Recognition on trigger condition of autonomous braking system

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Back Ground

Automobiles carrying Autonomous Braking System (or Autonomous Emergency Braking System, AEBS) are prevailing. More than 40% of vehicles sold in Japan in 2016 have been equipped with the systems.

While the reduction of traffic accidents is expected due to the widespread use of the system, there are concerns that many drivers are using the system without the proper understanding of the trigger conditions.

Fig. trend of AEBS in Japan

Back Ground : Trigger conditions of AEBS

Example scenes where AEBS may not work properly
- The pedestrian's height is very high or very low
- Pedestrians are moving in groups
- Weather is bad such as heavy rain, thick fog, snow, sandstorm
- Water, snow, dirt, and so on are rolled up from the vehicle in front

Example scenes where AEBS may work accidentally
- When there is a vehicle, a pedestrian, and a structure beside the road at the entrance of the curve section
- When driving in a place with a structure such as a tunnel with a low ceiling or a road sign above the road

Aim

Ambiguous recognition of such "trigger conditions" can also have serious adverse effects, such as promoting dangerous driving.

Purpose of the study

1. Recognition of the trigger condition of the AEBS of the drivers holding the vehicle equipped with the system
2. The influence factors on that recognition
Method

How to analyze recognition of the trigger conditions
- The trigger conditions of AEBS were referenced from the automaker’s website
- Asking understanding of each trigger condition through a questionnaire survey
- As preprocessing of analysis of factors influencing AEBS recognition, Principal Component Analysis (PCA) is carried out to integrate each recognition of trigger conditions

Recognition of the trigger conditions

Factors1: Personal attitude
- Age
- Gender
- Ability of daily living
- Size of vehicle (light, small, regular)
- Driving frequency (per week)
- Driving style

Factors2: Contact opportunities of information on AEBS
- Experience of the AEBS before/after purchasing
- Reference level of information about AEBS provided by various mediums (TV, magazine, etc.)

Method

How to identify influence factors regarding recognition of AEBS trigger conditions
- Asking “personal attitude” and “contact opportunities of information on AEBS” to drivers who own his/her vehicle equipped with AEBS
- Developing a multiple regression model with the Recognition of the trigger condition of the AEBS

Method

How to evaluate Ability of daily living
- Using the Japan Science and Technology Agency Index of Competence (JST-IC)\textsuperscript{(1,2)} to get the data of Ability of daily living

*Respondents answer with yes (=1 point) or no (=0 point)
*The score is calculated by the sum of the answers with each category

Use of new equipment
- Can you use a mobile phone?
- Can you use AM/FM?
- Can you use a mobile phone or a personal computer?
- Can you judge the authority of health information?
- Do you watch educational programs?

Information gathering
- Do you take measures to avoid suffering from headache, sneezing, cough, etc.?
- Do you have a habit of eating healthy food?
- Do you participate to regional festivals and events?
- Do you participate in the neighborhood association?

Life management
- Are you taking measures to avoid suffering from fraud, snatching, burglar, etc.?
- Do you have a bit of ingenuity in your life?
- Can I take care of a sick person?

Social participation
- Are you participating in regional festivals and events?
- Are you participating/active in the neighborhood association?
- Can you take care of the local residents association or undertake a board member of that?
- Are you doing any volunteer activities?

Method

How to evaluate driving style
- Using Driving Style Questionnaire (DSQ) developed by Research Institute of Human Engineering for Quality Life\textsuperscript{(3)} to get the data of driving style
- DSQ has 8 scales composed of 18 questions

*Respondents answer each question with 4 levels (from “quite applicable” to “not at all”)
*The score of each scales are calculated by the sum of the each answer

\textsuperscript{1)}Motomori Ishibashi, Masayuki Okuwa, Shun’ichi Doi, Motoyuki Akamatsu: Indices for characterizing driving style and their relevance to car following behavior, SICE Annual Conference 2007, DOI: 10.1109/SICE.2007.4421155
\textsuperscript{2)}http://www.cit.nihon-u.ac.jp/kouendata/No.38/1_kikai/1-029.pdf (in Japanese)
Method

How to get the data
- This analysis must be conducted on a particular group holding vehicle with AEBS
- Therefore, we collected the data through a web research company (Rakuten Insight, former Rakuten Research) with a large population that can be screened

Population of the survey
1.22 million who own car themselves

Procedure
- Sending a survey sheet for screening to 9,999 monitors randomly selected by gender and age group for this population and confirmed own vehicle with AEBS ownership status
- Sending the main questionnaire to the respondents who passed the screening
- The survey was finished at the stage of obtaining answers of target numbers by gender / age group

Period for survey
March 5th - 7th, 2018

The number of respondents
200 for each of 4 groups divided by elderly / non-elderly and gender (male and female) (total = 800)

Result

Experience of the AEBS before/after purchasing
-20% of respondents had experienced AEBS through seminars etc. before purchasing vehicles
- Men of 18-64 year old have frequently experienced the AEBS after purchase, but Women of 65 or more have fewer done


Before purchasing the car with AEBS (through seminars)

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-64</td>
<td>30%</td>
<td>20%</td>
</tr>
<tr>
<td>65 or more</td>
<td>10%</td>
<td>5%</td>
</tr>
</tbody>
</table>

After purchasing the car with AEBS

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-64</td>
<td>50%</td>
<td>40%</td>
</tr>
<tr>
<td>65 or more</td>
<td>10%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Significant difference (P<0.05) by Pearson’s Chi-squared test

Reference level of information about AEBS provided by various mediums
- Explanations by car dealer, in manufacturer catalogs, newspapers & magazines and TV programs are more referred to by elderly drivers

Significant difference (**P<0.01, *P<0.05) by Pearson’s Chi-squared test

Recognition of the trigger conditions (rate of recognition)
- Only half of the respondents answered “knew it” under almost trigger conditions (especially female is lower)

<table>
<thead>
<tr>
<th>Trigger conditions</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC1 Your car’s speed is too slow or too fast</td>
<td>79%</td>
<td>79%</td>
</tr>
<tr>
<td>TC2 Velocity difference between collision target and your car is extremely large</td>
<td>70%</td>
<td>63%</td>
</tr>
<tr>
<td>TC3 The pedestrian’s height is very high or very low</td>
<td>63%</td>
<td>58%</td>
</tr>
<tr>
<td>TC4 Pedestrians are moving in groups</td>
<td>50%</td>
<td>36%</td>
</tr>
<tr>
<td>TC5 A part of the pedestrian (head, limbs, etc.) is hidden by luggage etc.</td>
<td>53%</td>
<td>39%</td>
</tr>
<tr>
<td>TC6 Weather is bad such as heavy rain, thick fog, snow, sandstorm</td>
<td>71%</td>
<td>67%</td>
</tr>
<tr>
<td>TC7 Water, snow, dirt and so on are rolled up from the vehicle in front</td>
<td>69%</td>
<td>60%</td>
</tr>
<tr>
<td>TC8 The surroundings are dark such as in the nighttime and in the tunnel</td>
<td>64%</td>
<td>54%</td>
</tr>
<tr>
<td>TC9 The object to collide is the side part of the vehicle, the oncoming vehicle, the vehicle that comes back</td>
<td>60%</td>
<td>42%</td>
</tr>
<tr>
<td>TC10 The object of collision is a fence or a wall</td>
<td>60%</td>
<td>48%</td>
</tr>
<tr>
<td>TC11 The object of collision is a special vehicle such as a low floor trailer with a low loading platform</td>
<td>54%</td>
<td>45%</td>
</tr>
<tr>
<td>TC12 Increasing the accelerator, brake, steering wheel during AEBS activate</td>
<td>60%</td>
<td>57%</td>
</tr>
<tr>
<td>TC13 When there is a vehicle, a pedestrian and a structure beside the road at the entrance of the curve section</td>
<td>58%</td>
<td>47%</td>
</tr>
<tr>
<td>TC14 When driving on a place with a structure such as a fence with a low string or a road sign above the road</td>
<td>53%</td>
<td>41%</td>
</tr>
<tr>
<td>TC15 Cause of going to an occurring vehicle on a curve section</td>
<td>53%</td>
<td>41%</td>
</tr>
</tbody>
</table>
### Result

Making a comprehensive index for recognition of the trigger conditions

To make comprehensively index for recognition of the trigger conditions of AEBS, PCA was used

- Since all the characteristic vectors of the first principal component (PC1) show positive values, a comprehensive index could be expressed

<table>
<thead>
<tr>
<th>Contents of trigger conditions</th>
<th>PC1</th>
<th>PC2</th>
<th>PC3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Your car’s speed is too slow or too fast</td>
<td>0.28</td>
<td>-0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td>2. Velocity difference between collision target and your car is extremely large</td>
<td>0.24</td>
<td>-0.07</td>
<td>-0.16</td>
</tr>
<tr>
<td>3. Pedestrians are crossing in groups</td>
<td>0.19</td>
<td>-0.13</td>
<td>-0.06</td>
</tr>
<tr>
<td>4. Part of the pedestrian’s body, such as a shoulder, is hidden by luggage</td>
<td>0.52</td>
<td>0.24</td>
<td>-0.06</td>
</tr>
<tr>
<td>5. Pedestrian is not in a walking position, such as crouching posture</td>
<td>0.65</td>
<td>0.09</td>
<td>0.06</td>
</tr>
<tr>
<td>6. Weather is bad such as heavy rain, thick fog, snow, sandstorm</td>
<td>0.23</td>
<td>-0.17</td>
<td>0.45</td>
</tr>
<tr>
<td>7. Perturbation of driving lines, such as a bump on the road</td>
<td>0.48</td>
<td>-0.01</td>
<td>-0.21</td>
</tr>
<tr>
<td>8. Information gathering</td>
<td>0.28</td>
<td>0.09</td>
<td>3.10</td>
</tr>
<tr>
<td>9. Confidence in driving skill</td>
<td>0.66</td>
<td>0.16</td>
<td>4.08</td>
</tr>
<tr>
<td>10. Experience of the AEBS before purchasing</td>
<td>0.25</td>
<td>-0.12</td>
<td>0.10</td>
</tr>
<tr>
<td>11. The object to collide is the side part of the vehicle, the oncoming vehicle, the vehicle that comes back</td>
<td>0.26</td>
<td>-0.06</td>
<td>-0.11</td>
</tr>
<tr>
<td>12. The collision objective is a fence or a wall</td>
<td>0.24</td>
<td>-0.08</td>
<td>-0.13</td>
</tr>
<tr>
<td>13. The object of collision is a special vehicle such as a two-way truck with a low towing partners</td>
<td>0.24</td>
<td>-0.08</td>
<td>0.04</td>
</tr>
<tr>
<td>14. The difference between the vehicle and collision target is extremely large</td>
<td>0.25</td>
<td>-0.12</td>
<td>0.11</td>
</tr>
<tr>
<td>15. When there is a vehicle, a pedestrian, and a structure beside the road at the entrance of the curve section</td>
<td>0.24</td>
<td>0.53</td>
<td>0.02</td>
</tr>
<tr>
<td>16. When driving is a place with a structure such as a tunnel with a low ceiling or a road sign above the road</td>
<td>0.24</td>
<td>0.53</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Adjusted R-squared = 0.2562, Significant difference: ***P<0.001, **P<0.01, *P<0.05

### Conclusion

1. Recognition of the trigger condition of the AEBS of the drivers holding the vehicle equipped with the system

- Only half of the respondents answered “knew it” under almost trigger conditions (especially female is lower)

2. The influence factors on that recognition

- Men, the ability of information gathering, confidence in driving skill, having experienced AEBS before purchasing, referring to catalogs of automobile manufacturers, newspapers and magazines and results of performance evaluation in public agencies are positively related to recognition of AEBS trigger conditions

- 65 or more (especially 70 or more) and referring to Introduction by manufacturer’s CM are negatively related to recognition of AEBS trigger conditions

Future works

- Focusing on the following things:
  - the difference of driving behaviors of people with less recognition for the AEBS trigger conditions between before/after own the car with AEBS (i.e. become more careless or not);
  - the extent of reliance about AEBS by people with less recognition (i.e. excessive or not)

Thank you for your attention
Characteristics of respondents