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Adaptive Torque-based Vehicle Slip Control using Super-twisting Theorem for Steering Vehicle Control on Cornering Road

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Abstract: The inertia of vehicle's slip caused by oversteered is a crucial part that need to be considered in vehicle dynamics and control system design especially in the cornering road. This is particularly important for steering vehicles, as inertia might lead to high accidents with peer walls. Therefore, this research has taken the initiative to contribute to the investigation of a better solution for vehicle control challenges that are special to cornering road maneuvering. The adaptive torque-based vehicle slip control (AT-VSC) is proposed using super-twisting algorithm to allow coping with the issue by indirectly shaping inertia forces. The Rack Steering Vehicle (RSV) is used in this research as the targeted platform. The vehicle velocity, inertia, and kinetic energy reduction of the RSV in the cornering track were all simulated and analyzed. The results shows that the proposed control strategy AT-VSC offers improved performance in terms of speed increase time and vehicle stability that gives impact to the RSV being skidded or collided to any obstacles during cornering period.

Keywords: steering vehicle, inertia reduction, super-twisting theorem and torque control

1. INTRODUCTION

The inertia of vehicle's slip caused by oversteered is a crucial part that to be considered in vehicle dynamics and control system design. Yet, it is usually difficult to be controlled as reported in [1]. Oversteered that causes by the friction interference in the wheeled vehicle provided inertia generation that disturbing a lot in vehicle handling. The situation is obvious in standard vehicle design with the rack steering configuration. Rack steering vehicle (RSV) having a crucial situation in handling inertia especially at the cornering and confined area. Active steering system (ASS) or active front steering (AFS) system [2] in common RSV is prone to inertial factors according to its non-skid configuration. This type of vehicle is vulnerable to collisions with the wall or off-road incidents, particularly on cornering tracks, as a consequence of overdriven [3]. The situation may become worse when this vehicle needs to pass through the uneven terrain and slippery terrain [4]. The RSV mechanisms itself will converting circular motion into linear motion along with transverse axis of the vehicle when it comes to oversteering. At high speeds, the counter phase steering unable to reduce the turning radius of the vehicle. The hard turning can reach the minimum turning radius of the vehicle hence accident may happen.

Various approaches have been done by the designer and researchers to reduce and eliminates this problem either using the advance vision and tactical sensors technology, control technology as well as advance automotive components. Kamaras et al. for example had emulated the environment friction force used by the vehicle's slip to design a slip control that can avoid disturbances. The method has producing high performance on the vehicle at any working scenarios with clutch slip control [5]. On the other hand, in [6], the path following and the wheel vehicles' performances were improved by using the proposed a Dual-Layer Adaptive Unscented Kalman Filter (DAUKF). The research was done by identifying the variance between nominal and measured velocity vectors by using an adaptive slip correction to examine a difficult handling situation while conducting a tight spot maneuver.

The control system approach gets intelligent when artificial intelligent (AI) system is deployed either direct or indirect situation. For example, Gao et al. used the fuzzy controller to tune and optimize the vehicle in real time [7]. Same goes to the progress reported in [8] where fuzzy logic algorithm was adapted on its proposed inverted pendulum control for vehicle balancing and stability on the cornering path. According to Ma et al., inertia occurs due to abrupt maneuvering in a turn, leading to oversteer. The model-based and robust control approach also becoming favorable approaches among the researchers such as reported in [9] and [10]. Singh et al. had approached the Model Predictive Controller (MPC) to improve the level of vehicle stability and safety in terms of handling on the complex extreme conditions [11]. On the other hand, Chen et al. proposed a nonlinear model called NMPC to address the same issues considering vehicle constraints such as sideslip angles of vehicle movement on narrow roads for path tracking and orientation accuracy assurance [12].

Therefore, this research has taken initiative to propose a torque-based slip control that considering the inertia and energy shaping of the vehicle using adaptive approach with super-twisting algorithm named as Torque-based Vehicle Slip Control (AT-VSC). RSV is used as model plant in this study and the study is focusing on its velocity, inertia, and kinetic energy during maneuver in cornering road. The results shows that the proposed control strategy AT-VSC offers improved performance in terms of speed increase time and vehicle

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