Automotive Active Safety Systems

INTRODUCTION TO THE SPECIAL SECTION

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Global passenger vehicle sales exceed 60 million units per year while continuing to experience strong growth, especially in emerging markets around the world. With the increasing number of vehicles on the road, safety has become a focal point of consumers, governments, and society. This special issue is focused on reviewing the history and background of automotive safety systems by presenting recent developments.

Passive safety systems, such as seat belts, head rests, and air bags, have become standard equipment in passenger vehicles and have been effective in reducing injuries and fatalities in accidents. To further mitigate casualties, semi-active control is used to improve the performance of passive safety systems, for example, by pretensioning seat belts prior to an accident and deploying smart air bags with variable intensity as a function of impact speed. Furthermore, if accidents can be prevented, better occupant and pedestrian protection can be realized. This desire calls for the implementation of active safety systems.

The primary objective of active safety systems is to help the driver control the vehicle to avoid accidents and enhance the driving experience under various road conditions and traffic patterns. For example, vehicle stability can be maintained by coordinating steering, braking, and the drive train to ensure safety during critical maneuvers. Vehicle handling can be enhanced by distributing engine torque to individual wheels. Like many technologies in the control field, recent advances in sensors, actuators, and computers enable new features in the development of active safety systems. Environmental sensors, such as infrared, camera, and GPS, are the "eyes" of active safety systems by capturing information from the trailing region to the curvature of the road ahead. Environmental information is sent to the "brain" of the active safety systems, that is, the controllers. The control system makes decisions ranging from simple warning messages to proactive intervention depending on the potential severity of the situation. The final command is then executed through the "arms and legs" of the active safety systems, that is, actuators for steering, braking, and the drive train.

The key enabling technologies for active safety systems include electronic stability control with estimation of vehicle states and road surface conditions, active rollover prevention, active collision avoidance, and individual wheel torque control. This special issue includes articles covering each of these areas. Electronic stability control applies active control to the brake or steering to maintain vehicle lateral stability. For example, under a split-mu road surface, an equal amount of brake forces applied to the left and right wheels can steer the vehicle toward the side with greater friction. Braking pressure can be reduced or modulated to create differential braking torque and compensate for split-mu road surfaces. Active steering control can also be used to maintain vehicle stability by changing the lateral forces generated at the front or rear axles. Implementing these technologies requires road and vehicle state information, such as the road-friction coefficient, vehicle yaw rate, lateral velocity, and slip angle. Some of this information cannot be measured in real time, however, due to the lack of commercially viable sensors. Therefore, estimation of vehicle states and road surface conditions is performed in real time. Active rollover prevention can be realized by active braking, steering, and suspension control with a rollover-prediction algorithm. Active collision avoidance is implemented by detecting the vehicle separation distance and closing speed and by applying the brakes

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to reduce the vehicle speed. Human factors and the human-vehicle interface is a critical element in implementing active collision avoidance to ensure driver satisfaction. Individual wheel-torque control or a torque-vectoring system is enabled by distributing the engine torque to individual wheels. This feature can be used to enhance vehicle handling and help ensure vehicle stability.

The objective of this special section is to offer readers a comprehensive and thorough understanding of the status and future directions of automotive active safety systems. This section also demonstrates how control technologies can enable many of the critical features of active safety systems. We hope you enjoy reading the articles.

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