Examining Senior Drivers’ Acceptance to Advanced Driver Assistance Systems

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Abstract

Advanced driver assistance systems (ADAS) can help maintain seniors’ safety and mobility with their decline in cognitive and physical capabilities. An early step of investigating the adoption and merits of ADAS for senior drivers is examining the factors that influence senior drivers’ acceptance of the technology. This paper presents our modeling effort on the acceptance of 18 senior drivers towards adaptive cruise control (ACC) and lane control features after six weeks of naturalistic driving with study vehicles. Adapting the Technology Acceptance Model (TAM), our model is built on questionnaire data on perceived usefulness (PU), perceived ease of use (PEoU), use-based trust (T) and perceived satisfaction (PS) in predicting behavioral intention to use (BIU) ADAS. Two major findings in our modeling effort are that (i) perceived ease of use has significant influence on trust and (ii) perceived satisfaction has significant influence on behavioral intention to use.

I. Introduction

With the population aging, the number of senior drivers is projected to increase drastically from current forty-two million [1] to over sixty million by 2030 [2]. More senior drivers on the road bring concerns to the public about transportation safety due to the age-related declines in sensory, cognitive, and psychomotor abilities typically experienced by this age group (e.g., [3]). Many researchers postulate that advanced driver assistance systems (ADAS) can be a potential solution to mitigating declining driving abilities, and thus enhancing safety and mobility of seniors [4]. However, senior drivers must accept and use ADAS in order to realize any potential benefits. Compared to the younger drivers, seniors seem more reluctant [5] and resistant to adopting innovative technologies [6]. Further, the trust in automation decreases with age [7]. Hence, examining factors influencing senior drivers’ acceptance of ADAS presents an important first step towards deploying new vehicle technology to sustain their mobility and road safety.

The cognitive process to reach a decision on whether to accept a familiar or unfamiliar technology is complex, involving many determinants. The most cited work is the Technology Acceptance Model (TAM), which was proposed by Davis [8][9] to study customers’ acceptance of information technology. Several adaptations of TAM have been proposed to study advanced vehicle technology by including concepts such as trust, perceived risk, and compatibility. However, existing empirical models of driver acceptance of ADAS do not include data of users with experience using those technologies. At the early development stage, car manufacturers would need to determine intention to use without any exposure to ADAS. However, as ADAS technology become mature and widely available, intention to use given exposure or even learning experience of the technology become relevant for investigation. Thus, the purpose of the study is to build an empirical model of the key factors influencing seniors’ post-exposure acceptance of the ADAS.
II. Background and Study Model

A. TAM and study model

Technology Acceptance Model (TAM) [8][9] is originally composed of five components (Fig 1(a)). Three determinants - perceived usefulness (PU), perceived ease of use (PEoU), attitudes towards using (A) influence the behavioral intention to use (BIU) that in turns increase likelihood of actual use. The relationship between the constructs was shown in Fig 1(a).

In the driving domain, trust has been introduced into modified the original TAM [10]–[16] (see example, Fig 1(b)). As mentioned, the majority of the existing modeling work on BIU does not involve exposure to the ADAS features. Hoff and Bashir [17] precisely referred trust prior to exposure to the technology as “initial trust” in contrast to “dynamic trust”, which emerges from the actual interaction with a technology. In our model, we added the component “use-based trust’ to represent the trust from experiencing the technology. Further, our adaptation replaced “attitudes toward using automation” with “perceived satisfaction”. Fig 2 summarized the hypothesized relationships in the adapted version of TAM for our study.

B. ADAS Features

For the purpose of testing our adaptation of TAM, we collected questionnaire data on ACC and lane control features (lane-departure warning and lane keep assist) for empirical modeling.

B.1. ACC

ACC allows the driver to set the speed, modulated by a set distance from a lead vehicle. When ACC is activated without a lead vehicle detected, the vehicle maintains the pre-set speed. When a lead vehicle is detected, the vehicle slows, as necessary, to maintain the pre-set headway distance. The driver always has the authority to take control of the vehicle.

B.2. Lane Departure Warning & Lane Keep Assist

Lane-departure warning sends the notifications to inform the driver about the vehicle leaving its lane. The notification could be visual, audio, or tactile. The notification is suppressed when the driver uses the turn signal for turning or changing lane. Lane keep assist not only issue notifications but also steer the vehicle back into the lane automatically. Both functions are designed to help drivers avoid lane drifting. Therefore, the combination of lane
keep assist and lane departure warning are considered as “lane control” in this study.

III. Methodology

A. Participants, Data Collection and Procedure

Eighteen drivers aged 70-79 were recruited from the New River Valley area of Virginia. All participants held valid driver licenses, with a mean age of 74 (SD=2.85, 9 female, 9 male). Each participant drove a study vehicle equipped with the ADAS for six weeks. Upon return of the vehicles, the participants responded to a questionnaire on their experiences and perception of using the ADAS.

B. Measurement

Participant responses to the questionnaires (Appendix A) provided the data for analysis. Based on literature review and our specific study scenario, our adapted TAM included five components: PU, PEOU, T, PS and BIU (Appendix A). All questionnaire items were responded in a seven-point Likert-like scale, ranging from “Strongly Disagree (1)” to “Strongly Agree (7)”. Participants responded to a set of questionnaire on their perceived usefulness, perceived ease of use, level of trust on ACC and lane control. The questionnaire items also include their perceived satisfaction and behavioral intention to use on ADAS in the study vehicle.

C. Data Analysis

The data analysis consisted of descriptive statistics, reliability tests, and hierarchical regression. The internal consistency was assessed with Cronbach’s alpha, of which a criterion of above 0.7 is considered sufficiently reliable [18]. Hierarchical regression was conducted to test the hypothesized relationships between model components.

IV. Results

A. Descriptive Statistics of Constructs

Table 1 reported the means, standard deviation, and Cronbach’s α of ratings to the questionnaire items. Participants agreed that ACC was useful (mean=5.36, SD=1.53), and easy to use (mean=5.83, SD=1.58). They trusted ACC above the neutral level, (mean=5.38, SD=1.38), and they were satisfied with their experience using ACC (mean=5.50, SD=1.62). The behavioral intention to use (BIU) was rated at 6.06 (SD=1.43). Multi-item subscales of the questionnaire on ACC - T and PU - have Cronbach’s α of .85 and .65, respectively. T and PU are sufficiently and marginally reliable for further analysis, respectively.

<table>
<thead>
<tr>
<th>Subscale</th>
<th>N of questionnaire item</th>
<th>Mean</th>
<th>SD</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>PU – ACC</td>
<td>2</td>
<td>5.36</td>
<td>1.53</td>
<td>.62</td>
</tr>
<tr>
<td>PEOU – ACC</td>
<td>1</td>
<td>5.83</td>
<td>1.58</td>
<td></td>
</tr>
<tr>
<td>T – ACC</td>
<td>4</td>
<td>5.39</td>
<td>1.38</td>
<td>.85</td>
</tr>
<tr>
<td>PU – Lane control</td>
<td>2</td>
<td>5.94</td>
<td>1.26</td>
<td>.70</td>
</tr>
<tr>
<td>PEOU – Lane control</td>
<td>1</td>
<td>6.44</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>T – Lane control</td>
<td>4</td>
<td>5.32</td>
<td>1.70</td>
<td>.46</td>
</tr>
<tr>
<td>PS</td>
<td>1</td>
<td>5.50</td>
<td>1.62</td>
<td></td>
</tr>
<tr>
<td>BIU</td>
<td>1</td>
<td>6.06</td>
<td>1.43</td>
<td></td>
</tr>
</tbody>
</table>


Participants agreed that the lane control features were useful (mean=5.94, SD=1.26), and easy to use (mean=6.44, SD=0.70). They trusted ACC above the neutral level (mean=5.32, SD=1.70), and they were satisfied with their experience using ADAS (mean=5.50, SD=1.62). The BIU score was higher than the neutral indicating positive feelings about using the lane control features. Multi-item subscales of the questionnaire on ACC - T and PU - have Cronbach’s α of .46 and .7, respectively. Cronbach’s α for PU is low, so modeling result should be interpreted with caution.

B. Hierarchical Regression

For predicting behavioral intention to use ACC, hierarchical regression was applied to the ratings of questionnaire items divided into five subscales: PU, T, PEOU, PS and BIU (Table 2; Fig 3(a)).

- Sub-model 1 (BIU). PS and PU significantly influence BIU. PS has positive (β=0.95, p<0.001) influence on BIU, indicating that higher PS leads to higher BIU; but PU has negative influence (PU: β=-0.42, p=0.04), indicating higher PU leads to lower BIU.
works should focus on validating the model using larger sample size and use control. Further, significant influence on trust 

The data collected is limited by sample size. Further, ratings on perceived usefulness and behavioral intention to use refers to all ADAS features as opposed to adaptive cruise control and lane control features separately. Future works should focus on validating the model using larger sample size and gather more precise data on acceptance of acceptance.
individual ADAS feature. Other influences on senior drivers for using ADAS should be examined to expand the model.

References

Appendix

Table A1. Questionnaire items measuring the components in the proposed model of ACC and lane control features. Response was given in a 7-point rating scale with higher score reflecting more positive attitude (strongly disagree = 7, strongly agree =1).

<table>
<thead>
<tr>
<th>Construct</th>
<th>Questionnaire item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Usefulness (PU) – ACC</td>
<td>I feel safe using the acceleration and braking features (ACC).</td>
</tr>
<tr>
<td></td>
<td>Acceleration and braking features (ACC) feature provide alerts when needed.</td>
</tr>
<tr>
<td>Perceived Ease of Use (PEoU) – ACC</td>
<td>I am familiar with the acceleration and braking features (ACC)</td>
</tr>
<tr>
<td>Use-based Trust (T) – ACC</td>
<td>I trust the acceleration and braking features (ACC). I can rely on acceleration and braking features (ACC) properly while I am doing something else. Acceleration and braking features (ACC) are dependable. Acceleration and braking features (ACC) give too many false alerts. *</td>
</tr>
<tr>
<td>Perceived Usefulness (PU) – Lane Control</td>
<td>I feel safe using the lane control features.</td>
</tr>
<tr>
<td>Perceived Ease of Use (PEoU) – Lane Control</td>
<td>I am familiar with the lane control features.</td>
</tr>
<tr>
<td>Used-base Trust (T) – Lane Control</td>
<td>I trust the lane control features. I can rely on lane control features properly while I am doing something else. Lane control features are dependable. Lane control features give too many false alerts. *</td>
</tr>
<tr>
<td>Perceived Satisfaction (PS)</td>
<td>I have high degree of satisfaction with automated vehicle technologies in my study vehicle.</td>
</tr>
<tr>
<td>Behavioral Intention to Use (BIU)</td>
<td>Cost consideration aside, I would prefer the next vehicle I purchase to have some level of automated vehicle technologies.</td>
</tr>
</tbody>
</table>

*The items were mirrored so that higher ratings reflect more positive attitudes (strongly disagree = 7, strongly agree =1)