Perception of the
Driving Environment

Assessment of Lane Recognition Systems

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Assessment of Lane Recognition Systems

Overview

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2. **Principle**
3. **Reference System “GroundView”**
4. **Evaluation**
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Motivation

Perception is generally unsafe

Motivation
Active Safety

- **up to now: main use in Driver Assistance Systems (DAS)**
- **future: increasing use in Active Safety (AS)**

➡ **demanding requirements on perception systems**

Motivation

Requirement

Objective assessment of perception systems for

- **development and optimization**
- **test and validation**
- **clearance (amount of testing!)**

also as regression test in the laboratory

Principle

Comparison to “ground truth”

compare the results of the assessed target systems with the “real world” (ground truth reference data)

Principle

Assessment Criteria

for comparison with the ground truth:

- **What is perceived (e.g. additionally neighbouring lanes)**
- **Availability (correct / false negative / false positive)**
- **Accuracy (and Dependability)**
- **Number of state changes**
- **Computational complexity**

Quality measures: distance metrics to ground truth

Dependability: (correctly) available and sufficiently accurate

Principle

Ground Truth

How to get the ground truth:

- **Human**
- **Simulation (be careful!)**
- **Reference system**

Principle

Reference Systems

Use of better sensors and algorithms:

- **additional sensors**
- **optimised positioning of sensors**
- **better environment conditions (lighting)**
- **more elaborate algorithms**
- **more computation power**
- **offline processing and human interaction**

Reference System „GroundView“

Hardware

- **2 cameras on rooftop rack looking downwards**
- **compact Car-PC with frame grabber und CAN-interface**

Reference System „GroundView“

Hardware

- **Laser range finder: movement of car body**

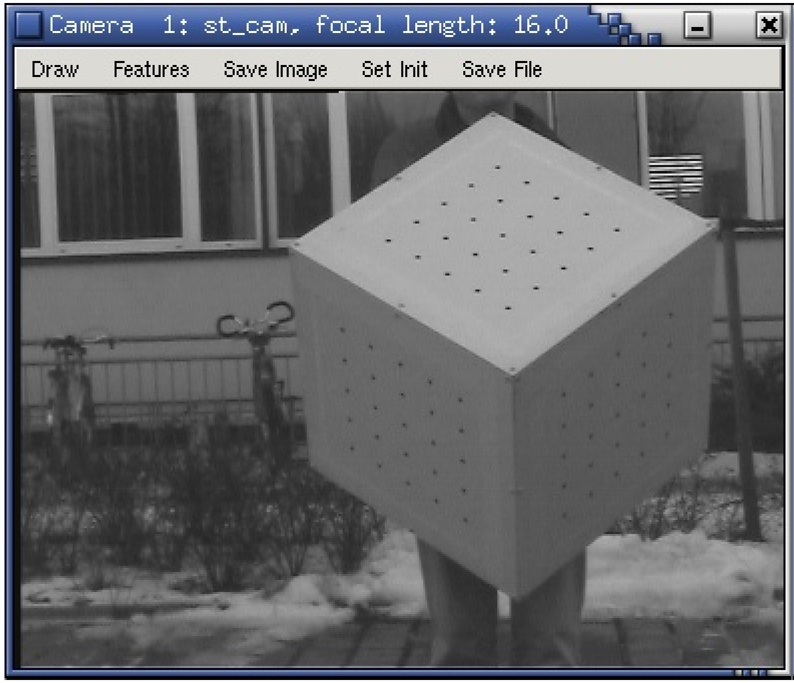
Reference System „GroundView“
Hardware Extensions

- **Inertial platform with**
  - **Laser gyros**
  - **accelerometers**
- **Carrier Phase Differential GPS**
- **Reference camera oder target system looking forward**
- **Additional reference camera looking rearward**
- **(Infrared) lighting sidewards and rearwards**

Reference System „GroundView“

Intrinsic Calibration: „Cube“

- **Software of FORWISS Passau (Project ElectronicEye)**
- **Ongoing work: Flat calibration object instead of cube**



Reference System „GroundView“

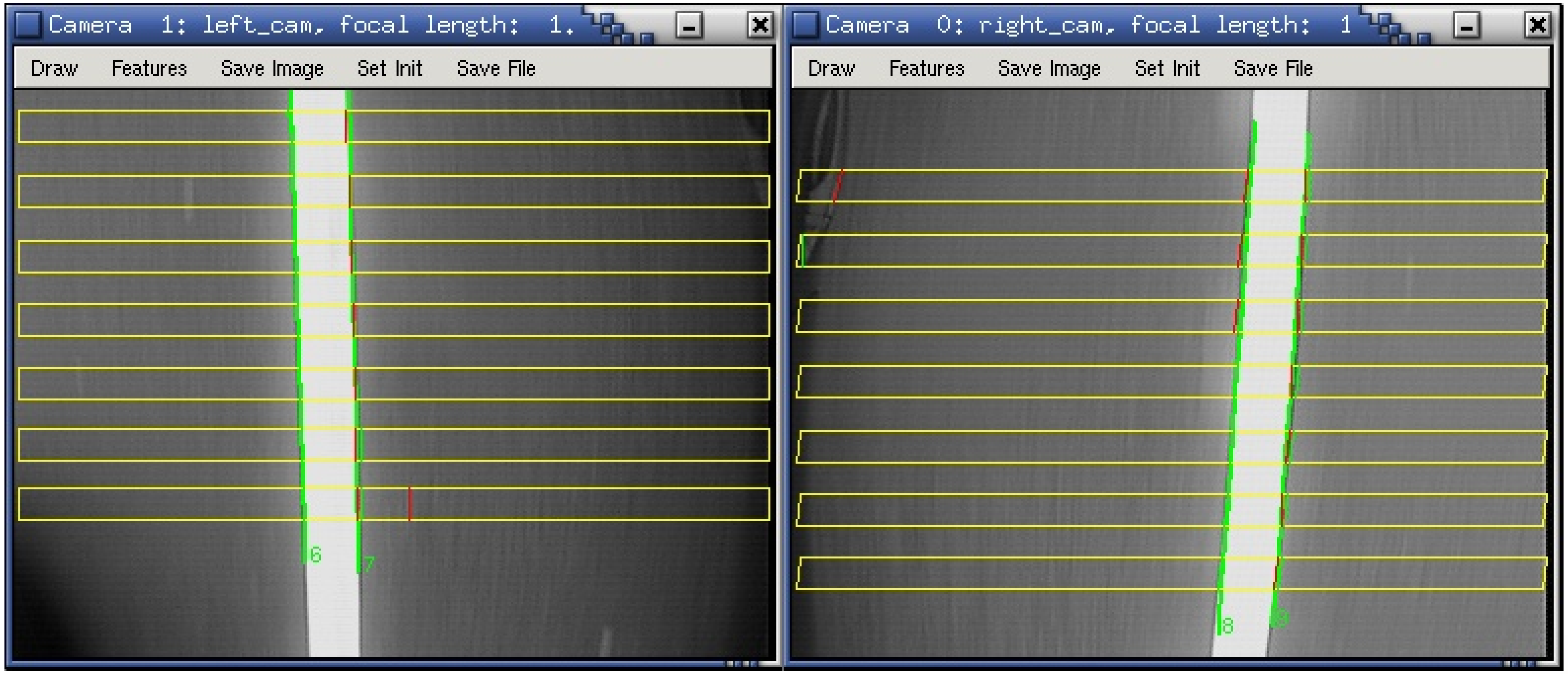
Extrinsic Calibration: „Carpet“

- **Software of FORWISS Passau (Project ElectronicEye)**

Reference System „GroundView“

Line Extraction

- **Lane Recgnition-Software (Realis) refactored and adapted**
- **Interactive Post Processing of the Reference Data**



Evaluation
Perception Performance

Availability: Percentage of
- **correctly not available (nothing there)**
- **correctly available**
- **false negative (item not detected)**
- **false positive (“ghost” item)**

for left and right lane marking and outer lane markers

Not dependable is worse than not available:
False positives are particularly critical

Low number of state changes desired

Evaluation
Perception Performance

Accuracy of estimated parameters
Offset: tolerance band according to ISO
+/- 15 cm at the desired warning position
(large line offsets have lesser requirements)

Other values: yaw angle, curvature, line widths

- **mean absolute/relative differences**
- **root mean square**

Evaluation
DAS/AS Performance

DAS/AS Availability LDWS (TLC/HC):

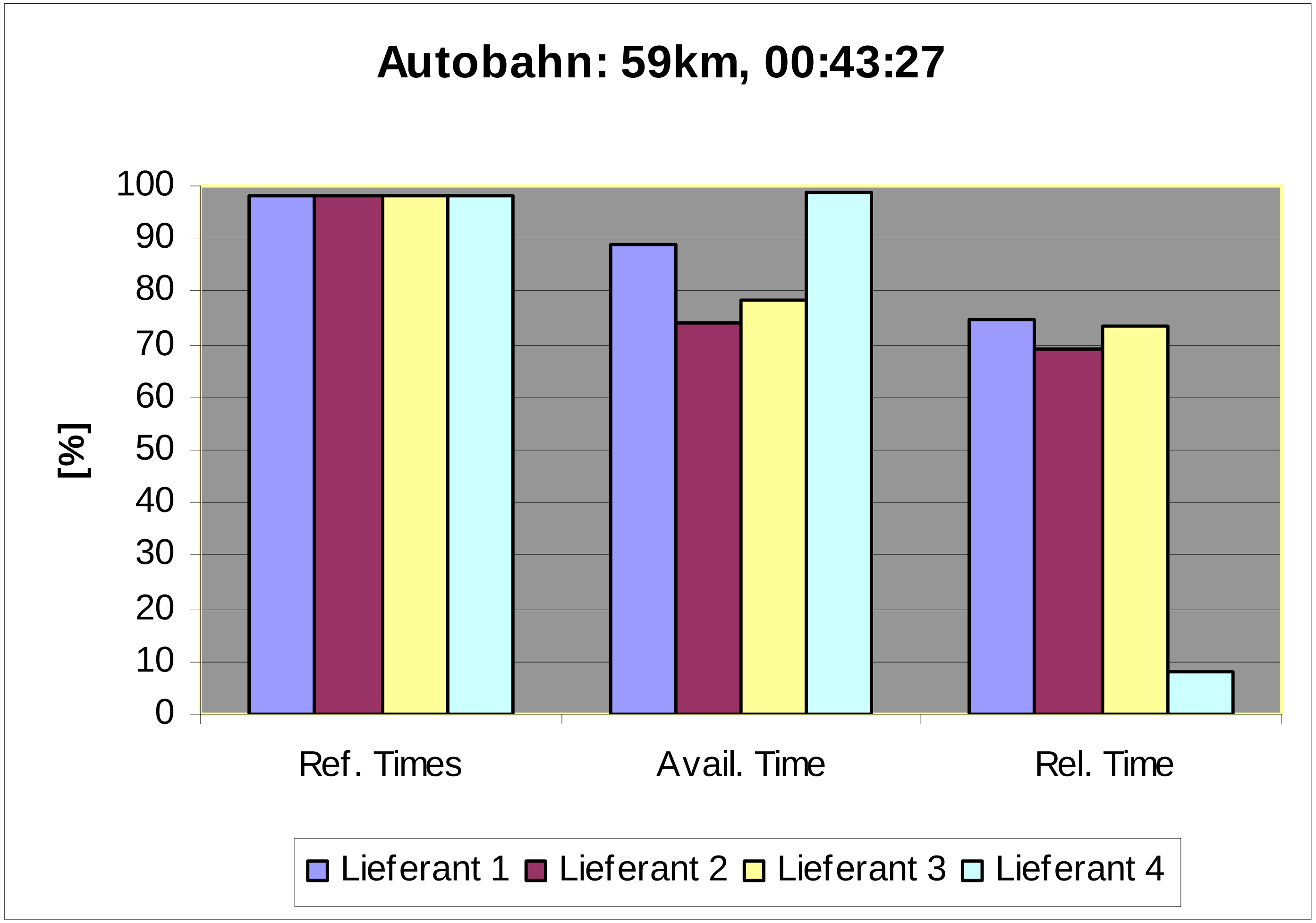
- **Two lines detected**
- **Speed > 60 km/h**
- **No blinker or warning light**
- **No braking, no massive acceleration**
- **System reaction close to line only**

➡ **Functional relevance of perception problems**

DAS/AS performance can be derived from perception performance

Evaluation

Example



Evaluation
Break Down of Results

Road Type: Autobahn, country road, city/village

Known problematic situations:
- **bad lane markings (USA: Botts dots)**
- **Rain, snow, back light, shadows**
- **Tunnels, construction areas, tar grooves**
- **Double lines, split/merge, widening/narrowing**
- **Short dashes, long gaps (France)**
- **checkered lane markings (Sweden)**

Evaluation

Break Down of Results

specific regression test data sets

- **Attributing of video clips: Typology**
- **automatic testruns**

also due to huge amount of data:

- **Data rate with image processing about 10-100 GB/h**
- **in total, at least several 100h are desired for DAS, more for AS, especially of the problematic situations**
- **Image/video compression 1:10-1:50; artefacts!**
- **Image data server: several TB**

Implementation

Advantages of Ada 95

- **Ada-mindset (beyond coding)**
- **Quality and Safety**
- **Refactoring**
- **Development process**
- **Reuse of existing software**
- **Portability**

… but loads of provisos…

Extensions

Ground Truth in Digital Maps

Ground truth:

- **Up to now: discrete (attributes of typology) or dynamical (data track), but always related to a specific video clip**
- **Future: static data geo-referenced in digital maps or map extensions**

Advantages:

- **Ground truth will be available for new recordings and sensors**
- **Good environmental conditions can be used to gather ground truth, can then be used under hard conditions**