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Parking Planning with Genetic Algorithm for Multiple Autonomous Vehicles

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Abstract

The past decade has witnessed the rapid development of autonomous parking technology, since it has promising capacity to improve traffic efficiency and reduce the burden on drivers. However, it is prone to the trap of self-centeredness when each vehicle is automated parking in isolation. And it is easy to cause traffic congestion and even chaos when multiple autonomous vehicles require of parking into the same lot. In order to address the multiple vehicle parking problem, we propose a parking planning method with genetic algorithm. Firstly, an optimal mathematic model is established to describe the multiple autonomous vehicle parking problem. Secondly, a genetic algorithm is designed to solve the optimization problem. Thirdly, illustrative examples are developed to verify the parking planner. The performance of the present method indicates its competence in addressing parking multiple autonomous vehicles problem.

Introduction

Thanks to the rapid development of science and technology, including computer technology, chip technology, sensor technology and so on, the research of autonomous parking has made great achievements in recent decades[1,2,3,4,5].

In order to implement autonomous parking, lots of efforts have been paid into parking planning[6,7,8,9]. The geometric method is the most simple and practical implementation. Among the geometric curves, the arc[10], B spline[11] and clothoid[12] are most employed. Li[13] designs a single circular method that divides parking trajectory into three segments: a straight line, a circular arc, and another straight line. Wang et al[14] develop double circular trajectory to adapt to the change of the initiation parking pose. In order to make the joints of segments be continuous, Li et al[15] program double-constant-velocity parking trajectory. Kawabata et al[16] adopt Bezier curve to generate smooth trajectory. However, geometric methods are often only appropriate for specific parking scenarios. In order to unify parking planner, the sampling and search method has is concerned by worker unceasingly[17, 18]. Feng et all[19] combine model-based target tree and rapidly-exploring random tree (RRT), in order to accelerate the sampling process. Han et al[20] develop a unified parking planner for parallel, vertical and oblique slot based on RRT algorithm. But, since the core of RRT has a random seed, the planned path has randomness. In order to guarantee the planning efficiency and track quality, graph search method is widely used, such as A*[21] and hybrid A*[22]. Since the grid resolution is always difficult problem for graph search method[7, 8, 23], lots of machine learning method have been studied, such as artificial neural networks (ANN)[24], support vector machine (SVM)[25], General Radial Basis Function (GRBF)[26], and radial basis functions networks (RBFN)[27].

Although the parking planning algorithm of a single autonomous vehicle can be applied to real cars, however, there are two drawbacks impeding the existing parking planning algorithm directly applied to multiple autonomous vehicles. One of the drawbacks is the trap of self-centeredness when each vehicle is automated parking in isolation. And the other is traffic congestion and chaos since multiple autonomous vehicles requiring parking into the same lot. Therefore, we present a parking planning method to address those problems. Firstly, we establish an optimal mathematic model to describe the parking planning of multiple autonomous vehicles. Secondly, a genetic algorithm is developed to solving the built optimal problem. The remainder of the paper is structured as follows: In Sec. II, a description of problem for multiple autonomous vehicle parking planning. Illustrative Examples are discussion in Sec. III. Finally, Sec. IV provides the conclusion.

TABLE 3 Slot Allocation and Results

FCFS method		Our method	
AVs in Slots	*J/s*	*AVs in Slots*	*J/s*
(1, 2, 3, 4)	0.74	(2, 3, 1, 4) (2, 4, 1, 3) (3, 2, 4, 1) (4, 2, 3, 1) (2, 3, 4, 1) (2, 4, 3, 1)	0

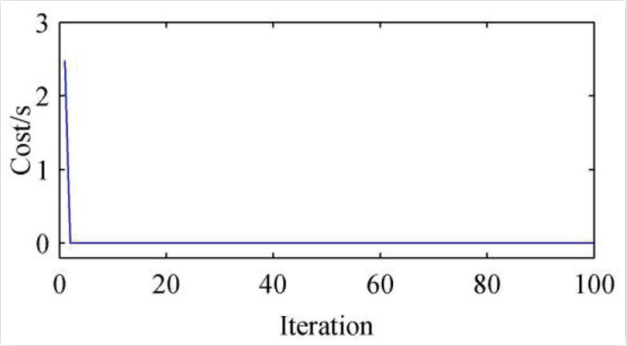
TABLE 4 Time of Autonomous Vehicle Arriving Entry Node

Parameters	$t_{1,0}$	$t_{2,0}$	$t_{3,0}$	$t_{4,0}$
Value/s	11	20	72	80

TABLE 5 Slot Allocation and Results

FCFS method		Our method	
AVs in Slots	*J/s*	*AVs in Slots*	*J/s*
(1, 2, 3, 4)	2.48	(4, 2, 3, 1) (2, 4, 1, 3)	0

FIGURE 7 Cost results.



Conclusions

We propose a parking planning method with genetic algorithm for multiple autonomous vehicles taking two problems into account. One of the problems is to avoid the trap of self-centeredness when each vehicle is automated parking in isolation. The other problem is to avoid traffic congestion and chaos due to multiple autonomous vehicles require of parking into the same lot. In order to address the problems, an optimal mathematic model is built to describe the problems firstly. And, secondly, a generic algorithm is applied to solve the problems. By comparing with the first-coming-first-serve (FCFS) planning method, the results illustrate that our method has competence in addressing parking multiple autonomous vehicles problem.

The further work will focus on real vehicle implementation and testing. Dynamic scenarios that multiple vehicles parks in and out. It may worth processing the uncertainty of sensors.

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