Benefit Analysis of Automated Safety Systems

Nutzenanalyse der automatisierten Schutzkonzepte

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System Benefit
cooporative sensor technology

Cooperative Sensors

Other Essential Components

- Brake Actuator
- Electronic Control Unit
- Steering Torque Actuator
- Human Machine Interface

System Benefit

- Precise environment perception
- Fast detection of hidden obstacles
- Reliable and fast information about acceleration of obstacles
- Fast recognition of critical traffic situations
- Take advantage of maximal transmittable wheel forces
- Situation dependent active reaction of system

- Collision avoidance or mitigation by preventive measures
- Optimization of the crash compatibility

- Reducing the number of
  - death,
  - heavily injured,
  - slightly injured
  - and also physical damages
Pre processing
Data Preparation

GIDAS Crash Database
- Accident Data Analysis: VuFo*
  - 35 scenarios
- Data Reconstruction: VuFo*
  - 453 scenarios

Simulation
Precrash and in crash

- Simulation with active evasive assistent system
  (simulation up to crash)
  - VuFo*
  - Continental AG

- Simulation with active emergency brake assistent system
  (simulation up to crash)
  - FZD**

Post Processing
Data Analysis

- Crash Simulation
  - Collision Parameters
  - VuFo*

- Calculation of the Injury Risk Function
  - Simulation data with system intervention
  - VuFo*

- Real crash data without system intervention
  - FZD**

Efficiency and Benefit Analysis

453 Crash Scenarios, 906 Vehicles and 1654 Persons are taken into account.

*VuFo: Die Verkehrsunfallforschung an der TU Dresden **FZD: Fachgebiet Fahrzeugtechnik der TU Darmstadt

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Benefit Analysis of Automated Safety Systems
The brake assistant and the evasive assistant system have different system design and address different crash scenarios, therefore no direct system comparison is possible.
**Injury Risk Function:** how crash severity influences injury risk in vehicles crashes

**Dynamic Variables**
- $dv$ in km/h: 1
- EES in km/h: 2
- Impact momentum in Ns: 3
- Average acceleration in m/s²: 3
- Rotational velocity in °/s: 4

**Boolean Variables**
- Seat place (near/far): 1
- Passenger compartment crashed (yes/no): 1

**Parameter Study and Correlation Analysis (VuFo)**

$dv = V_1 \text{ in km/h} - V_2 \text{ in km/h}$

**Parameter with Priority Class 1 (VuFo)**

$X_1 = dv \text{ in km/h}$

$X_2 = \text{Seat Place [0,1]}$

$X_3 = \text{Passenger Compartment Crashed? [0,1]}$

**Injury Risk Probability**

$$P(X) = \frac{1}{1 + e^{-\sum_{i=1}^{3} b_i \cdot X_i}}$$

$X_i$: Parameters

$b_i$: Weighting Coefficients

**Injury Risk Potential**

- Seat place near and crash in PC
- Seat place near and no crash in PC
- Seat place far and crash in PC
- Seat place far and no crash in PC

**Multiple Logistic Regression Analysis (VuFo)**
Injury Risk Function
Different Injury Severities are Taken into Account

Different Injury Severities:
- No Injury
- Slight Injury
- Serious Injury
- Fatal Injury

Injury Risk Function

Reduction Potential:

<table>
<thead>
<tr>
<th>Injury Severity</th>
<th>Reduction Potential for Evasive Assistant [%]</th>
<th>Reduction Potential for Emergency Brake Assistant [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>38%</td>
<td>59%</td>
</tr>
<tr>
<td>Seriously Injured</td>
<td>33%</td>
<td>57%</td>
</tr>
<tr>
<td>Slightly Injured</td>
<td>21%</td>
<td>54%</td>
</tr>
</tbody>
</table>

\[
P_{\text{fatal injury}} = P_{\text{min. fatal injury}}
\]

\[
P_{\text{serious injury}} = P_{\text{min. serious injury}} - P_{\text{min. fatal injury}}
\]

\[
P_{\text{slight injury}} = P_{\text{min. slight injury}} - P_{\text{min. serious injury}}
\]
Efficiency Analysis
Optimization of the Crash Compatibility

Evasive Assistant

Emergency Brake Assistant

Effective (mitigation)
Neutral
Not effective
Efficiency Analysis
Reduction in Number of Death

Evasive Assistant

Reduction in Number of Death

Number of Death

[Graph showing the reduction in number of death over years for Evasive Assistant with different penetration rates.]

- one equipped vehicle is required (ideal penetration rate)
- one equipped vehicle is required (ESP penetration rate)
- two equipped vehicles are required (ideal penetration rate)
- two equipped vehicles are required (ESP penetration rate)

Emergency Brake Assistant

Reduction in Number of Death

Number of Death

[Graph showing the reduction in number of death over years for Emergency Brake Assistant with different penetration rates.]

- one equipped vehicle is required (ideal penetration rate)
- one equipped vehicle is required (ESP penetration rate)
- two equipped vehicles are required (ideal penetration rate)
- two equipped vehicles are required (ESP penetration rate)
Potential Benefit of the System

Potential Risk Reduction

\[ P_{\text{Slight Injury}} = \frac{\text{number of slightly injured}}{\text{number of cars}} \approx \frac{28200}{43 \text{ Mil.}} \]
\[ P_{\text{Serious Injury}} = \frac{\text{number of seriously injured}}{\text{number of cars}} \approx \frac{3500}{43 \text{ Mil.}} \]
\[ P_{\text{Fatal Injury}} = \frac{\text{number of death}}{\text{number of cars}} \approx \frac{125}{43 \text{ Mil.}} \]

Source: GIDAS 2011

\[ P_{\text{EBA}} \]
\[ P_{\text{EA}} \]

Potential Benefit

\[ \text{Benefit}_{\text{EA}} = \sum P_i \times PRR_i \times \text{Time of use in year} \times \text{Insurance Cost in Euro} \approx 70 \text{ Euro.Year} \]
\[ \text{Benefit}_{\text{EBA}} = \sum P_i \times PRR_i \times \text{Time of use in year} \times \text{Insurance Cost in Euro} \approx 126 \text{ Euro.Year} \]

Source: BASt 2009

The **Potential Benefit** of the system for the average time of use of 15 years in Germany could be estimated for Evasive Assistant as 70 Euro.Year and for Emergency Brake Assistant as 126 Euro.Year.
Thank you for your attention!