International Journal of Automotive Technology (2024) 25:369–380
https://doi.org/10.1007/s12239-024-00031-9

A Cost Effective Solution to an Automated Valet Parking System

Ömer Dönmez[1] · Ondřej Vaculín[1] · Thiago de Borba[1]

Received: 26 May 2023 / Revised: 31 July 2023 / Accepted: 26 October 2023 / Published online: 21 March 2024

Abstract
Automated Valet Parking Systems (AVPS) relieve the driver of the entire parking process. Many of the systems known today rely on a combination of automotive sensors with sensors of the infrastructure. For this purpose, parking facilities are equipped with comprehensive sensor technology to support the vehicles in environment sensing and route planning. This approach is comparatively expensive which is why many parking operators don't provide that technology to their customers. This paper proposes a lean AVPS system architecture that requires minimal effort to adapt the infrastructure. At the same time, state-of-the-art vehicle technology is used to make AVPS more profitable overall. At the beginning, an overview will be given describing the state of the art of AVPS. Subsequently, requirements for the AVPS will be elaborated, whereby the system can be designed and implemented in the following. Finally, the presentation of simulation results shows that one doesn't have to extend the infrastructure with sensors to develop a safe and reliable AVPS.

Keywords Automated driving · Automated valet parking · Trajectory planning · Smart parking · System architecture

1 Introduction

A study on parking by Cookson and Pishue (2017) shows that motor vehicle drivers in Germany spent an average of 41 h a year trying to find a parking space. The extra time spent looking for a parking space results in additional fuel consumption, which in turn leads to increased emissions and costs. As a result, German drivers lose an average of 896 euros a year. However, focused on big cities the values are higher, e.g. for New York City where the average driver spends 107 h a year searching for a parking lot.

Smart automated parking systems can already completely relieve the driver of the search for a parking space with certain vehicles in selected parking facilities. The problem here is the limited accessibility of this technology because vehicles and parking facilities have to be equipped accordingly. This is because many of the systems known today use sensors within the parking facility in addition to the sensors in the vehicle. Current vehicles already have the necessary sensors. For parking operators, however, this usually results in high costs because the corresponding sensor technology must be integrated into the parking facility, which is why many parking operators ultimately decide against implementing such a system in their parking facilities.

The objective of the paper is to present a lean AVPS system architecture, which builds on the vehicle's onboard sensors. Such an approach will reduce the necessary investments to the parking facility. Therefore, state-of-the-art Automated Valet Parking Systems (AVPS) are analyzed in the beginning. Based on current implementations, the requirements for an AVPS with minimal extension of the parking facility will be investigated. In this context, the question of how vehicles and parking facilities must be equipped at least to develop such an AVPS will be answered. The main contribution of this research is the presentation of simulation results of a lean AVPS system architecture that uses a minimal set of sensors.

2 Related Work

When implementing an AVPS, there are two ways of obtaining the needed information. On the one hand, data from the vehicle's sensors can be used to move the vehicle safely to the parking space. For example, built-in radars, ultrasonic sensors, LiDAR sensors or cameras can be used

✉ Ömer Dönmez
oemer.doenmez@carissma.eu

[1] Technische Hochschule Ingolstadt, CARISSMA Institute of Safety in Future Mobility (C-ISAFE), Esplanade 10, 85049 Ingolstadt, Germany