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【論文の内容の要旨】

Let start with a scenario where we are sitting behind the wheel of car, staring at mobile phone, reading a new e-mails message, texting a friend or others activities instead of looking at the road or the car in front. Suddenly, the driver in the car ahead slams on the brakes or we might crash with some avoidance. Rather than becoming a victim of distracted driving, we might feel a gentle deceleration as ours car comes to a stop on its own, easily avoiding a collision, the car starts itself up again as soon as the road is clear. The most diligent drivers can choose the wrong moment to glance at a navigation screen or distracted by a minor things during the journey. According to the National Highway Traffic Safety Administration, driver distraction contributed to almost 20 percent of crashes which injuries to vehicle passenger.

The more advanced models and control technologies can warn of obstacles, adjust the distance to a car ahead, and activate the brakes when a distracted driver does not. Avoidance control strategy first started with anti-lock braking system (ABS) that prevented loss of steering control due to wheels locking up with hard braking or low friction. Vehicle dynamics control (VDC) further developed to include traction control: a system that optimally distributes tractive forces and prevents excessive wheel slip. The most recent developments have been in the area of electronic stability control (ESC). As vehicle technology has evolved over the years, ABS and ESC are now becoming standard on most vehicles. For every driver, active-safety systems and automated-driving technologies will provide not only assistance and support but also the valuable gift of time.

As a result, efforts have been made to develop intelligent control strategies and enhancing vehicle control dynamics with test maneuvers to quantify dynamic properties. This research focuses on studying standard with emergency maneuvers and developing new strategies to control, evaluate, and rate the performance of modern vehicles equipped with advanced VDC systems.

The purpose of this study is to take the advantages of the model predictive control (MPC) method that can be used effectively for the constraint and multivariable systems particularly focuses on VDC systems. The first stage of study is conducted in order to improve the ground vehicle performance of the autonomous sport utility vehicles (SUVs) with emphasis on path-following control and yaw stability control through proposed integrated control maneuver.

The second contribution of this thesis is improvement of the ground heavy duty vehicle performance of the single lorry with emphasis on rollover prevention, yaw stability control, and fast safe lane change trajectory control through proposed integrated control maneuver. These findings and conclusions are divided into 6 chapters which are shown as follows:

Chapter 1: This chapter describes the overall system that covers in the thesis. It consists of background, problem statement, research objectives, research methodology, scope of research, and the thesis outline.

Chapter 2: This chapter discusses the literature review on research and development of VDC systems with focus on path-following control, yaw stability control, and roll stability control of autonomous ground vehicle and heavy duty vehicle. The basic concept of MPC control theory is described and its design is explained. The design covers the MPC rule, cost function and the optimization problem. Related literature reviews regarding an implementation of MPC to the VDC systems are studied.

Chapter 3: This chapter explains the modeling of complete nonlinear vehicle model, nonlinear tire model, disturbances model i.e. crosswind and bank angle for simulation purpose. A little modification of the vertical forces particularly related to roll motion and lateral acceleration are taken into account. The rollover indicator called load transfer ratio is explained with a few enhancement of the indicator by considering the lateral acceleration. The development of the vehicle model is validated through standard maneuvers test. Based on the vehicle responses in yaw rate, roll rate and lateral acceleration, it is proven and shown that the vehicle model is validated and corrected, thus, can be implemented for controller design.

Chapter 4: The improved MPC with proposed proportional integral (PI) and feedforward (FF) controller for autonomous SUV systems is discussed in this chapter. Thorough discussion of MPC structure, PI/FF control design, control allocation between the active front steering (AFS) and ABS maneuver are also presented. The simulation results showed that, by including roll dynamics in the linear vehicle model leads to considerable improvements in the stability and trajectory performance of the vehicle. It is also highlighted that the MPC structure capable of keeping the actuators within the limited boundaries during a lane change is the important component of the control system. Furthermore, the results showed that by adding the PI/FF controller with MPC, it proved that the vehicle stability, handling, and maneuverability can be enhanced and the lateral position tracking can be improved. The simulations also proved that MPC is more useful than linear quadratic control for multivariable systems and systems with constraints. The results also proved that the right and left wheels' brake distribution in direct yaw moment control (DYC) are more effective and successfully implemented with the combination of AFS for vehicle steering maneuver.

Chapter 5: Chapter five discusses the improvement of yaw stability and rollover prevention control of heavy duty vehicle through switching MPC (SMPC). Switching technique of the MPC controller and the trade-off between the path tracking, yaw stability, and rollover are discussed. The controller design process using the linear vehicle into the nonlinear heavy system is presented. The simulation result showed that the vehicle stability, driver handling, and maneuverability can be improved through SMPC instead of nominal MPC. Emergency braking of the front vehicle or obstacle appeared suddenly without warning can be avoided and collision can be prevented through the proposed method by minimizing the lateral position tracking error. The results also demonstrated that the brake pressure distribution between the difference braking torque at the right and the left rear axles providing the differential braking control are more sufficient and adequately applied with combination of active rear steering (ARS) rather than mixture of ARS with DYC.

Chapter 6: In this chapter, results obtained in the previous chapters are summarized and discussed. Overall conclusions of the research work and significant future directions of this research are presented.