Cooperative Pedestrian Protection

Kooperativer Fußgängerschutz

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Motivation

Accident statistics by types of accidents 2009:

<table>
<thead>
<tr>
<th>Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTYP 7 - Other</td>
<td>19.10%</td>
</tr>
<tr>
<td>UTYP 6 - Alongside</td>
<td>3.30%</td>
</tr>
<tr>
<td>UTYP 5 - Stationary Vehicles</td>
<td>1.80%</td>
</tr>
<tr>
<td>UTYP 4 - Crossing</td>
<td></td>
</tr>
<tr>
<td>UTYP 3 - Turn, Intersect</td>
<td>0.50%</td>
</tr>
<tr>
<td>UTYP 2 - Turning</td>
<td>11.50%</td>
</tr>
<tr>
<td>UTYP 1 - Driving</td>
<td>1.20%</td>
</tr>
<tr>
<td></td>
<td>62.60%</td>
</tr>
</tbody>
</table>

Causes of accidents: Inattention, misjudgment, visual obstruction

Killed VRUs:

Caused by: Unbraked collisions (33%), No evasion (80%)

Very high potential to avoid most of the collisions by means of Active Safety Systems
State of the art pedestrian detection:
• Warn or brake decision based on sensor fusion
• E.g. combination of (mono) camera and radar
• Recall and precision limited by hardware
• Depending on line of sight

Potential of cooperative systems:
• Possible candidate for sensor fusion
• Mono / Stereo Camera + Ko-TAG:
  • Systematic hypothesis generation
  • Scene-optimized use of the processing capabilities
  • Improved detection delay in obscured scenarios
• Stereo Camera + Ko-TAG:
  • Complementary position measurement
  • Improved precision and higher reliability
Physiological pedestrian movement model

- Based on empirical assessment of motion capabilities
- First stage:
  - Simple model of the maximum physiological potential
  - Typical pedestrian movement velocities
  - Physiological potential of acceleration and rotation
- Second stage:
  - Model of the physiological motion range
  - Weighted movement area
Potential of the physiological pedestrian movement model

- Improved tracking algorithms:
  - Traditional object tracking in Cartesian coordinates
  - Filter prediction based on generic movement models
  - Noise / Prediction enhancement with the physiological model
  - e.g.: Kalman Filter with constant velocity movement model

- Refined ADAS functions:
  - More precise movement information for pedestrians
  - Improved scene understanding and collision risk estimation
  - Reliable warn and brake functionality of the system
Collision Risk Prediction

Movement area of a pedestrian (2s)

Vehicle possible driving path (2s)

Time discrete trajectories of a pedestrian

Time discrete position of a vehicle
Collision Risk Prediction

Collision risk model: Area-Pedestrian-Car (APC)

\[ A_{pc} = \frac{A_p \cap A_c}{A_p} \]

Collision risk model: Probabilistic Monte Carlo (PMC)

\[ P_{mc} = \frac{\text{Collision Count}}{\text{Trajectory Count}} \]
System architecture of a Pedestrian Safety System

![Diagram of Pedestrian Safety System Architecture](image.png)

- **Sensors**
  - Ko-TAG
  - Vehicle Dynamics
  - Camera

- **Tracking**
  - Association
  - Correction
  - Prediction
  - Fusion

- **Collision Risk**
  - Collision Risk Calculation
  - Decision Module

- **Actuators**
  - HMI
  - Retractor
  - Brake

- **Pattern Recognition**
  - Hypothesis Generation
  - Image-Based Detection

**Verdeckung:**

**Unverdeckt:**
Testing Possibilities

- **Control Room:** For control, data acquisition, and power source, heated
- **Guide Rail:** Easy assembly in various setups including curves
- **Carriage:** Cable driven, with robust dummy suspension
- **Aluminum Frame:** Easy assembly in various setups
- **Width:** 16m
- **Clearance:** 2.9m
- **Light-Barrier Trigger:** (not pictured), light-barrier for triggering a movement with adjustable delay
- **Electric Drive:** Precise positioning with external absolute encoder
- **Soft Shell Dummy:** Impact resistant, interchangeable, Adult / Child dummy
- **Radar Deflectors:** Preventing the frame from disturbing radar signals
Testing Possibilities

- Crossing (un)obstructed
- Alongside then crossing
- Alongside in Vehicle Lane
- Turn, Intersect

Also suitable for Radar due to Radar deflectors

Dummy strikeable without damage
System Demonstration

Cooperative Pedestrian Protection
Thank you for your attention!