능동안전(제어) Ⅰ

정상상태입력 기반 모델예측제어를 통한 강건 경로 추종 제어기 설계

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Design of a Robust Path Tracking Controller using Model Predictive Control Based on Steady-state Input

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Key Words : Autonomous driving (자율주행), Path tracking (경로 추종), Model predictive control (모델예측제어), Robust control (강건제어)

ABSTRACT

This paper presents a robust path tracking controller based on a Model Predictive Control (MPC) with steady-state inputs considering disturbance. The conventional MPC-based path tracker has a possibility of divergence due to model uncertainty and disturbance. Divergence possibility increases due to the increasing model uncertainty under extreme steering conditions such as a double lane change. Not even severe steering conditions, the heavy noise of the sensor measurement, and disturbance caused by the external environment cause a deterioration in path tracking performance. An autonomous vehicle with affordable sensors has a large measurement error which can lead to a risky situation due to the degradation of the control. The conventional robust controller is proposed to prevent the divergence of the controller. However, the constraints for state and control inputs are not explicitly reflected in the conventional robust controller. In addition, control responsiveness is low due to characteristics that generate control input only when errors occur. Therefore, this study focused on the development of a robust path-tracking controller, which considers the constraints. The proposed controller uses the steady state solution and the MPC is designed to optimize the additional control inputs to deal with the model uncertainty and measurement noise. Therefore, the proposed controller achieves robustness. This study validates robustness of the proposed algorithm by increasing disturbance magnitude in severe driving conditions. A double lane change scenario is used to evaluate the proposed algorithm by using the co-simulation environment of MATLAB/Simulink and CarSim. Simulation results show that the proposed method is more robust against an increase in disturbance, thus suppressing an increase in path tracking error.

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자율주행 트랙터-트레일러의 경로 추종을 위한 비선형 모델 예측 제어

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Nonlinear Model Predictive Control for Path Tracking of Autonomous Tractor-trailer

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Key Words : Nonlinear Model Predictive Control(비선형 모델 예측 제어), Path Tracking (경로 추종), Tractor-Trailer (트랙터-트레일러)

ABSTRACT

This paper presents a nonlinear model predictive control(NMPC) for path tracking of autonomous tractor-trailer vehicle system. The control objective is positioning the geometric center of trailer on the desired path. An error model is formulated as continuous time nonlinear state equations. The state variables include lateral and heading error of tractor and trailer with respect to the reference path, and hitch angle. The reference state is assumed to be a steady state based on geometric relationships considering curvature of desired path. The optimization objective function is defined to minimize error between state variables and reference state. The nonlinear programming problem is solved by interior point method. The performance has been evaluated via numerical simulation studies and the results show that proposed NMPC performs accurate tracking.

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모델 예측 제어 기법을 이용한 사륜 조향 차량의 경로 추종 제어 알고리즘

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Path Tracking Control for Four-wheel Steering Vehicles Based on Model Predictive Control

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Key Words : Model predictive control(모델 예측 제어), Autonomous driving(자율주행), Rear wheel steering(후륜조향), Lateral control (횡방향 제어)

ABSTRACT

This paper presents a path tracking control for four-wheel steering (4WS) vehicles based on model predictive control (MPC). In applicable commercial vehicles, four-wheel steering generally serves an auxiliary role to improve vehicle maneuverability and lateral stability. Steering for the rear wheels is within a range of 10 degrees of less. In this paper, a 4WS control algorithm has been configured based on MPC which utilizes a wider range of steering for the rear wheel. A lateral bicycle model with a four-wheel steering input has been adopted as the vehicle model. As for the tire dynamics, the dugoff tire model was used, with the assumption that tire slip angle is negligible and that lateral tire forces and side slip angles are linearized. The proposed algorithm has been verified through CARSIM and MATLAB/SIMULINK for several path tracking scenarios. Verification results have shown that the proposed algorithm was capable of improving vehicle maneuverability and lateral stability to a significant extent.

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자율주행차량 첨단 운전자 보조 시스템 시험용 로봇 시스템 개발

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Development of Robot System for Testing Advanced Driver Assistance System for Autonomous Vehicles

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Key Words : Autonomous vehicle(자율주행차량), Advanced driver assistance systems(첨단 운전자 보조 시스템), Robot system(로봇 시스템)

ABSTRACT

The Advanced Driver Assistanced Systems(ADAS) of autonomous vehicles not only assist the driver in driving safely in general driving situations, but also assist in avoiding accidents in accident situations that are difficult to respond to. In order for the driver to trust and safely use the ADAS, many safety actual vehicle tests for the ADAS are being conducted. However, if a vehicle-to-vehicle collision and occurs in an actual vehicle test that tests the ADAS in an accident situation, it is dangerous due to vehicle damage and personal injury, and repeated testing is impossible. This paper deals with the development of a robot system for ADAS testing that enables safe and repeatable testing of actual vehicle tests in accident situations for ADAS.

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횡단 보행자 충돌 회피를 위한 모델 예측 제어 기반 적응형 종방향 거동 계획

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MPC-based Adaptive Longitudinal Motion Planning for Collision Avoidance of Crossing Pedestrian

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Key Words : Autonomous vehicle(자율주행 자동차), Active safety(능동안전), Collision avoidance(충돌회피), Pedestrian (보행자), Acceleration control(가속도 제어), MPC(모델 예측 제어)

ABSTRACT

One of the most significant challenges for urban autonomous driving is securing the safety of road users, especially pedestrians at the point of crossing. Predicting the future states of pedestrians enables the driving system to proactively determine the correct course of motion, avoiding any potential collisions and disruption of traffic flow. In this paper, adaptive longitudinal motion planning for autonomous vehicles is proposed considering predicted states of pedestrians and ego vehicle. Two driving modes, "stop" and "pass" are selected depending on the presence or absence of conflict point with pedestrians. The Model Predictive Control (MPC) is employed to manage optimal control inputs of longitudinal acceleration. To secure pedestrian safety, constraints for safety distance and control inputs were considered. The acceleration and jerk terms were also included for the objective function of MPC to enhance ride comfort. The presented algorithm is verified via the simulation studies, including the Monte-Carlo simulation and comparisons with baseline. The effectiveness of the suggested algorithm is confirmed by performing a more stable and safer longitudinal motion than the previous approach.

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자율주행을 위한 칼만필터 기반 차량 요 각속도 추정 전략

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Vehicle Yaw Rate Estimation Strategy for Autonomous Driving using Kalman Filter

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Key Words : Extended Kalman filter(확장 칼만 필터), Yaw rate estimation(요 각속도 추정), Ackermann model(애커만 모델), Bicycle model(자전거 모델)

ABSTRACT

This paper presents a vehicle yaw rate estimation strategy using Kalman Filters. In the field of vehicle control, yaw rate is one of the important parameters that affect vehicle motion. Inaccurate yaw rate estimation may result in reduced ride comfort, and even result in accidents. In order to accurately estimate the yaw rate, the proposed algorithm has utilized a filter that serially connects the Extended Kalman Filter (EKF) and Kalman Filter (KF), each of which using the Ackermann model and the bicycle model, respectively. The EKF estimates the longitudinal velocity, longitudinal acceleration and yaw rate with data obtained from the chassis can, which are then transferred to the KF and used to estimate the yaw rate with the EKF. The main advantage of this approach is the improved accuracy in estimating the vehicle yaw rate by configuring a separate Kalman Filter for only the yaw rate. The proposed algorithm has been verified through left turn, lane change, and circular turn scenarios in an automated vehicle. Evaluation results have shown that the proposed algorithm was able to guarantee accurate yaw rate estimation in the aforementioned scenarios.

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