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Driver Training Guidelines for Advanced Driver-Assistance Systems

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Safe-D UTC

Fueled by the inevitable changes in our transportation system, the Safety Through Disruption (Safe-D) University Transportation Center (UTC) endeavors to maximize the potential safety benefits of disruptive technologies through targeted research that addresses the most pressing transportation safety questions.

The mission of Safe-D is to proactively promote safety through a data-driven collaboration among the nation's brightest researchers.

Safe-D is a joint activity between the Virginia Tech Transportation Institute, the Texas A&M Transportation Institute, and the San Diego State University.

For more Safe-D information and information related to this project please visit:

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Background

The advent of advanced driver-assistance systems presents the opportunity to improve significantly transportation safety. Complex sensor-based systems within the vehicles can take responsibility for tasks typically performed by drivers thus reducing driver-related error as a source of crashes. While there may be a reduction in driver errors, these systems fundamentally change the driving task from manual control to supervisory control.

A significant challenge, given this fundamental change in the driving task, is that there are no established methods to train drivers on the use of these systems which may, as a result, be counterproductive to safety improvements.

The aim of the project was to develop training protocol guidelines that could be used by advanced driver assistance system trainers to optimize driving safety.

The guidelines were developed based on the results of three project activities that included:

- the development of a taxonomy of the knowledge and skills necessary to operate advanced driver-assistance systems,
- a driving simulator study that examined the effectiveness of traditional training protocols,
- and a test track study that examined the efficacy of a vehicle-based training protocol.

Results of both studies suggested the value of differing training protocols is most beneficial in terms of driver cognitive load and visual scanning as opposed to short-term changes in performance.

The project was funded through the SAFE-D: Safety through Disruption University Transportant Center.

ADAS

Advanced driver-assistance systems facilitate a driver's ability to manage the larger process of driving. Many ADAS systems perform tasks for drivers or automate various driving tasks such as detecting and avoiding a crash, steering a vehicle, or both.

ACC

Similar to traditional cruise control, adaptive cruise control maintains a predetermined vehicle speed and also maintains a safe distance to vehicles in front.

FCW

Forward collision warning systems can detect an impending collision with a vehicle in front will notify the driver of the situation. Forward coll

LKAS

A roadway departure warning system warns a driver when their vehicle moves out of their lane while lane keep assist will automatically steer a vehicle back into their lane.

Three major research organizations partnered to examine ways in which drivers could be trained on ADAS vehicle technologies.

Knowledge and Skills Taxonomy

A critical foundation for the conduct of driver training studies was to identify the essential knowledge and skills that should be included in training protocols that would allow sufficient operation of a vehicle equipped with ADAS features. The results of taxonomy development activity indicated five main elements which should be included in ADAS training protocols.

Purpose of ADAS Systems - Drivers should be made aware of several factors including overall purpose of ADAS, drivers' attitudes toward ADAS, changes in mental workload, trust in ADAS, confidence in self-skills, how levels of risk influence drivers' decisions on using ADAS, and the potential consequences of ADAS use.

Understanding Levels of ADAS - Drivers' education on the differences between levels of automation is probably the most important requirement of a training program. Specifically, information is needed regarding driver responsibility while engaging different types of ADAS or levels of automation.

Transition Between ADAS and Manual Modes – Driver training protocols would benefit from including information and training that focuses on how to transition between ADAS features and levels of automation.

Familiarity with System Components and Placement - Drivers need to be familiar with main components of the automated systems in their vehicle and know where they are located on the vehicle. For example, many ADAS features utilize data collected from sensor and camera systems to adjust speed. If these systems are blocked, they could produce inaccurate information.

Understanding of ADAS Limitations - While drivers' familiarity with ADAS operation is important, it is not sufficient. There is low level of knowledge among drivers not only about emerging safety technologies (e.g., ACC, FCW), but also about commonly used technologies (e.g., automated braking systems). Driver training protocols should increase drivers' understanding of the capabilities and limitations of such systems as well. Many automated systems that use sensors or cameras may not function properly in certain conditions (e.g., ACC will exhibit limitations on winding or hilly roads).

Driving Simulators

Driving simulators are tools used by researchers and practitioners to allow drivers to experience the processes associated with driving.

Driving simulators are similar to gaming environments in that they feature real vehicle seats, steering wheels, accelerator and brake pedals, and ignition switches. Drivers navigate through a computer generated world that is presented on three large screens.

Driving simulators are an attractive tool for researchers because drivers will exhibit normal driving behaviors which can be easily studied but do so in a safe environment.

The work summarized here represents a multi-disciplinary approach incorporating driver training, human factors, and engineering.

Traditional Training Protocol Evaluation

Introduction – The provision of ADAS are intended to vary aspects of driving including performance, attention allocation, and workload. Although ADAS are increasingly ubiquitous in vehicles there are no established protocols that key stakeholders can use to train drivers on ADAS use. The purpose of this study was to compare the effectiveness of two traditional driver training protocols that focused on ADAS use against a no training protocol condition on driving performance, attention allocation, and workload.

Methods – Participants aged 55 and older, equally balanced between females and males, used a driving simulator to navigate through typical driving environments. Participants drove in manual and in ADAS vehicle control segments in which they could activate ACC and LKAS.

Prior to driving all participants received ADAS training that differed only in the type of training protocol. Participants in the video based-training protocol watched instructional videos which was analogous to online training. Participants in the demonstration-based condition received training via an instructor which was analogous to typical driver training approaches. Participants in the no instruction training protocol were not provided with instructions which was analogous to drivers who learn vehicle-based systems through exploration.

Results/Discussion - Overall, results of this research indicated that performance and attention allocation relative to ADAS can all be impacted in different ways through the provision of training protocols but that their effects are intertwined with other factors such as driver gender.

The practical implications suggest that there are no performance advantages as a result of providing either ADAS training protocol to drivers and, in fact, for females the provision of each protocol resulted in the adoption of safety margins consistent with males. This finding must be considered in parallel with the notion that levels of mental effort for females were also higher after the provision of some training protocols. A positive finding is that attention allocation to the road ahead was increased through the provision of either training protocol.

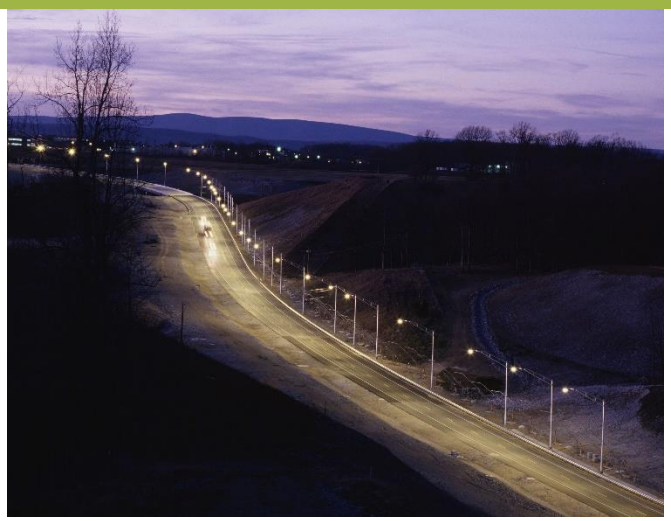
These combined results suggest an approach that considers individual differences to ADAS training protocols will likely be effective and ADAS training protocols should be tailored to specific driver demographics.

Test Tracks

Test tracks typically consist of actual roadways that allow drivers to use an actual car.

The roadways are typically short, ranging from .5 mile to 3 miles but depict many of the features found on actual roadways including lane markings, signs, and shoulders.

Test tracks are often used for research because they offer a realistic driving experience albeit in a relatively safe environment.



The results of the current studies can be used by driver trainers and educators in the development of their own ADAS driver training curriculums.

Vehicle-Based Training Protocol Evaluation

Introduction – The prevalence of advanced driver assistance systems (ADAS) has steadily increased in new vehicles over the last decade. Despite the potential benefits associated with their use, many of these systems are misunderstood by operators with regard to their capabilities and limitations. The purpose of this study was to compare the effectiveness of two in-vehicle training protocols; a conventional protocol (review of the owner's manual) and a videobased multimedia protocol on operator knowledge of ADAS, eye glance behavior while using ADAS, and attitudes toward ADAS.

Methods – Forty participants who were 18 – 25 and 55 – 75 years were randomly assigned to one of the two training protocols. All participants completed their assigned training in the parked research vehicle. After completing the training, participants drove a vehicle along a closed test track while performing secondary tasks both with and without ADAS active. Participant attitudes were measured before and after training, and after driving the vehicle. The results of the knowledge assessments were given immediately following the completion of training and after driving the vehicle on the test track.

Results/Discussion – The results of this study demonstrate that:

- Mode of training presentation elicits limited differences in knowledge scores and no difference in driver behaviors or attitudes.
- Behaviors and attitudes were influenced by time and experience with the driving automation system while knowledge of the vehicle systems remained unchanged.

These findings highlight the deficiencies of current training material. Current training content is not sufficient to teach operators how systems work, particularly when it comes to system limitations.

Drivers need to be better educated about the capabilities and limitations of ADAS, brief experience with the system after training does not sufficiently alter misconceptions about the boundaries of system operational design domain. Drivers may become more aware of system limitations with prolonged exposure, however previous studies have shown that safety critical misunderstandings of system limitations persist over time.

Guidelines for ADAS Driver Training

It is recommended that drivers of vehicles with ADAS be trained on the following items:

- Purpose of using automated systems (risks and benefits).
- Understanding levels of automation (capabilities and limitations).
- Transition between automated and manual mode and handling critical situations (system malfunctioning).
- Familiarity with system components and placement (sensor, radar, camera, etc.).
- Understanding limitations of driver assistant systems (ACC, LKAS, AEB, etc.).

Training protocols should address:

- Why drivers need to focus their attention on the roadway at all times but particularly during ADAS use.
- The need for training protocols to be developed that incorporate individual differences in learning and with multiple stake holder involvement.

It is recommended that training programs be designed and implemented using a variety of techniques, covering the requisite material, and be broadly available from many different stakeholders for voluntary use by drivers.

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