

Parking Assistance System Control Using a Disturbance Observer for Hybrid Electric Vehicles

Jinkyom Cho^{1,2} · Byeonghee Yang¹ · Joonyoung Park¹ · Sungdeok Kim¹ · Hyeongcheol Lee²

Received: 7 March 2024 / Revised: 12 June 2024 / Accepted: 1 July 2024 / Published online: 16 August 2024

© The Author(s), under exclusive licence to The Korean Society of Automotive Engineers and Springer-Verlag GmbH Germany, part of Springer Nature 2024

Abstract

This paper presents a remote smart parking assist (RSPA) control algorithm for hybrid electric vehicles based on a disturbance observer (DOB) and feedback control. The purpose of the proposed control algorithm is to improve the departure/stop agility and speed control performance of the RSPA. The DOB, activated when the hydraulic brake is released and vehicle departure initiates, estimates disturbances such as slippery road, road slope and bump road, and quickly compensates for these disturbances. The feedback controller corrects the motor torque based on the target speed and current vehicle speed. The gain of the feedback controller is adjusted according to the road gradient, which is estimated by a gradient observer. To validate the proposed control algorithm, actual vehicle test is performed using the Kia Niro Plug-in hybrid electric vehicle (PHEV). The results of the vehicle test show that the proposed control algorithm improves the robustness of the RSPA function.

Keywords Disturbance observer · Slope estimation · Integrated control · Feedback control · Robustness · Electrification · Remote smart parking assist

Abbreviations

RSPA Remote smart parking assist
HCU Hybrid control unit
TCU Transmission control unit
IBAU Integrated brake assist unit
MCU Motor control unit

1 Introduction

Parking assistance functions are being developed to increase the convenience of entering and exiting vehicles. The representative function is the remote smart parking assistance (RSPA) system. The RSPA is a function that helps the driver, and passengers enter and exit the vehicle more easily when maneuvering into or out of a narrow parking space. Since the driver is not in the vehicle, this function limits

the output torque during remote forward/reverse control for safety reasons and limits the vehicle speed to a low approximately 1.5 kph.

However, the driving environment, such as different slope, obstacles (speed bumps, potholes, or stones), and degree of road slippage, affects vehicle speed control. If the external driving environment is not considered, the vehicle speed may reach the target speed late or may not maintain the target speed. Research on vehicle speed control, such as cruise control and adaptive cruise control, began in the 1990s (Gerdes & Hedrick, 1997; Kato et al., 1991). Early vehicle speed control technology demonstrated reliable performance, especially on highways. PID controller technology, a representative technology for vehicle speed control, has been widely applied (Yi et al., 2000). Gain scheduling or the off-line gain optimization technique implemented by the PID controller is applied to vehicle speed control (Hong et al., 2011; Shakouri et al., 2011, 2015). Research on disturbance observers, which can reduce model inaccuracy and the influence of disturbances, began in the 1980s (Nakao et al., 1987). Various studies utilizing disturbance observers have been conducted (Dote et al., 1990). Disturbance observer (DOB) based control algorithms have also been applied to vehicle speed control (Yang & Jo, 2014). They showed significant performance improvement in vehicle

✉ Hyeongcheol Lee
hlee@hanyang.ac.kr

¹ Vehicle Control Development Team, Hyundai Motor Company, 150 Hyundaiyeonguso-Ro, Namyang-Eup, Hwaseong-Si 18280, Gyeonggi, Korea

² Electrical Engineering Department, Hanyang University, Seoul 34141, Korea