HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY
FALTY OF COMPUTER SCIENCE AND ENGINEERING

CAPSTONE PROJECT
COMPUTER ENGINEERING

Motion Planning around Obstacles

Semester 251

Instructor: Assoc. Prof. Le Hong Trang

STT	Full name	ID	Note
1	Nguyen Tran Dang Khoa	2211635	
2	Ho Dang Khoa	2211xxxx	

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Abstract

Trajectory optimization offers mature tools for motion planning in high-dimensional spaces under dynamic constraints. However, when facing complex configuration spaces, cluttered with obstacles, roboticists typically fall back to sampling-based planners that struggle in very high dimensions and with continuous differential constraints. Indeed, obstacles are the source of many textbook examples of problematic nonconvexities in the trajectory-optimization prob- lem. Here we show that convex optimization can, in fact, be used to reliably plan trajectories around obstacles. Specifically, we consider planning problems with collision-avoidance con- straints, as well as cost penalties and hard constraints on the shape, the duration, and the velocity of the trajectory. Combining the properties of Bézier curves with a recently-proposed framework for finding shortest paths in Graphs of Convex Sets (GCS), we formulate the planning problem as a compact mixed-integer optimization. In stark contrast with existing mixed-integer planners, the convex relaxation of our programs is very tight, and a cheap round- ing of its solution is typically sufficient to design globally-optimal trajectories. This reduces the mixed-integer program back to a simple convex optimization, and automatically provides optimality bounds for the planned trajectories. We name the proposed planner GCS, after its underlying optimization framework. We demonstrate GCS in simulation on a variety of robotic platforms, including a quadrotor flying through buildings and a dual-arm manipulator (with fourteen degrees of freedom) moving in a confined space. Using numerical experiments on a seven-degree-of-freedom manipulator, we show that GCS can outperform widely-used sampling-based planners by finding higher-quality trajectories in less time.

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Chapter 1

Introduction

In chapter 1, the overview, objectives and goals of the research's project are illustrated. The outline of the report is also presented.

1.1 Motivation

1.2 Goals

1.3 Scope

1.4 Thesis structure

There are five chapters in this capstone project:

- Chapter 1 briefly describes the project about problem's motivation, as well as the project's objectives and scope
- Chapter 2 is dedicated to presenting the foundational knowledge about ...
- Chapter 3 arranges the discussion of related works on the same task to deepen the understanding of existing methods and their constraints.
- Chapter 4 depicts approach to...

- Chapter 5 summarizes whole project and the plan for future development.

Chapter 2

Theoretical Background

In Chapter 2, it presents about preliminary knowledge in this project.

2.1 Convex analysis and optimization

2.2 Mixed-integer optimization

2.3 Graphs

Chapter 3

Related works

Large language models have emerged as a powerful tool for a variety of tasks. These models, trained on vast amounts of data, have demonstrated remarkable capabilities in understanding and generating human-like text **NEURIPS2020_1457c0d6**. *However, despite their impressive performance, these models are not without their limitations. The need to enhance their knowledge base and improve their efficiency and accuracy is a pressing concern. In this context, Chapter 3 delves into several related works that explore different approaches to address these challenges. The chapter provides a comprehensive overview of these methods, highlighting their strengths and weaknesses, and sets the stage for our proposed solution.*

3.1 Sampling-Based Methods

3.2 Discussion

In this chapter, we have seen three distinct approaches to enhance...

Chapter 4

Proposed Solution

As mentioned in Chapter 3, the enhancement of knowledge of . Chapter 4 presents the proposed solution for enhancing .

4.1 Baseline methods

4.2 Proposed solution: ...

4.2.1 Architecture

4.2.2 Training

4.2.2.1 Supervised Fine-Tuning

4.3 Experiment setup

4.3.1 Implementation details

4.4 Results and analysis

Chapter 5

Conclusion

5.1 Summary

5.2 Future Work

Future research will focus on...

- ...
- ...

Appendix A

...

A.1 ...

A.2 ...