Comparison of Optimal Path Planning Algorithms for Autonomous Mobile Robot

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Abstract

In this paper, an optimal control approach is used to solve a two-dimensional path planning problem for a differential drive mobile robot. Several optimal control methods are presented and analyzed, including a linear quadratic tracker (LQT), generalized predictive control (GPC), and dynamic programming. The various methods were implemented on an experimental platform, and were applied to the task of GPS navigation with obstacle avoidance. Different methods aim to find an optimal path where the tracking error to the GPS target is minimized, while maximizing the distance from each obstacle.

Keywords: optimal control, mobile robot, GPS navigation, obstacle avoidance, path planning

1. Introduction

With the steady advancement of computers and software development tools, modern control techniques such as optimal control are becoming much easier to develop, simulate and implement. As a result, greater opportunity exists to exploit these advanced algorithms to tackle control problems that in the past have been approached using less sophisticated classical control techniques.

The problem of GPS navigation with obstacle avoidance for an autonomous mobile robot is addressed in this paper. Several methods of optimal control are applied and compared. The general strategy is to compute an optimal control sequence to drive the vehicle toward the target GPS coordinate while maximizing the distance from each obstacle on its map. The control sequence is then recomputed at every step using a receding horizon technique.

A linear quadratic tracker (LQT) [1] is investigated, whose cost function definition and resulting optimal control law is modified to achieve the desired results. Also, generalized predictive control (GPC) [2] is addressed, whose main advantage over the LQT is the inherent simplicity of the algorithm, but lacks guaranteed stability and robustness. Finally, a dynamic programming-based approach is analyzed, which is more suited for applying several constraints to the control problem, such as when the robot is in the presence of several obstacles without much room between them. The derivation of the various control schemes is presented, and the simulation and experimental results are compared.

2. References

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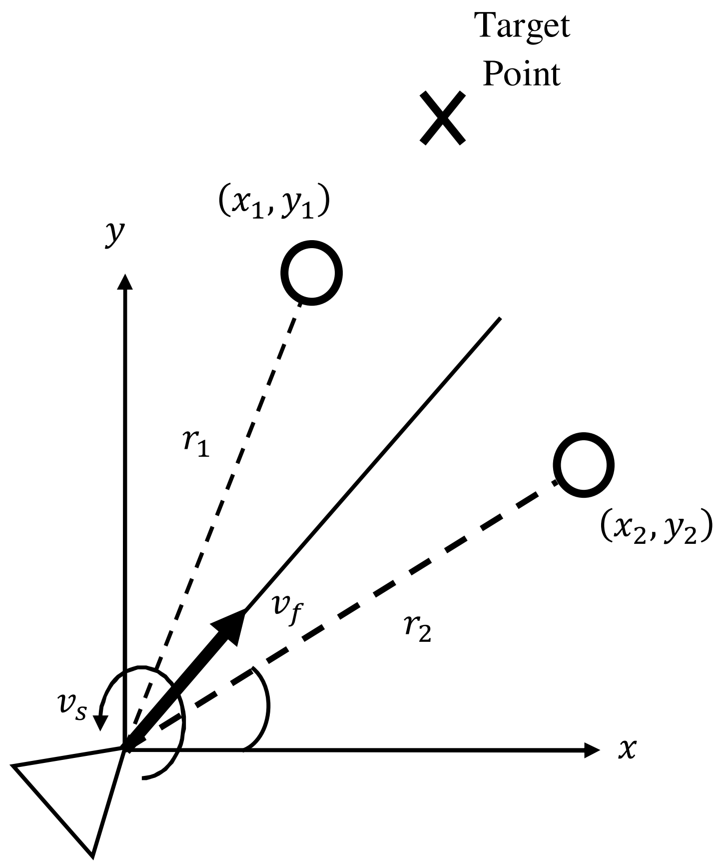

Figure 1 – Diagram illustrating the control problem. The cost function is defined to drive the vehicle toward the target point, while maximizing the distance from the obstacles.