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

Technical investigation

Medical investigation

≈ 2.000 accidents/year

Ø 3.500 single information/accident

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Necessity of traffic accident research

Criteria

Only accidents with personal damage

Investigation area

Source: Google Maps & GIDAS

Database

- 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, Spitzhützl 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

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

[Diagram showing the process of VUFO Accident Simulation Toolbox (VAST)]

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

GIDAS

MathWorks®
Simulink

GIDAS-PCM
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

$t_u = f(\Delta v, \mu); v_{obj} = 40 \text{ km/h}$
$\Delta v = 2 \ldots 100 \text{ km/h}, \mu = 0,1 \ldots 1,0$

$t_u$ 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 und 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><strong>Passenger car</strong></td>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Graph" /></td>
</tr>
<tr>
<td><strong>Camping van</strong></td>
<td><img src="image4.png" alt="Graph" /></td>
<td><img src="image5.png" alt="Graph" /></td>
<td><img src="image6.png" alt="Graph" /></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)

2015

Renault Espace:
→ Marital-problems

Suzuki Swift:
→ Divorce

Renault Megane:
→ New relationship

VW Caddy:
→ Responsibility for children

2016

Renault Megane:
→ Crisis in relationship

2017

Renault Laguna:
→ On-Off relationship
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Naturalistic driving study (NDS)
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Naturalistic driving study (NDS) vs. Real world accident
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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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