

# Path Planning

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## 1 Introduction to Path Planning

Path planning is a fundamental aspect of autonomous systems and robotics that involves determining the optimal path from a starting point to a desired destination while avoiding obstacles and adhering to specific constraints. Path planning algorithms play a crucial role in ensuring efficient and safe movement for robots, drones, self-driving cars, and various other intelligent systems. By enabling machines to navigate complex environments, path planning algorithms contribute to improved productivity, reduced costs, and enhanced safety.

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## 2 Types of Path Planning Algorithms

Path planning algorithms can be broadly categorized into two main types:

1. Deterministic algorithms, such as Dijkstra's algorithm and the A\* algorithm, guarantee an optimal solution but may struggle with large-scale environments due to their computational complexity.
2. Probabilistic algorithms, like the rapidly-exploring random tree (RRT) algorithm and its variants, provide suboptimal solutions but excel in high-dimensional spaces where finding the exact optimal path is challenging.

These algorithms strike a balance between efficiency and speed, making them suitable for real-time applications.

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## 3 Local Planner and Global Planner

Path planning involves two key components, both interact together to ensure a smooth and safe trajectory.

1. The local planner focuses on short-term decisions, such as obstacle avoidance and maneuvering around dynamic objects. It operates within a local vicinity of the robot or vehicle and responds quickly to changes in the environment.
  2. the global planner considers the overall mission or objective and generates a high-level plan that guides the robot towards the destination. It takes into account the complete environment, including static obstacles, terrain, and other global constraints.
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## 4 Challenges and Future Trends in Path Planning

Path planning faces several challenges, including complex and dynamic environments, uncertainty, real-time decision-making, and the need for adaptability. Real-world scenarios often involve unpredictable obstacles, varying terrain, and dynamic changes in the environment. Incorporating real-time sensor data, machine learning techniques, and advanced algorithms can help address these challenges. Future trends in path planning include the integration of artificial intelligence, deep learning, and reinforcement learning to enhance decision-making and adaptability. Additionally, research is being conducted to develop cooperative path planning algorithms that enable multiple robots to navigate collaboratively, optimizing overall mission efficiency.

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## 5 Practical Applications of Path Planning

Path planning finds application in various fields, including robotics, autonomous vehicles, logistics, and aerospace.

In robotics, path planning enables autonomous robots to navigate warehouses, hospitals, or hazardous environments.

Self-driving cars rely on path planning algorithms to choose safe and efficient routes, considering traffic conditions, road rules, and obstacles.

In logistics, path planning algorithms optimize package delivery routes, minimizing travel time and fuel consumption. Aerospace applications involve trajectory planning for satellites, unmanned aerial vehicles, and space missions.

Path planning is also utilized in video games, virtual reality, and augmented reality for creating realistic and interactive environments.

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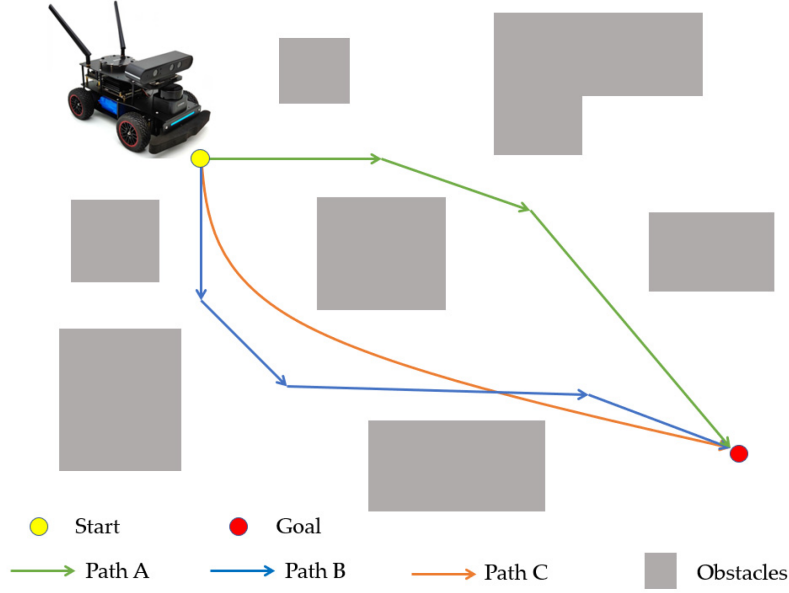


Figure 1: Fig1. Path Planning Diagram

## 6 Conclusion

Path planning is a critical component of autonomous systems, enabling efficient and safe navigation in complex environments. Deterministic and probabilistic algorithms, along with local and global planners, work together to ensure optimal path selection while considering real-time constraints. Despite challenges such as environmental uncertainty and dynamic obstacles, ongoing advancements in artificial intelligence and machine learning offer promising solutions. The practical applications of path planning span across multiple industries, improving productivity, safety, and overall efficiency.

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