SIMPATO – the Safety Impact Assessment Tool of Interactive

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interactIVe - Project overview

The interactIVe vision:
Accident-free traffic and active safety systems in all vehicles

• Facts:
  • Duration: 48 months (January 2010 – November 2013)
  • 29 partners of 10 countries
  • Budget: 30 Million € (Founding by the European Commission: 17 Million €)

• interactIVe systems:
  • SECONDS (Safety enhancement through continuous driver support)
  • INCA (Integrated collision avoidance and vehicle path control)
  • EMIC (Cost-efficient emergency intervention for collision mitigation)
interactIVe Demonstrators

**SECONDS**
- Continuous Support
- Curve Speed Control
- Enhanced Dynamic Pass Predictor
- Safe Cruise

**INCA**
- Lane Change Collis. Avoid.
- Oncoming Vehicle Collis. Avoidance/Mitigation
- Rear End Collis. Avoidance
- Side Impact Avoidance
- Run-off Road Prevention

**EMIC**
- Emergency Steer Assist
- Collision Mitigation
Safety impact assessment

• What would be the effect of these functions on the number of fatalities and injuries if they were deployed in Europe?

• Characteristics
  • Prototype systems → Limited amount of test results available on technical performance and user behaviour → ex ante evaluation
  • Many different functions, combinations of functions, and demonstrators → evaluation of the functions
  • Need in-depth accident data to define accident scenarios, but not available on EU level
  • Three of the most relevant accident types are
    • Rear end
    • Road departure
    • Lane change
    → Consider only these
Approach

function description -> target scenarios

- technical assessment
- user-related assessment
- GIDAS accident database

real life effectiveness

usage

reconsider accident with effects of new function

scale up using CARE/national databases

Deployment scenario; penetration rate

Focus of this presentation
Safety Impact Assessment – Methodology

- Literature review on impact assessment methodologies:
  - Safety Mechanisms
  - Accident Reconstruction
  - Neural Network
  - FOT – Approach

- Chose appropriate methodology by considering the available data as well as advantage and disadvantages of the methodologies:
  - Nine Safety Mechanisms

- Direct effects
  1. Direct in-car modification of the driving task, **Only in-car functions**
  2. Direct influence by roadside applications,
  3. Indirect modification of user behaviour,
  4. Indirect modification of non-user behaviour,
  5. Modification of interaction between users and non-users,

- Indirect effects on user
  6. Indirect modification of user behaviour,
  7. Modification of modal choice,
  8. Modification of route choice,

- Exposure effects

- Effects on post-accident consequence modification
  - Exposure effects, typically small
  - Only post-collision
Direct effect – Accident evolution

- Function may warn or intervene; driver may react to warning
  - Warning and intervention time points: technical assessment
  - Driver reaction time and reaction strength: user related assessment & literature review
  - Function intervention strength: technical assessment
Direct effects - Possible effects of an interactive ADAS

- How can an interactive function affect an accident?
- Example for rear end:

Focus of this presentation
Direct effects – Rear-end scenario (Braking)

- Initial condition (in-depth accident database)
Direct effects – Rear-end scenario (Evade)

- Initial condition (in-depth accident database)
Accident reconstruction for rear end

- Example rear end accident scenario
- With RECA function

**Longitudinal motion**

Trajectories in X direction accident id 81 system RECA

**Lateral motion**

Trajectories in Y direction accident id 81 system RECA

Evasion
364 in-depth accident cases analysed
• Relevant for 4 functions
• Varying results: 21%-77% rear ends potentially avoided, others mitigated
• This holds for selection of GIDAS scenarios → need to be scaled up
Road departure

- Only avoidance
- Only steering
- Similar for curved roads

Reference

Equipped case
150 in-depth accident cases analysed, relevant for 2 functions

Departure (over lane marking): 3-94% potentially avoided

Departure 50 cm outside lane marking: 25-100%

More effective on straight roads than curved, due to timeliness of warning and intervention time points
Conclusions

- interactIVe safety functions have significant potential to improve safety by avoiding or mitigating accidents
- Results are widely varying between functions. For the GIDAS data:
  - 21%-77% rear ends potentially avoided, many others mitigated
  - 3%-94% road departures potentially avoided
- This will be scaled up to EU level

- Accident reconstruction method is suitable for ex ante study. Limitations:
  - Accident evolution is first approximation: fits with available data, no consideration of impact zones, body mechanics, etc.
  - Modelling of realistic driver reactions needs more data: attention, workload, risk compensation, …
  - GIDAS accident scenarios are for Germany
  - Nr of fatal accidents in GIDAS is low, especially for rear end
- Thus, method provides safety potential rather than “real” safety impact.
Thank you.

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Backup slides
SP7 “Evaluation and legal aspects” - Overview

SP7 role in interactIVe:

- Definition of a test and evaluation framework for each application with respect to human factors and technical performance
- Development of test scenarios, procedures, and evaluation methods
- Provision of tools for evaluation like equipment, test catalogues, questionnaires or software and support for testing
- Definition of test and evaluation criteria
- Analysis of legal aspects for broad exploitation of the applications

Evaluation for interactIVe is divided into:

- Technical assessment
- User-related assessment
- Impact assessment

SP Leader:

Technical assessment
User-related assessment
Impact assessment
Legal aspects
SP7 “Evaluation and legal aspects” - Methodology

Methodology for the evaluation bases mainly on the PReVAL methodology:

- Step 0: System and function description
- Step 1: Expected impact and hypotheses
- Step 2: Test scenario definition
- Step 3: Evaluation method selection
- Step 4: Measurement plan
- Step 5: Test execution and analysis

Assessment of the whole functions (not components)
Safety Impact Assessment – Approach

Deployment scenario
- Penetration rate
- Target year & region
- No. of target scenarios, ref year & region
- No. of target scenarios, target year & region

Accident statistics
- Target scenarios

Functional description
- Target scenarios

Technical Assessment
- Operational conditions
- Effectiveness
- False alarms (+/-)

User-related Assessment
- Usage
- Unintended behaviour

Effect on non-user

Exposure effects

Relation time – injury risk

Legend:
- Choice
- Step in other part of interactIve
- External data
- Step in safety impact assessment

(1,2) Potential effect in deployment scenario
(3) Effect incl. user tactical behaviour
(4,5) Effect non-user
(6,7,8) Effect exposure
(9) Mitigation

Safety effect in deployment scenario
Input data from technical and user-related Assessment

- Input from the technical assessment:
  - warning / intervention point in time
  - intervention strength (longitudinal lateral acceleration)
  - Overall 908 test runs considering 8 accident related test scenarios (e.g. rear-end, blind-spot or run-off road conflicts)

- Input from the user-related assessment
  - Intended usage of the functions for motorways, urban and extra urban road
  - Results base on the questionnaires during the interactlVe user studies.
  - Literature review on long term effects of ADAS
Use of accident database for the Impact Assessment

- GIDAS Database
  - Real Accidents are used in order to re-simulated real accidents with the interactIVe functions
    - Rear-end conflicts
    - Blind-spot conflicts
    - Run-off road conflicts
    - Accident for the re-simulation must fulfil certain requirements
  - Determine the change in the accident risk base

- CARE Database / National accident databases
  - Scaling up of the reconstruction results on European level
  - Identify potentially affected accidents for the interactIVe function, for which reconstruction was not possible (e.g. Speed related accidents, pedestrian accidents).
Direct effects – Accident re-simulation

- With system
- Without system

- Location
- Time

- Vehicle 1
- Vehicle 2

- $v_{0,OV}$
- $v_{0,HV}$
- $v_{1,OV}$
- $v_{1,HV}$
- $v_{3,OV}$
- $v_{3,HV}$

- $t_{\text{Function warns}}$
- $t_{\text{Function intervenes}}$
- $t_{\text{Driver reacts, with}}$
- $t_{\text{Driver reacts, without}}$
- $t_{\text{Accident, with}}$
- $t_{\text{Accident, without}}$

- Acceleration $a_{1,OV}$
- Acceleration $a_{1,HV}$
- $a_{1b,HV}$

- Collision

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Direct effects – Driver Reaction

- In order to consider the effect of a warning, driver reactions are defined.
- Basis for the driver reaction are the interactIVe user-related tests and a literature review:
  - Three different reactions were defined:
    - Rear-end: braking (90%) and evading (10%)
    - Run-off road and blind spot: steering (100%)
  - In order to consider different drivers, the relevant parameter (max. acceleration and reaction time) are varied.
  - For each case, 100 different driver reaction are generated.
Direct effects – Rear-end (collision mitigation)

- Speed $v_{0,HV}$ and $v_{0,OV}$ collision are known!
- Derive speed $w_k$ from just after collision based billiard mechanics (correction factor $c_k$)
- Calculate $\Delta v_{HV} = w_k - v_{0,HV}$ and $\Delta v_{OV} = w_k - v_{0,OV}$, the change of speed at collision for the host and the other vehicle, with and without the system
- Use known relations between $\Delta v$ in order to calculate injury risk…
Direct effects – Run-off road scenario

• In the run-off road scenario it is only checked, whether the accident is avoided or not
• No mitigation, because the depend on the location, which can not be considered due to missing data in the re-simulation with the system
Direct effects – Lane change scenario

• In principle same approach as for the run-off road scenario
• Only collision avoidance is analyse
• Time based avoidance is not considered by the re-simulation
• In contrast to the run-off road scenario the trajectory of the vehicle before the intervention needs to be changed:
  • A sinusoidal shape is presumed

\[ y(x) = w_{\text{lane}} \left( \frac{x}{L} - \frac{1}{2\pi} \sin \left( \frac{2\pi x}{L} \right) \right), \text{ for } 0 \leq x \leq L \]  
[SPO98]

• Length of the lane change \( L = v_0 T \) (deceleration due to steering manoeuvre is not considered)
• Distributions of the lane change time can be found in [SCH07, PFE07] for different vehicle types. From this one can draw the conclusion that
  • for passenger cars the mean lane change time is approximately 5 s, and in 95 \% of the cases is between approximately 3 s and 7 s.
  • for trucks the mean lane change time is approximately 7 s, and varies between 4 s and 11 s.
Indirect effect

- Different indirect effects are known (e.g. Distraction, Workload, Usage, Misues)
- Consideration of indirect effects in interactVe is difficult:
  - Most of the indirect effects are difficult to quantify
  - Based on the short term test in interactVe long-term effects could not be derived
- Only the usage of the function is considered
Example (Preliminary) Results

• Sample result for a rear-end collision avoidance system (warning & intervention):
  • 364 in-depth rear end accident scenarios analyzed
  • Avoided: 24.2 % (with driver reaction) / 22.4 % (without driver reaction)
  • Mitigated: 75 % (with driver reaction) / 76.8 % (without driver reaction)
  • 100% deployment in EU would save XX % fatalities and XX % injuries per year

• Sample result for a rear-end collision mitigation system (no warning):
  • 364 in-depth rear end accident scenarios analyzed
  • Avoided: 33.5 %
  • Mitigated: 42 %
  • 100% deployment in EU would save XX % fatalities and XX % injuries per year
Summary & Next steps

- Impact Assessment for the interactIVe function was conducted
- The effect of the interactIVe was analysis in detailed in three accident scenarios by the re-simulation of real accident scenario
- Results were scaled up to European Level by means of the CARE Database
- Analysed function showed a positive effects with respect to the European road safety

**Final Event:**
- 20-21 November 2013 in Aachen
- Joint event with eCoMove
- November 20: Presentations & Exhibition in Aachen
- November 21: Demo drives on Ford Proving Ground in Lommel
- Subscription is open at the interactIVe website: [http://interactive-ip.eu](http://interactive-ip.eu)
Direct effects – Collision Mitiation

- Speed $v_{0,i,\text{with}}$ and $v_{0,i}$ for vehicle $i$ from just before collision are known!
- Derive speed $v_{-1,i,\text{with}}$ and $v_{-1,i}$ from just after collision based billiard mechanics
- Calculate $\Delta v_{i,\text{with}} = v_{1,i,\text{with}} - v_{0,i,\text{with}}$ and $\Delta v_i = v_{1,i} - v_{0,i}$, the change of speed at collision for the host and the other vehicle, with and without the system
- Use known relations between $\Delta v$ and injury risk…
- … to determine change in risk $R_i$ between with and without, for both vehicles

\[
(m_1 + m_2) \cdot \frac{w_{k,\text{OV}}}{c_k} \cdot (m_1 v_1 + m_2 v_2)
\]

Risk ratio $R_i$ for vehicle $i$:

\[
R_i = \frac{\text{Risk}_{i,\text{with}}}{\text{Risk}_{i,\text{without}}}
\]
Project overview: Facts

• Budget: EUR 30 Million
• European Commission: EUR 17 Million
• Duration: 48 months (January 2010 – November 2013)
• Coordinator: Aria Etemad, Ford Research and Advanced Engineering Europe
• 10 Countries: Czech Republic, Finland, France, Germany, Greece, Italy, Spain, Sweden, The Netherlands, UK
Consortium

• OEMs

• Suppliers

• Research

• SMEs
Objectives

- More scenarios covered
- Sensor platform
- Decision strategies
- Active interventions
- Integration of functions

System intelligence
Low cost segment
Full collision avoidance | mitigation
interactIVe - Project overview

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# Project structure

**Sub-project 1: Integrated project (IP) management**

Integrated advanced driver assistance systems (ADAS) for continuous support and emergency intervention

**Sub-project 2: Perception**
Specifications for sensor interfaces and fusion modules

**Sub-project 3: Information, warning and intervention (IWI) strategies**
Definition of use cases and requirements | Specifications for IWI strategies

**Sub-project 4: SECONDS**
Safety enhancement through continuous driver support

**Sub-project 5: INCA**
Integrated collision avoidance and vehicle path control

**Sub-project 6: EMIC**
Cost-efficient emergency intervention for collision mitigation

Seven demonstrator vehicles: six passenger cars and one truck

**Sub-project 7: Evaluation and legal aspects**
Test and evaluation framework for interactIVe applications | Analysis of legal aspects