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A comparison of local path-planning interpolation methods for autonomous driving in urban environments

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PROGRAMA AUTOPIA VEHÍCULOS AUTOMATIZADOS

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Abstract

This work aims to provide an insight in the curve interpolation step within the path-planning architecture for autonomous vehicles. Taking into account information from previous motion planning steps, the planner use the current pose of the vehicle and some waypoints in order to obtain the final path the vehicle will follow. This path is required to have continuous curvature. This planning step is intended to run fast due to it has to be continuously running. In this context, we present a comparison between different methods of interpolation based on Bézier curves, for obtaining optimal paths while the time and performance requirements are met. Furthermore, different optimization algorithms and heuristics are applied to find the optimal values of several parameters of the curves.

Introduction

Autonomous driving involves the integration of a number of technologies related to perception, localization, decision-making, path-planning and control. Among them is particularly relevant the path-planning as it plays a key role in ensuring driving safety and comfort [3]. In recent years, there has been extensive research on path-planning approaches for autonomous vehicles [2, 4]. In this context, motion planning algorithms must be able to quickly react to changes that occur on the vehicle environment. Usually most of motion planning architectures divide the problem in global and local planning. In turn, local planning is generally structured in 3 steps (see Fig. 1). Besides, within the local planning, a number of different techniques are today being evaluated. According to [1], these techniques can be split in four groups: graph search, sampling, interpolating and numerical optimization.

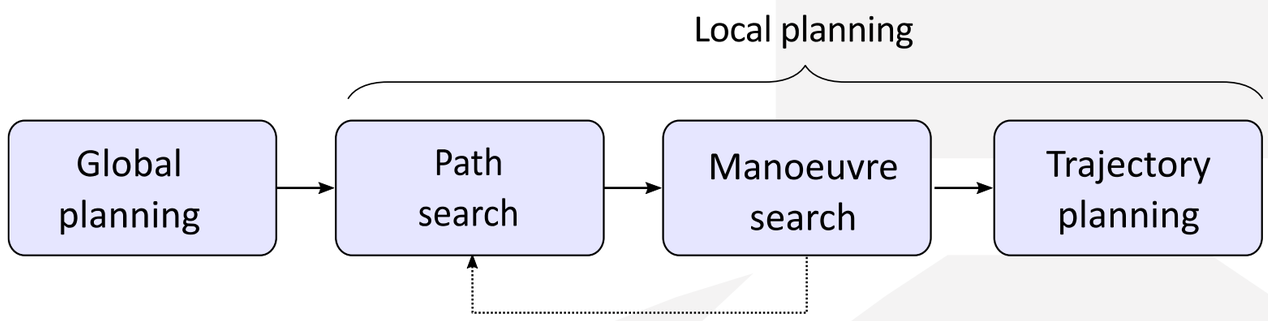


Fig 1. Path planning architecture scheme

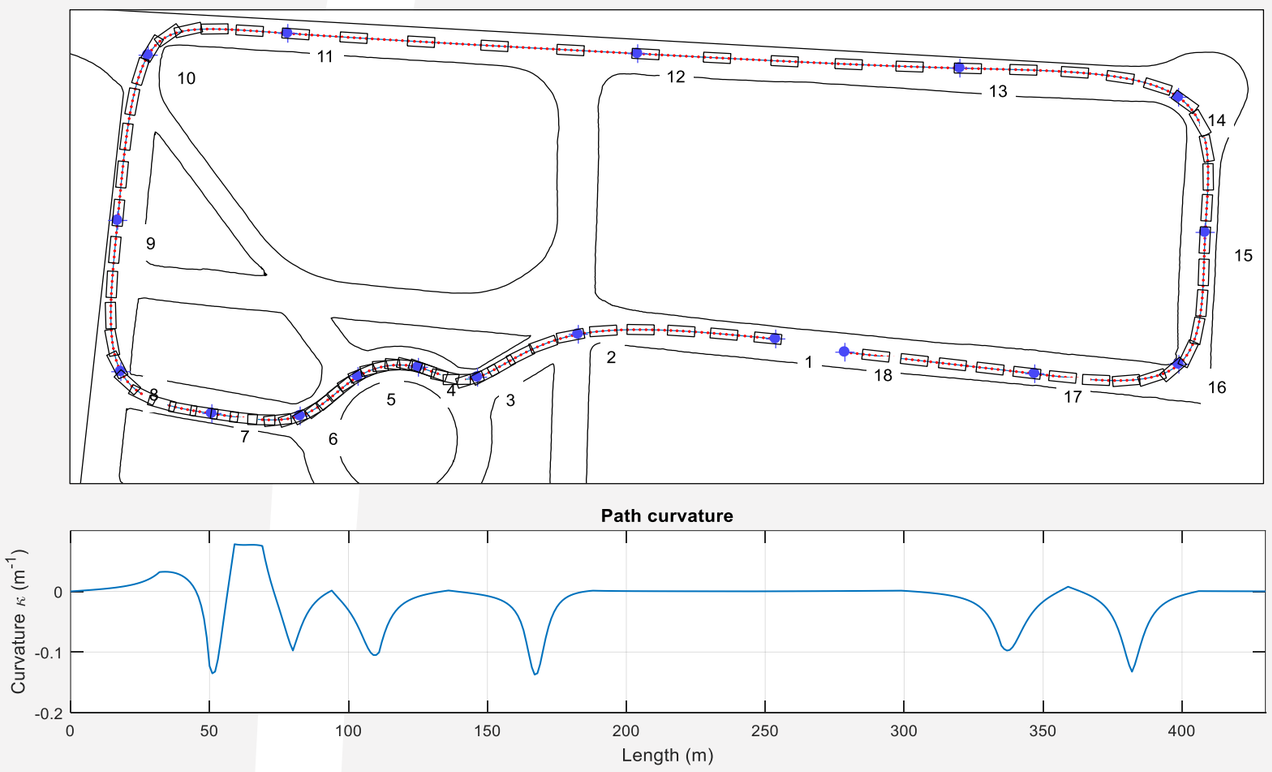
Local path-planning interpolation approaches

Taking into account information from previous motion planning steps, interpolation curve planners use the current pose of the vehicle and some way-points in order to obtain the final path the vehicle will follow. This path is required to have continuous curvature. This planning step is intended to run fast. In this context, we present a comparison between different methods of interpolation based on Bézier curves, for obtaining optimal paths while the time and performance requirements are met. Our purpose is to generate a piecewise Bézier curve path maintaining C^2 continuity in way-points i.e. in the joints of two Bézier curves. In our approach we addressed quintic Bézier curves and B-splines defined as composites of cubic Bézier curves, to meet the above mentioned requirements. Furthermore, different optimization algorithms and heuristics were applied to find the optimal values of several parameters of the curves. The objective is to minimize $J_p = \int_0^{s_f} [|\kappa(t)|^2 + |\dot{\kappa}(t)|^2]\, ds$, where κ is the curvature, s is the length over the path and s_f the total path length.

Results

Curve type	Optimization type	Continuity	Execution time aprox. (s)*
Bézier 3rd	Interior point: control points position	C^1	1.19
Bézier 5th	Heuristic: 1st derivative + Interior point optimization	C^2	1.52
Bézier 5th	Heuristic: 1st derivative + Interior point optimization	C^2	1.12
Bézier 5th	Heuristic 1: 1st derivative + Heuristic 2: 2nd derivative	C^2	0.00005
Bézier 5th	Heuristic: 1st derivative + 2nd derivative optimization	C^2	0.025
B-Splines	-	C^2	0.011

*Execution time for a path of 6 waypoints



Conclusions & future work

The results are intended to help in future decisions about the most appropriate approach for local path-planning interpolation. In this sense, a comparison of the execution time between different interpolation methods has been carried out.

The future work will focus on the development of the whole path-planning architecture for autonomous vehicles of AUTOPIA Program:

- How to properly choose the points between which the path will be created.
- How to optimize the whole spatio-temporal problem, i.e. the motion planning.

References

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