# Path planning

Ahmed Frag

September 7, 2023

**Table of content**

## path planning

Path planning is the process of finding a feasible path from a start node to a goal node in a map or grid without colliding with obstacles on the way. It is a fundamental problem in robotics and autonomous systems, and it requires mobile robots to be equipped with sensors, on-board computers, and motion systems to plan and move. In this article, we will cover the basics of path planning, the types of path planning algorithms, local and global planners, challenges and future trends in path planning, practical applications of path planning, and resources for further learning.

## Introduction to Path Planning

Path planning is a critical task in robotics and autonomous systems, as it enables robots to navigate in complex environments and perform tasks efficiently. The goal of path planning is to find a feasible path from a start node to a goal node while avoiding obstacles on the way. Path planning algorithms can be classified into two categories: search-based algorithms and sampling-based algorithms.

Search-based algorithms, such as $A*$ and $D*$, use a search tree to explore the space of possible paths and find the optimal path from the start node to the goal node. These algorithms are efficient for small to medium-sized environments but can be computationally expensive for large environments.

Sampling-based algorithms, such as Rapidly-exploring Random Trees (RRT) and Probabilistic Roadmap (PRM), use random sampling to generate a set of feasible paths and connect them to form a roadmap. These algorithms are efficient for high-dimensional spaces and can handle complex environments with many obstacles.

## 2 Types of Path Planning Algorithm

### 1.1 A* algorithm

A* is a search-based algorithm that combines the advantages of Dijkstra's algorithm and greedy best-first search. It uses a heuristic function to estimate the distance from the current node to the goal node and chooses the path with the lowest estimated cost. A* is widely used in robotics and autonomous systems for path planning.

### 1.2 RRT algorithm

RRT is a sampling-based algorithm that generates a tree of feasible paths by randomly sampling the configuration space. It is useful for applications where the environment is complex and the robot needs to explore a large area to find a feasible path.

### 1.3 dijkstra algorithm

Dijkstra's algorithm is a search-based algorithm for finding the shortest path between nodes in a weighted graph, which may represent road networks or other applications. It was conceived by computer scientist Edsger W. Dijkstra in 1956 and published three years later. The algorithm works by maintaining a set of unvisited nodes and a set of tentative distances to each node. Dijkstra's algorithm uses a data structure for storing and querying partial solutions sorted by distance from the start. The algorithm can be extended with a variety of modifications, and it is widely used in robotics and autonomous systems for path planning.

### 1.4 PRM algorithm

Dijkstra's algorithm is a search-based algorithm for finding the shortest path between nodes in a weighted graph, which may represent road networks or other applications. It was conceived by computer scientist Edsger W. Dijkstra in 1956 and published three years later. The algorithm works by maintaining a set of unvisited nodes and a set of tentative distances to each node. Dijkstra's algorithm uses a data structure for storing and querying partial solutions sorted by distance from the start. The algorithm can be extended with a variety of modifications, and it is widely used in robotics and autonomous systems for path planning.

## 3 Local planner and Global planner

Path planning algorithms can be divided into two categories: local planners and global planners. Local planners generate a path from the current position of the robot to the next waypoint, while global planners generate a path from the start node to the goal node.

Local planners are used for short-term navigation and can handle dynamic obstacles and changes in the environment. They are typically reactive and can quickly adjust the robot's path to avoid obstacles and reach the next waypoint.

Global planners are used for long-term navigation and can handle static obstacles and complex environments. They generate a complete path from the start node to the goal node and optimize it for efficiency and safety

## 4 Challenges and Future Trends in Path Planning

### 4.1 common challenges

- High-dimensional spaces: Path planning algorithms must handle high-dimensional spaces efficiently and avoid the curse of dimensionality.
- Dynamic environments: Path planning algorithms must handle dynamic obstacles and changes in the environment and adjust the robot's path accordingly.
- Uncertainty: Path planning algorithms must handle uncertainty in the robot's sensors and motion systems and generate robust and safe paths.

### 4.2 future trends

- Learning-based approaches: Path planning algorithms can be improved using machine learning and deep learning techniques to learn from data and improve their performance.
- Multi-agent path planning: Path planning algorithms can be extended to handle multiple robots and coordinate their paths to avoid collisions and optimize efficiency.
- Human-robot interaction: Path planning algorithms can be improved to handle human-robot interaction and generate paths that are safe and intuitive for humans.

## 5 Practical Applications of Path Planning

Path planning has many practical applications in robotics and autonomous systems, including:

- Autonomous driving: Path planning algorithms are used to navigate autonomous vehicles in complex environments and avoid collisions with other vehicles and pedestrians.
- Robotics: Path planning algorithms are used to navigate robots in warehouses, factories, and other environments and perform tasks efficiently.
- UAVs: Path planning algorithms are used to navigate unmanned aerial vehicles (UAVs) in complex environments and perform surveillance, mapping, and other tasks.

## 5 Conclusion and Resources

Path planning is a critical task in robotics and autonomous systems, and it requires mobile robots to be equipped with sensors, onboard computers, and motion systems to plan and move. In this article, we covered the basics of path planning, the types of path planning algorithms, local and global planners, challenges and future trends in path planning, practical applications of path planning, and resources for further learning.

If you want to learn more about path planning, here are some resources to get you started:

- "Path Planning in Complex 3D Environments Using a Probabilistic Roadmap Method": click here
- "Real-time path planning for autonomous vehicle based on teaching–learning-based optimization": click here
- "Optimal Robotic Path Planning Using Intelligent Search Algorithms": click here
- "RRT-Connect: An Efficient Approach to Single-Query Path Planning": click here

These resources provide more in-depth information on path planning algorithms, their implementation, and their applications.

Thank you for reading.