Ibeo Automotive Systems GmbH

Automatic Scenario Generation by Advanced Offline Processing for Ground truth Evaluation

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Ibeo Automotive Systems GmbH

- 1998 Foundation of Ibeo Company
- 2000 Ibeo becomes part of Sick AG
- 2000-2008 Laserscanner Innovations
  - Development of Laserscanner Technology
  - Several Projects on Autonomous Driving
  - Development of Intersection Safety Assist (funded by the European Commission)
  - Intensive Marketing on Laserscanners
  - Worldwide Sales of Laserscanner Samples
- 2009/10 Management Buy-Out
- 2010 Cooperation Contract with VALEO for mass production Laserscanner (Scala)
- 2013 Reference Sensor for Automatic Scenario Generation for PreScan (TASS)
- 201x SOP of Ibeo Scanning Technology
ITFVHA 2013 - Presentations

- VOLVO Trucks
  - Truck shown with 1 Ibeo Laserscanner
- NISSAN
  - Car shown with 3 Ibeo Laserscanners
  - Car shown with 6 Ibeo Laserscanners
- ENERGY ITS
  - Trucks shown, each with 1 Ibeo Laserscanner
- CITYMOBIL2
  - INDUCT veh., each with 4 Ibeo Laserscanners
- AUTONET
  - VALEO named: Ibeos mass production partner
- AMAS
  - Trucks shown, each with 2 Ibeo Laserscanners

Great Day – Thank you!
Ibeo sponsors all drinks tonight!
Ibeo Massproduction Laserscanners

**SOP 2015/16 (Valeo)**
- FOV 145 x 3.2 deg (4 Layers)
- Range 0.3 m ... 200 m
- Resolution 4 cm / 0.25 deg

**SOP tbd, Samples 2014 (Ibeo)**
- FOV 180 x 2.0 deg (1 Layer)
- Range 0.05 m ... 40 m
- Resolution 4 cm / 1.0 deg
Ibeo miniLUX: 3D Parking Slots / Curbstones / …

Prototype will be shown on Ibeo stand at ITS 2013

Miniaturized Laserscanner ibeo miniLUX for Hatchdoor Mounting
**ScaLa 1403** vs. **ibeo LUX(s)** vs. **ibeo miniLUX**

**Ibeo Automotive Reference Laserscanners**
- **ibeo LUX/ LUX 8L**
  - 90° HFOV, 4/8 Layers x 0.8°,
    - range 0.30 to 200 m,
    - resolution 4 cm/ 0.10°
- **ibeo LUX HR/ 16L** (New 2014)
  - 90° HFOV, 8/16 Layers x 0.4°,
    - range 0.30 to 250 m,
    - resolution 4 cm/ 0.10°

**Ibeo Automotive Mass Production Laserscanners**
- **ScaLa 1403**
  - 145° HFOV, 4 Layers x 0.8°,
    - range 0.30 to 150 m,
    - resolution 4 cm/ 0.25°
- **ibeo miniLUX** (New 2014)
  - 180° HFOV, 1 Layer x 2.0°,
    - range 0.05 to 40 m,
    - resolution 4 cm/ 1.0°

*) produced by Valeo
## Reference Laserscanner ibeo LUX

<table>
<thead>
<tr>
<th>Specification</th>
<th>ibeo LUX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave length</td>
<td>905 nm</td>
</tr>
<tr>
<td>Range min - max</td>
<td>0.3 - 327 m</td>
</tr>
<tr>
<td>Distance resolution</td>
<td>0.04 m</td>
</tr>
<tr>
<td>Field of view (hor)</td>
<td>90°</td>
</tr>
<tr>
<td>Angular resolution (hor)</td>
<td>0.25°/0.10°</td>
</tr>
<tr>
<td>Field of view (ver)</td>
<td>3.2°</td>
</tr>
<tr>
<td>Angular resolution (vert)</td>
<td>4 layers @ 0.8°</td>
</tr>
<tr>
<td>Measurement Range (Veh.)</td>
<td>&gt; 200 m</td>
</tr>
<tr>
<td>Measurement Range (Ped.)</td>
<td>&gt; 65 m</td>
</tr>
<tr>
<td>Distance error</td>
<td>&lt;0.1m</td>
</tr>
<tr>
<td>Velocity accuracy ((v_x,v_y))</td>
<td>1 m/s</td>
</tr>
<tr>
<td>Update Rate</td>
<td>25 Hz (40ms)</td>
</tr>
<tr>
<td>Processing latency</td>
<td>&lt;60 ms</td>
</tr>
<tr>
<td>Dimensions WxDxH [mm]</td>
<td>128x93x85</td>
</tr>
<tr>
<td>Weight</td>
<td>900 g</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>&lt;12W</td>
</tr>
<tr>
<td>CAN Interface</td>
<td>yes (500kb)</td>
</tr>
<tr>
<td>Flexray Interface</td>
<td>no</td>
</tr>
<tr>
<td>other Interfaces</td>
<td>ETH (debug)</td>
</tr>
<tr>
<td>embedded object tracking</td>
<td>&gt;30 tracks (*)</td>
</tr>
</tbody>
</table>

Laserscanner Ibeo LUX with Embedded Object Tracking
Ibeo LUX: Design Integration (examples)

... – Daihatsu – Citroen – Volkswagen – BMW – Mercedes – MAN – Volvo Trucks – ...

Ibeo LUX is used for (1) application development and (2) reference sensing.
GM/CMU's new autonomous Cadillac (February 2013)

6x ibeo LUX Laserscanner:
• Two at bumper level facing forward
• One mounted on the roof facing forward
• One inside each rear side window looking out sideways
• One facing backward.
6x ibeo LUX Laserscanner:
- One mounted under the licence plate facing forward
- Two mounted at bumper level at the front corners turned to the sides
- Two mounted at bumper level behind the rear tyres facing sideways
- One facing backward

BMW's new Connected Drive 5series (February 2013)
6x ibeo LUX Laserscanner:
- One mounted over the licence plate facing forward
- Two mounted at bumper level at the front corners turned to the sides
- Two mounted at bumper level before the rear tyres facing sideways
- One facing backward

NISSAN's LEAF: Advanced Driver Assistance System (September 2013)
Automatic Scenario Generation
Modelling the Reference Object Track

A: Detection of the object at high distance at T0

Video: Landstrasse
Modelling the Reference Object Track

A: Detection of the object at high distance at T0
B: Classification of the object in near field at TX

BSC: Best Situation Classification
Modelling the Reference Object Track

A: Detection of the object at high distance at T0

B: Classification of the object in near field at TX

C: Forward-/Backward Tracking with Best Situation Classification from TX and to T0 (Ref)

Time Machine Approach
Modelling the Reference Object Track

A: Detection of the object at high distance at T0

B: Classification of the object in near field at TX

C: Forward-/Backward Tracking with Best Situation Classification from TX and to T0 (Ref)

D: Autolabelled Object with consistent Track for Reference Purpose from T0 to TX (Ref)
Automatic Scenario Generation

- Auto-Classified & Auto-Labelled Objects
- Relevant Background Information
- Scenarios are Scanner-independent
- Lane Markings & Curbstones (ongoing)
Real World Scenarios
Roundabout in Gothenbourg on 01 Sept. 2013

Video: Roundabout_Forward_Ibeo
Highway for Multi-Target-ACC on 08 May 2013

The video image shows 4 vehicles. The Laserscanner birdview shows 5 vehicles. Reason: 2 ibeo LUX laserscanners mounted at the corners.

Video:
ACC_BAB 7_2er Fusion LUX_C_Forward-Backward-Tracking-Advanced_130508
Optional Features
Lanemarkings & Curbstones

- Ibeo Laserscanner Lane Marking Detection and Curbstone Detection
- Verification of Road Users (pedestrian is either located on pavement or on road)
- Provision of Integrated Maps, meaning that all Traffic Participants are positioned and tracked with respect to lane markings and road edges
Sign Recognition

- Today Ibeo Laserscanner detect and track road signs on highways and country roads.
- An Automatic Offline Interpretation of the sign content can be implemented (an automatic process that is based on pictures of the signs taken during the test ride).
- For detection of road signs in urban areas/cities, an additional laserscanner is required and an additional camera for taking pictures in the near field.
Real World Scenarios automatically transferred into the virtual world of PreScan for further Evaluation
Automatic Scenario Generation – WHY?

1) USERS of PreScan

prescan
Simulation tool for ADAS and active safety systems

tass international

In the PAST:
- Users got standard scenarios delivered by TASS
- Users had to design their scenarios manually

TODAY:
- Users can get access to a TASS database with real world scenarios
- Users can generate their individual scenarios automatically from the real world
2) OEMs/TIERs to evaluate their Sensors

In the PAST:
- OEMs/TIERs had to label all relevant objects after a test ride manually
- OEMs/TIERs had to search for relevant scenarios semi-automatically/manually

TODAY:
- OEMs/TIERs can label all relevant objects after a test ride automatically
- OEMs/TIERs can search for relevant scenarios automatically

\[ d = 85.6 \text{ m} \]
(1) Real World Test Drives
(1) Real World Test Drives
(2) Automatic Scenario Generation

(3) Virtual World Evaluation
(1) $\rightarrow$ (2)
Automatic Scenario Generation from Real World Driving

(2) $\rightarrow$ (3)
Automatic Transfer into the Virtual World of PreScan for Evaluation

(3) Virtual World Evaluation
From Reference Sensing to DUT Evaluation

- Device under Test
- Test driving
- Reference sensor system

- Process data (online & offline)
- Process data (online)
- Process data (offline)

- Tracked & classified data
- Difference

- Scenario variation & DUT evaluation
- Real-life scenarios
- Auto-generation of PreScan scenario models
- Selection of relevant events

Passion for Scanning
Model variation of PreScan

Automated modification of model parameters

• Different weather conditions
• Adverse light conditions
• Different pedestrian speeds and directions
• Different vehicle speeds
• Different road conditions
• Etc.

Extra road users
Evening + street lights
Snow conditions
Finally...
Coming soon: Foundation of TCA

Integral toolchain for intelligent vehicle design

Automotive Industry (OEMs and Supply chain):
Request for virtual & experimental evaluation of new algorithm

SIMULATION
(MIL, SIL, DIL & HIL)

TESTING
(proving ground & public roads)

VALIDATION

TASS
Scenario and Sensor Simulation
Automated Parameter Variation

Ibeo
Onboard Reference Sensing
Automatic Scenario Generation

XCube
Worldwide Data Management
Automatic Event Detection

Standardized Toolchain Products

Customized TC Services

Automated Verification of DUTs and Applications

Passion for Scanning
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