‘How should I inform my driver?’
Effective advisory warnings based on cooperative perception

„Wie sage ich es meinem Fahrer?”
Effektive Fahrerinformationen basierend auf kooperativer Perzeption

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IZVW
Focus of HMI-research

Development of strategies for **early driver assistance in impending conflict situations.**

- **Effect of cooperative perception:**
  - Information about conflict ‘advisory warnings’
  - Goal: Attention direction, Preparation for possible reaction
  - Early information without annoyance and lowering of acceptance

- **Effect of cooperative perception:**
  - Optimisation of warning ‘imminent crash warning’
  - Goal: Immediate reaction (braking, steering)
  - Optimal time frame for warning

Conflict can be **reliably predicted cooperatively**
Conflict can be **perceived by onboard sensors/driver**

Potential conflict can be predicted **cooperatively**

Warning signal too late for collision avoidance

Time to impact

(Neukum, 2011)
Experimental studies conducted at the IZVW

Unassisted 'normal behavior' in impending conflict situations

- Determination of the drivers' need for assistance and impact of visual obstructions

Example scenario

Visual obstruction

No obstruction

Experimental studies on the design of the human machine interface

Study I: Effectiveness of prototypical driving assistance

Example scenario

Direction and conflict specific HUD-display

Study II: Minimal time frame for effective advisory warnings

Time to impact [ms]

Variation of the timing of advisory warnings
($t_c$: latest possible warning timing)

Study III: Specificity of effective advisory warnings

Study IV: Modality of effective advisory warnings

Visual-auditory vs. visual

Experimental studies on system limits

Study V: Behavioral effects of false and unnecessary advisory warnings

Correct warning

Unnecessary warning

False warning

Study VI: Behavioral effects of false direction indications

Single conflict situation

Multiple conflict situation

18.09.2013

How should I inform my driver?
Experimental studies conducted at the IZVW

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Example scenario
Visual obstruction
No obstruction

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Study I: Effectiveness of prototypical driving assistance

Example scenario

Study II: Minimal time frame for effective advisory warnings

Variation of the timing of advisory warnings

A_r: latest possible warning timing

Time to issue [s]

Study III: Specificity of effective advisory warnings

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Single conflict situation
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How should I inform my driver?
Study I: Effectiveness of prototypical driving assistance

Strong reduction of critical situations through prototypical driving assistance

Turning vehicle (head-on) takes right of way
Crossing vehicle (right) takes right of way
Turning vehicle (right) takes right of way
Crossing vehicle (left) takes right of way
Crossing cyclist (left) takes right of way
Decelerating lead vehicle (highway)
Pedestrian on road (rural road)
Pedestrian crossing road (rural road)
Turning vehicle – crossing cyclist
Pedestrian on road (urban road)

Example scenario
Direction and conflict specific HUD-display

N = 20 drivers, 88 driving scenarios

Relative frequency of safety critical situations [%]
Experimental studies conducted at the IZVW

Unassisted 'normal behavior' in impending conflict situations

Determination of the drivers' need for assistance and impact of visual obstructions

Example scenario
Visual obstruction
No obstruction

Experimental studies on the design of the human machine interface

Study I: Effectiveness of prototypical driving assistance
Example scenario
Direction and conflict specific HUD display

Study II: Minimal time frame for effective advisory warnings
Study III: Specificity of effective advisory warnings

Variation of the timing of advisory warnings ($t_0$: latest possible warning timing)

Study IV: Modality of effective advisory warnings
Visual-auditory vs. visual

Experimental studies on system limits

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Correct warning
Unnecessary warning
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Single conflict situation
Multiple conflict situation

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How should I inform my driver?
Study II: Minimal time frame for effective advisory warnings

Relative frequency of safety critical situations [%]

- Turning vehicle takes right of way
- Crossing takes right vehicle of way
- Decelerating lead vehicle
- Pedestrian crossing road

N = 20 drivers, 6 driving scenarios (only scenarios with critical encounters are depicted)

Minimal time frame of effective advisory warnings: 1-2 seconds before latest possible warning timing (t₀)
Experimental studies conducted at the IZVW

Unassisted 'normal behavior' in impending conflict situations

Determination of the drivers' need for assistance and impact of visual obstructions

Example scenario

Visual obstruction

No obstruction

Experimental studies on the design of the human machine interface

Study I: Effectiveness of prototypical driving assistance

Direction and conflict specific HUD display

Study II: Minimal time frame for effective advisory warnings

Variation of the timing of advisory warnings

$k$: latest possible warning timing

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Experimental studies on system limits

Correct warning

Unnecessary warning

False warning

Study V: Behavioral effects of false and unnecessary advisory warnings

Study VI: Behavioral effects of false direction indications

Single conflict situation

Multiple conflict situation
Study III: Specificity of effective advisory warnings

Direction specific > direction unspecific in usefulness-ratings, although the effectiveness mainly depends on the warning timing.

n = 21 drivers, 6 driving scenarios (selection of the full scenario set is shown)
Experimental studies conducted at the IZVW

Unassisted 'normal behavior' in impending conflict situations

- Determination of the drivers' need for assistance and impact of visual obstructions
- Example scenario
- Visual obstruction
- No obstruction

Experimental studies on the design of the human machine interface

- Study I: Effectiveness of prototypical driving assistance
- Study II: Minimal time frame for effective advisory warnings
- Variation of the timing of advisory warnings
  - \( t_e \): earliest possible warning timing
  - \( t_l \): latest possible warning timing
- Study III: Specificity of effective advisory warnings
- Study IV: Modality of effective advisory warnings
  - Visual-auditory vs. visual

Experimental studies on system limits

- Study V: Behavioral effects of false and unnecessary advisory warnings
- Correct warning
- Unnecessary warning
- False warning
- Study VI: Behavioral effects of false direction indications
- Single conflict situation
- Multiple conflict situation

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How should I inform my driver?
Study V: False and unnecessary advisory warnings

Example: unnecessary advisory warning

Example: false advisory warning
Study V: False and unnecessary advisory warnings

**Relative frequency of safety critical situations (TTA\textsubscript{min} < 1s)**

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<thead>
<tr>
<th></th>
<th>visual-auditory</th>
<th>visual</th>
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<tbody>
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<td>Turning</td>
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<td>vehicle takes</td>
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<td>Crossing</td>
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<td>Crossing</td>
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<td>right of way</td>
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**System reliability**

<table>
<thead>
<tr>
<th>HMI</th>
<th>100% with false warnings</th>
<th>60% with unnecessary warnings</th>
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<tbody>
<tr>
<td>Visual</td>
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<td>10</td>
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<tr>
<td>Visual-auditory</td>
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<tr>
<td>Baseline</td>
<td>20</td>
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Effectiveness of Ko-PER advisory warnings is not reduced by false and unnecessary alarms, especially in case of purely visual warnings.
Summary: How should I inform my driver?

- **Time frame:** Minimal time frame of effective advisory warnings: 1-2 seconds before latest possible warning timing ($t_0$)

- **Specificity:** Direction specific > direction unspecific in usefulness-ratings, although the effectiveness mainly depends on the warning timing

- **Modality:** Effectiveness of Ko-PER advisory warnings is not reduced by false and unnecessary alarms, especially in case of purely visual warnings
Thank you for your attention!