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VISION AND SENSORS

A LiDAR-Based Parking Slots Detection System

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Abstract
To improve the robustness and effectiveness for detecting free parking spaces, we propose a LiDAR-based parking sensing system, which contains multi-modules, i.e., perception, free space parking lots' construction, parking space tracking and obstacle detection. Comprehensive experiments demonstrate that our LiDAR-based parking sensing system can not only predict free parking spaces at a long distance, but also can achieve superior performance in terms of recall rate and accuracy of detected parking spaces. Moreover, our proposed LiDAR-based parking sensing system can achieve a significant gain over the ultrasonic-based one. Therefore, our proposed system can act an effective solution for detecting free parking slots at a long distance in the field of autonomous driving.

Keywords Autonomous vehicles · 3D LiDAR · Parking · Parking sensing system · Free space parking lots' construction

1 Introduction

With recent technical advancements of the automatic driving technology and the global high-speed urbanization process all around the world in the last few years, intelligent vehicle transportation system has become an important and necessary supporting facility element for improving daily convenience and efficiency, especially in the mega cities. Actually, such a hot topic has also attracted great attentions of researchers and further derived a series of directions, one of which is automatic parking (Ma et al., 2021). With the popularity of vehicles, it is an urgent need to quickly and accurately find parking spaces in large parking lots, and it is also a necessary pre-task for smart parking. However, the current research on automatic parking space recognition techniques is mainly based on ultrasonic waves (Kianpisheh et al., 2012; Park et al., 2008) and cameras (Li et al., 2017; Suhr & Jung, 2013). Neither of the two sensors can predict the parking spaces at a long distance. The ultrasonic sensor usually searches the parking space through the APA probe, and requires to scan the second vehicle to judge the parking space. On the another hand, the camera mainly recognizes the parking spaces based on the parking lines on the ground, which is hard to predict the parking spaces at a long distance due to occlusion. To quickly finding parking spaces in some underground garages, an indicator light is given above the parking space, where red represents for no parking space, and green represents for available parking space. To a certain extent, this meets people's needs for quickly finding parking spaces, but it will increase the cost of infrastructure construction and operation and maintenance.

Due to the benefits of high speed, accuracy and stability in obtaining the range data, LiDAR has attracted increasing attention in parking space detection (Im et al., 2019; Jimenez et al., 2022; Jung et al., 2008; Lee et al., 2017; Li et al., 2020; Park et al., 2019; Zhou et al., 2012). By identifying the surrounding environment of adjacent vehicles and further analyzing the space structure around the vehicles based on the LiDAR data, freespace-based methods can easily search and further feedback the available parking lots information to the vehicle terminal in real time. Notice that we particularly focus on addressing the intensive parking problem in urban area, while some of the extreme scenarios that may leading to inferior detection performance (e.g., spacious parking lots with few vehicles) are out of our consideration now.

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