

# path planning

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## 1 Introduction to Path Planning

Path planning is a vital component of various applications, including robotics, autonomous vehicles, and computer games. It involves finding an optimal path from a starting point to a goal while avoiding obstacles. Path planning algorithms play a crucial role in enabling autonomous systems to navigate complex environments efficiently and safely.

## 2 Types of Path Planning Algorithms

There are several types of path planning algorithms, each with its own characteristics and areas of application. Here are some commonly used algorithms:

### 2.1 Dijkstra's Algorithm

Dijkstra's algorithm is a well-known algorithm used to find the shortest path in a graph. It explores all possible paths from the starting point to the goal and selects the one with the minimum cost. This algorithm guarantees optimality but may be computationally expensive for large-scale problems.

### 2.2 A\* Algorithm

The A\* algorithm is an extension of Dijkstra's algorithm that incorporates heuristics to guide the search towards the goal more efficiently. It uses a combination of the cost to reach a node and an estimate of the remaining cost to the goal to determine the next best node to explore. A\* is widely used in robotics and video games due to its efficiency.

### 2.3 Rapidly-exploring Random Trees (RRT)

Rapidly-exploring Random Trees (RRT) is a sampling-based algorithm that constructs a tree by iteratively exploring the state space. It randomly generates new states and connects them to the existing tree, gradually expanding towards the goal. RRTs are particularly effective for high-dimensional and continuous state spaces.

## 2.4 Probabilistic Roadmaps (PRM)

Probabilistic Roadmaps (PRM) is another sampling-based algorithm that builds a graph representation of the environment. It randomly samples valid configurations and connects them based on certain criteria, forming a roadmap. PRM can handle complex environments but may require significant pre-processing time.

## 3 Local Planner and Global Planner

Path planning can be divided into two main components: local planner and global planner.

### 3.1 Local Planner

The local planner focuses on short-term decisions for navigating around immediate obstacles. It takes into account the current state and surroundings of the robot or vehicle and generates control actions to avoid collisions. Local planners are typically reactive and operate in real-time.

### 3.2 Global Planner

The global planner considers the entire environment and plans a path from the starting point to the goal. It utilizes path planning algorithms to find an optimal or near-optimal path while avoiding obstacles. Global planners are responsible for long-term navigation decisions and typically operate at a lower frequency than local planners.

## 4 Challenges and Future Trends in Path Planning

Despite significant advancements in path planning, there are still challenges that researchers and engineers are working to address. Some of these challenges include:

### 4.1 High-dimensional State Spaces

Path planning becomes increasingly challenging in high-dimensional state spaces, such as those encountered in robotics or complex virtual environments. Developing efficient algorithms for such spaces remains an active area of research.

## 4.2 Real-time Planning

Real-time planning is crucial for applications like autonomous vehicles, where decisions must be made quickly. Balancing the need for optimality with computational efficiency is an ongoing challenge.

## 4.3 Uncertainty and Dynamic Environments

Path planning algorithms need to account for uncertainties and dynamic changes in the environment. Handling unpredictable obstacles, moving objects, and uncertain sensor measurements is an important aspect of future path planning research.

# 5 Practical Applications of Path Planning

Path planning has numerous practical applications across various domains. Some notable applications include:

## 5.1 Robotics

Path planning is fundamental to autonomous robots, enabling them to navigate and perform tasks in complex environments. It finds applications in industrial automation, autonomous drones, and mobile robots in healthcare and logistics.

## 5.2 Autonomous Vehicles

Path planning plays a vital role in autonomous vehicles, allowing them to plan safe, efficient routes and make real-time decisions while avoiding obstacles. It is a critical component of self-driving cars and unmanned aerial vehicles (UAVs).

## 5.3 Video Games

Path planning algorithms are widely used in video games to create realistic and intelligent behaviors for non-player characters (NPCs). They enable NPCs to navigate dynamic environments, avoid obstacles, and pursue goals.

# 6 Conclusion and Resources

Path planning is an essential aspect of many autonomous systems, enabling them to navigate complex environments efficiently and safely. This article provided an overview of path planning, discussed different types of algorithms, explored the roles of local and global planners, highlighted challenges and future trends, and showcased practical applications. [Kovács et al., 2016 Kovács B., Szayer G., Tajti F., Burdelis M., Korondi P] [Kuffner et al., 2000 Kuffner, J.J. and LaValle, S.M. (2000). Rrt-connect: ] [LaValle et al., 1998 LaValle, S.M. et al. (1998). Rapidly-exploring random trees]