APPLICATIONS IN TRAFFIC ACCIDENT RESEARCH TO IMPROVE VEHICLE SAFETY

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Structure

1. Necessity of traffic accident research
2. Application assisted accident investigation
3. Data analyses for research on traffic safety
4. Pre-crash simulation to enhance traffic safety
5. Conclusion
Applications in Traffic accident research to improve vehicle safety
Necessity of traffic accident research

Accident research in the 1920s

Early "accident research" in Dresden

Source: Youtube
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Necessity of traffic accident research

Accident scenario in Germany

- Car occupants benefit from active and passive safety
- Numbers of accidents & casualties are stagnating since some years
- In 2017 persons:
  - Fatalities 3,186
  - Seriously injured 66,495
  - Slightly injured 323,659

Source: DESTATIS, Fachserie
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Necessity of traffic accident research

GIDAS – German In-Depth Accident Study, since 1999

General information

Accident sketch

\[ \approx 2,000 \text{ accidents/year} \]

\[ \varnothing 3,500 \text{ single information/accident} \]

Technical investigation

Medical investigation
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Necessity of traffic accident research

Criteria

Investigation area

Database

Only accidents with personal damage

Source: Google Maps & GIDAS

Accident level

~34,500 accidents

Vehicle level

~62,000 vehicles

Personal level

~85,000 persons
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Application assisted accident investigation

Some examples

- OpenStreetMap (OSM) for accident sketch
- Coding of injuries
- Signal processing of measurements
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Data analyses for research on traffic safety

Databases

Access and processing

Source: ESV 2017 – Bakker, Spitzhüttl et al.: “IGLAD - International harmonized in-depth accident data”
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Mathematical models – Injury Risk Functions (IRF); example: pedestrians in car accidents

Real accident:
$v_{\text{coll}} = 50 \text{ km/h}$

Accident with system (e.g. AEB):
$v_{\text{coll}} = 40 \text{ km/h}$
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Mathematical models – Injury Risk Functions (IRF)

Multidimensional
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Calculation of deformation frequencies

- Normalized car dimensions and discretization into voxel
- Accumulation of accident deformations for 1,000 passenger cars

→ Analyzation of potentially safe places for sensitive and/or dangerous energy storage (e.g. battery or gas)
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ACEA Safety Model

Sequence of a traffic accident

- $t_{\text{crit}}$: critical event
- $t_u$: collision unavoidable
- $t_0$: collision

Phase 1: Normal driving
Phase 2: Incident-Phase
Phase 3: Pre-Crash-Phase
Phase 4: In-Crash-Phase
Phase 5: Post-Crash-Phase

Active safety
Integral safety
Passive safety
Tertiary safety
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**VUFO Accident Simulation Toolbox (VAST)**

- Sketch
- External data
- Simulink

Source: Mathworks.com
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Evaluation of opponent’s position at specific TTC

* 400 ms before crash
  • 200 ms before crash
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VUFO Accident Simulation Toolbox (VAST)

Sketch

External data

MathWorks® Simulink

GIDAS

GERMAN IN-DEPTH ACCIDENT STUDY

PRE-CRASH-MATRIX
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Example accident – Sketch

Accident scene
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Example accident – Simulation

real accident situation

real accident situation

with ADAS System
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Point of no return $t_u$ when a collision is unavoidable

- Severity of damages as a function of time
  - continuous
  - differentiable
- No knowledge about the exact function
- $f(t_u) = 0$
  - no analytical solution possible
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Point of no return $t_u$ when a collision is unavoidable

Circle of forces / „Kamm'scher Kreis“

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Point of no return $t_u$ when a collision is unavoidable

- Severity of damages as a function of time
  - continuous
  - differentiable
- No knowledge about the exact function
- $f(t_u) = 0$
  - no analytical solution possible
  - approximation by iterative process and variable integration step size
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Point of no return \( t_u \) when a collision is unavoidable – Generic rear-end collision

\[
t_u = f(\Delta v, \mu); \quad v_{obj} = 40 \text{ km/h}
\]

\[
\Delta v = 2 \ldots 100 \text{ km/h}, \quad \mu = 0,1 \ldots 1,0
\]

\( t_u \) comparison of simulation and literature
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Point of no return $t_u$ when a collision is unavoidable – real accident’s rear-end collision

real accident situation

t$_u$ simulation
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Naturalistic driving study (NDS) → Incidents and Events
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Naturalistic driving study (NDS)

Real scenario

Recording
- Camera
- Accelerometer
- Rotation rate sensor
- GPS
- Sender and receiver device
- Processor and ring memory

Position
Movement
Video
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Naturalistic driving study (NDS)

Real scenario

Simulation
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Naturalistic driving study (NDS)
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Naturalistic driving study (NDS)

<table>
<thead>
<tr>
<th></th>
<th>Driver 1</th>
<th>Driver 2</th>
<th>Driver 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger car</td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
<td><img src="image3" alt="Diagram" /></td>
</tr>
<tr>
<td>Camping van</td>
<td><img src="image4" alt="Diagram" /></td>
<td><img src="image5" alt="Diagram" /></td>
<td><img src="image6" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Driver 1:
- Large scatter range
- Significant difference between passenger car and camping van
- High accelerations

Driver 2:
- Marginal difference between passenger car and camping van
- Experienced driving

Driver 3:
- Low scatter range
- Higher acceleration in passenger car

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Naturalistic driving study (NDS)

Renault Espace:
→ Marital-problems

Suzuki Swift:
→ Divorce

Renault Megane:
→ New relationship

VW Caddy:
→ Responsibility for children

Renault Megane:
→ Crisis in relationship

Renault Laguna:
→ On-Off relationship

2015

2016

2017
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Naturalistic driving study (NDS)

Ground truth labeling with

MathWorks®
Automated Driving System Toolbox
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Naturalistic driving study (NDS) vs. Real world accident
AGENDA

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Conclusion

- Assurance of **traffic safety** must be a very high society target. Human errors must not lead to fatalities in a modern traffic environment!

- In contrast to past trends, recent statistics show a **stagnation in the accident numbers**.

- The development of Highly Automated Driving needs some more efforts to ensure a **safe and modern concept of movement**.

- Therefore it is very important to improve on crucial aspects of
  - ensuring **functional safety**
  - study **real world scenarios**
  - progress on **perception infrastructure** to support vehicle systems.
THANK YOU FOR YOUR ATTENTION!

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