

Path Planning using L^AT_EX

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Abstract

Path planning is a crucial aspect of robotics and autonomous systems. It involves finding an optimal path from a starting point to a goal location, considering various constraints and obstacles in the environment. In this article, we will explore the fundamentals of path planning, different types of algorithms used, the role of local and global planners, challenges and future trends in path planning, practical applications of path planning, and available resources for further study.

1 Introduction to Path Planning

Path planning is the process of determining a sequence of actions or movements to navigate a robot or an autonomous agent from an initial position to a desired goal location. It is an essential component in several fields, including robotics, autonomous vehicles, computer graphics, and video games. The ultimate goal of path planning is to find an optimal and collision-free path while considering factors such as the robot's kinematics, the environment's obstacles, and any constraints imposed by the task.

2 Types of Path Planning Algorithms

Various algorithms have been developed to tackle path planning problems. These algorithms can be broadly classified into two categories: complete and sampling-based algorithms.

2.1 Complete Algorithms

Complete algorithms guarantee finding a solution if one exists. They exhaustively explore the entire search space to find the optimal path. Some of the well-known complete algorithms include Dijkstra's algorithm, A* algorithm, and the Rapidly-exploring Random Tree (RRT) algorithm.

2.2 Sampling-based Algorithms

Sampling-based algorithms, on the other hand, build a roadmap of the environment by generating a set of random samples and connecting them to form a graph. These algorithms are probabilistically complete, meaning they have a high probability of finding a solution if one exists. Popular sampling-based algorithms include Probabilistic Roadmap (PRM) and the RRT* algorithm.

3 Local Planner and Global Planner

In path planning, the tasks of local planning and global planning are often distinguished. The local planner focuses on short-term decisions and is responsible for generating feasible trajectories to avoid obstacles or adjust the robot's pose. It operates within a local neighborhood around the current position of the robot. On the other hand, the global planner takes a higher-level view and plans the overall path from the start to the goal location. It considers the entire environment and aims to find an optimal path while avoiding obstacles.

4 Challenges and Future Trends in Path Planning

Path planning presents several challenges, including high-dimensional search spaces, dynamic environments, uncertainty, and real-time constraints. The growing complexity of autonomous systems and the need for safe and efficient navigation give rise to ongoing research and development in path planning. Some of the emerging trends in this field include:

- **Motion Planning under Uncertainty:** Path planners that can handle uncertain environments and sensor measurements are becoming increasingly important.
- **Multi-Agent Path Planning:** With the rise of swarm robotics and multi-robot systems, path planning algorithms need to account for interactions and coordination between multiple agents.
- **Learning-based Approaches:** Machine learning techniques, such as reinforcement learning and imitation learning, are being explored to enhance path planning capabilities.
- **Real-time and Parallel Planning:** Efficient algorithms that can handle real-time constraints and exploit parallel computing architectures are being developed.

5 Practical Applications of Path Planning

Path planning has a wide range of practical applications across various domains. Some notable examples include:

- **Autonomous Vehicles:** Self-driving cars rely on sophisticated path planning algorithms to navigate safely and efficiently in complex traffic scenarios.
- **Robotics:** Robots in warehouses, factories, and hospitals use path planning to optimize their movements and avoid collisions with humans and other obstacles.
- **Drone Navigation:** Drones require path planning algorithms to autonomously navigate through obstacles and efficiently reach their destinations.
- **Video Games:** Path planning is widely used in video game development to create realistic and intelligent character movements.

6 Conclusion and Resources

Path planning is a fundamental problem in robotics and autonomous systems. It involves finding an optimal and collision-free path from a starting point to a goal location, considering various constraints and obstacles. Different types of algorithms, including complete and sampling-based approaches, are used to tackle path planning problems. Local planners and global planners play distinct roles in generating feasible trajectories and planning the overall path, respectively. The field of path planning faces challenges such as high-dimensional search spaces and real-time constraints, but ongoing research and development are addressing these issues. Path planning finds practical applications in autonomous vehicles, robotics, drones, and video games, and continues to evolve with emerging trends such as motion planning under uncertainty, multi-agent path planning, learning-based approaches, and real-time and parallel planning.

For further exploration of path planning, here are some resources:

- Books:
 - "Principles of Robot Motion: Theory, Algorithms, and Implementations" by Howie Choset et al.
 - "Planning Algorithms" by Steven M. LaValle.
- Online Courses:
 - Coursera: "Robotics: Perception" by University of Pennsylvania.
 - edX: "Autonomous Navigation for Flying Robots" by ETH Zurich.
- Research Papers:

- "RRT-Connect: An Efficient Approach to Single-Query Path Planning" by Steven M. LaValle.
- "A* Search: A Theoretical Analysis" by Sven Koenig and Maxim Likhachev.

Path planning is a dynamic field with extensive practical applications. As technology continues to advance, path planning algorithms will play a crucial role in enabling safe and efficient navigation for robots and autonomous systems.