Personalized Driving Displays of Vehicle Automation to Improve Trust and Acceptance

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Abstract

Automation is becoming more commonplace in commercially available vehicles. In order to realize all of the potential benefits of the increased automation, it is necessary to ensure automation acceptance and trust. Customizable displays for automated driving may improve driver-automation interaction by leveraging non-automated driving styles to increase transparency of vehicle automation. Future research should evaluate the proposed profiles to determine how individual differences and display profiles impact trust and acceptance of automated vehicles.

Author Keywords

Automated driving; trust; automation acceptance; personality; displays; user interfaces.

CCS Concepts

• **Human-centered computing~Graphical user interfaces** • **Human-centered computing~HCI theory, concepts and models**

Introduction

More and more manufacturers are releasing semi-automated vehicles (Society of Automotive Engineers, SAE, level 2) that are available for purchase by general consumers. This technology has the potential to

revolutionize the way we interact with our vehicles. In order to ensure a smooth transition from manual vehicles (SAE Level 0) to semi-automated vehicles of today and fully automated vehicles of tomorrow, it is important that appropriate displays are available in the vehicle to aid in user understanding of the automated system [8]. This paper discusses our ongoing efforts to explore customized displays to a user's preferred style for automated vehicles.

Automated Driving

Automation levels are defined by task allocation from the human to the automated system. If the human has more responsibility over the system than the automation, there is a lower level of automation. If there is a higher level of automated system responsibility compared to the human, then a higher level of automation is assigned. There are many taxonomies for automation levels; however, the SAE has defined standards for automation levels specifically for automated driving. At Level 0, the driver performs all functions of the driving task; whereas, at Level 5, the vehicle automation performs all of the driving tasks. Automation will fundamentally change how drivers engage with their vehicles. Different levels of automation require different types of information be displayed to the driver.

Trust in Automation

Trust in automation is a key factor in the appropriate operation of automated systems [7]. Misuse, disuse, and abuse of automated systems can arise when there is not an appropriate level of trust in the system [7]. Further work has shown that trust should be appropriately calibrated to the system's performance throughout an interaction [4]. Appropriate trust is

especially important for highly automated vehicles as there is a potential for significant negative impacts if the system is over or under trusted. Displays can give operators insight into the underlying reasoning behind the vehicle's behaviors and give greater understanding to the operator of the system as a whole.

Automated Driving Displays

Research in the area of automated driving displays is an emerging field. Thus far, studies have primarily focused on displays for low automation levels (SAE levels 2-3). At this lower level, the driver and the vehicle share responsibility in the driving task. At higher levels of automation, the driver is only a supervisor (SAE Level 4) or is not engaged with the driving task at all (SAE Level 5) [8]. These higher levels of automation require different information to be presented to drivers than lower levels. For example, at lower levels of automation, drivers may want information regarding system performance [2,5,6]. Whereas, at SAE Level 5, drivers may be more interested in how long it will take to get to their destination than system performance as they will not have to drive the vehicle.

Proposed Display Profiles

Design Framework

In addition to the level of automation, a critical factor in display design is the motivation or goal orientation of the user. For the purposes of this research project, we operationalized this into three personalized display profiles: *Defensive Driving*, *Transit,* and *Thrill Seeking*. *Defensive Driving* can be defined as, "driving to save lives, time and money, in spite of the conditions around you and the actions of others" [1]. This is contrasted with the *Transit* profile that can be summarized as

Figure 1. The *Defensive Driving* display highlights known obstacles in the environment and road markings. Auditory displays (shown in orange quoted text) will give additional information regarding the behavioral intentions of the vehicle.

Figure 2. The *Thrill-Seeking* display emphasizes the speedometer and RPM and provides tire pressure information.

wanting to get to a destination as efficiently as possible. Modeled after public transportation systems such as buses and trains, this display highlights time to destination and route over other vehicle and roadway information. Finally, the *Thrill-Seeking* profile focuses on driving as enjoyment [3]. This focus allows for those who typically drive their non-automated vehicles as a hobby or pass-time to continue to get the same enjoyment out of operating their automated vehicles.

Information Content
The information presented in the display for each profile can be seen in Figures 1-3. Much of the information between each display overlaps, though it has different levels of emphasis. For example, speed is presented in all three displays; but, it is a minor component of the *Transit* display and a primary component of the *Thrill-Seeking* display.

Figure 3. The *Transit* display highlights the current location along the route to a destination, as well as estimated time to arrival (ETA), speed and fuel economy.

Proposed Use of Displays

These displays could be used in a progressive manner during trust development starting with *Defensive Driving*, moving to *Transit*, and finally, using the *Thrill - Seeking* displays when seeking enjoyment from driving. Alternatively, the displays could be used individually. For example, someone who is used to taking public transportation may be more comfortable using the transit display than the other two displays.

Discussion

These displays could aid in trust development by transitioning through displays progressively as trust develops. Different people may require different levels of experience prior to feeling comfortable with a *Transit* display that highlights less environmental information.

Transitioning drivers from non-automated to highly automated vehicles could prove difficult. Providing a variety of display choices, all with different foci, could help ease the transition by giving insight to vehicle behavior.

The *Thrill Seeking* display could improve enjoyment of automated driving if the operator likes driving non-automated vehicles for fun [3]. This could lead to higher levels of acceptance of automated vehicles for those that are hesitant to losing driving as a hobby or source of enjoyment.

Transparency of information regarding lane markings, projected route, and obstacles in the environment could aid in automation acceptance and human-automation trust development. Especially, the personalized displays would allow for tuning the information content to what the operator is interested in knowing specifically.

Supporting display personalization would allow fine-tuning for each operator, helping them feel more comfortable transitioning to this new technology and a different driving experience.

Future Work

Further research is needed to determine if the information presented in each display matches the mental models of current drivers and future drivers of highly automated vehicles. These displays should be thoroughly tested in a safe driving environment, such as a simulator, to determine the impact of the displays on acceptance and trust in automation over the time course of several interactions. Exploring this work would determine the impact of these adapted displays on acceptance and trust in automation, and allow us to better understand their role in trust development.

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