Dynamic Window Approach for real-time obstacle avoidance. These algorithms vary in their approaches, efficiency, and suitability for different scenarios, enabling machines to navigate autonomously

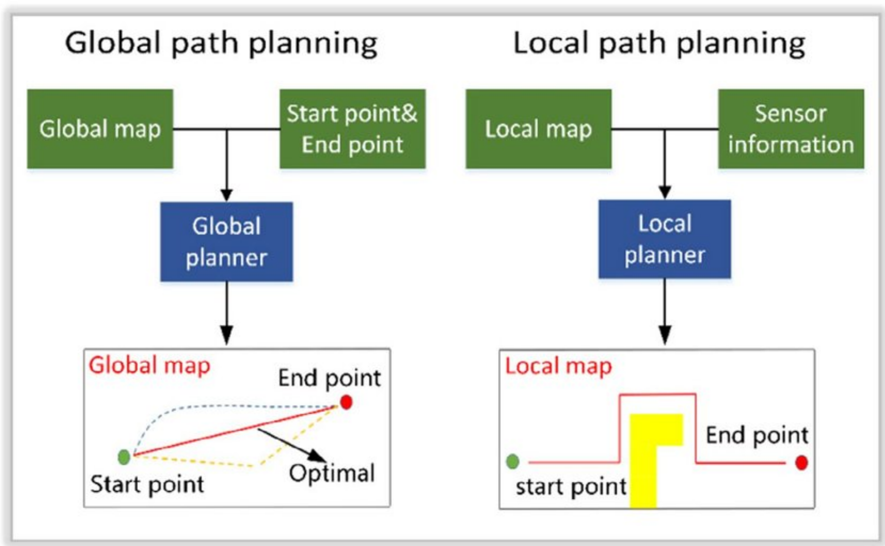

Figure 1: Global and Local path planning

in diverse and dynamic environments by combining global path planning for overall routes and local path planning for real-time obstacle avoidance and trajectory adjustment.

Path planning algorithms are classified based on various criteria, including their underlying principles, problem types, and application domains. there are some common classification: Deterministic and Probabilistic algorithms, static and dynamic path planning, Grid-Based and graph-based algorithms and optimal and suboptimal algorithms but generally the most common types of algorithms are global and local path planning

2.1 Global path planning

In Global path planning the environment is static, and its global information is known a priori in the control design. This approach is expensive in implementation and relatively well studied in the existing literature.

Global path planning focuses on finding an overall route from the starting point to the destination, considering the entire environment and its features, such as obstacles, terrain, and roads.here are some of its Characteristics:

- It operates on a high-level map or representation of the environment.

- Global planners typically use algorithms like A* (A-star), Dijkstra's algorithm, or potential fields to compute a path that optimizes certain criteria, such as distance, time, or energy consumption.
- The output is a series of waypoints or key poses that guide the robot or vehicle through the environment

2.2 Local path planning

In local path planning the path is generated by taking data from the sensors during the movement of the robot. Therefore, a robot can generate a new path to respond to a new environment. This method is more complicated in design but more applicable in practice.

Local path planning focuses on generating a path or trajectory that guides the robot or vehicle through the immediate vicinity, typically within a few meters or seconds of travel. Its primary goal is to navigate around obstacles that were not accounted for in the global plan..here are some of its Characteristics:

- It operates on a more detailed, local map or sensor data, often updated in real-time.
- Local planners take into account the robot's current state, such as its position, orientation, and velocity.
- The output is a path or trajectory that can be executed by the robot's control system to avoid immediate obstacles.

2.3 Some algorithms

Few of the common algorithms include Dijkstra's and A* for finding efficient routes in weighted graphs, RRT and PRM for complex spaces, and local navigation techniques like the Velocity Obstacle and Dynamic Window Approach for real-time obstacle avoidance. These algorithms vary in their approaches, efficiency, and suitability for different scenarios, enabling machines to navigate autonomously in diverse and dynamic environments by combining global path planning for overall routes and local path planning for real-time obstacle avoidance and trajectory adjustment.

3 Challenges and Future Trends

The field of path planning faces several challenges and is poised for significant future trends. Challenges include addressing real-time planning in dynamic environments with unpredictable obstacles, ensuring

safety and robustness in complex scenarios, and optimizing computational efficiency for resource-constrained platforms. Additionally, handling high-dimensional state spaces and incorporating uncertainty in planning remain important issues.

Future trends in path planning involve the integration of machine learning techniques to learn from data and adapt to changing environments, the development of more efficient and scalable algorithms, and the fusion of multi-modal sensor data for improved perception. Decentralized and swarm-based planning strategies are also emerging, enabling coordination among multiple agents. Furthermore, ethical considerations and regulatory aspects will become increasingly important as autonomous systems become more prevalent, necessitating the development of standards and guidelines for safe and responsible path planning in various applications, from autonomous vehicles to industrial automation.

4 Applications

Path planning has a wide range of practical applications across various domains. In autonomous robotics, it enables robots to navigate cluttered environments, perform tasks like warehouse automation, and assist in search and rescue missions. In self-driving cars, path planning is vital for route optimization, collision avoidance, and ensuring passenger safety. The aviation industry relies on path planning for aircraft navigation, optimizing flight routes, and ensuring airspace safety. In manufacturing, it facilitates the movement of robots and automated vehicles in production lines, optimizing resource utilization. Path planning is also crucial in the field of video game design, where non-player characters (NPCs) need to navigate virtual environments realistically. Moreover, it plays a pivotal role in logistics and supply chain management, where efficient routes for delivery vehicles can save time and resources. Overall, path planning is a fundamental technology with diverse applications, making it an essential component of modern automation and navigation systems.

5 Conclusion

Recent years have seen the rapid growth of artificial intelligence in driverless vehicles and other automated mobile systems. As a result, the amount of research into path planning has increased dramatically.path planning is an indispensable pillar of autonomous systems that continue to transform industries and shape our technological landscape. Its applications, ranging from robotics and self-driving

vehicles to logistics and video games, exemplify its versatility and impact. As we venture into an increasingly interconnected and automated future, the evolution of path planning will be pivotal. Anticipated trends such as the integration of machine learning, improved efficiency, and ethical considerations underscore the dynamic nature of this field. With each advancement, path planning not only propels innovation but also empowers us to navigate the complexities of our world with greater precision and efficiency, ultimately leading us towards a safer, smarter, and more efficient future.

6 References

1 Zheng, C.; Green, R. Vision-based autonomous navigation in indoor environments. In Proceedings of the 2010 25th International Conference of Image and Vision Computing New Zealand, Queenstown, New Zealand, 8–9 November 2010; pp. 1–7. [CrossRef]

2 Sariff, N.; Buniyamin, N. An Overview of Autonomous Mobile Robot Path Planning Algorithms. In Proceedings of the 2006 4th Student Conference on Research and Development, Shah Alam, Malaysia, 27–28 June 2006; pp. 183–188. [CrossRef]

3 Sariff, N.; Buniyamin, N. Ant colony system for robot path planning in global static environment. In Proceedings of the 9th WSEAS International Conference on System Science and Simulation in Engineering (ICOSSSE'10), Takizawa, Japan, 4–6 October 2010; pp. 192–197.

4 Zhang, H.Y.; Lin, W.M.; Chen, A.X. Path planning for the mobile robot: A review. Symmetry 2018, 10, 450. [CrossRef]