UPC industrial event

Veoneer long-term collaboration with UPC

Dr. Jan-Erik Källhammer
Director Visual Enhancement & Cognitive Systems
What we do
"This conference is an opportunity for the world to embrace a new agenda to radically reduce the number of lives lost on our roads and re-think how we can provide access to safe, affordable, accessible and sustainable transport systems for all."

Tedros Adhanom Ghebreyesus
WHO Director-General
Adding Prevention to Protection

Our heritage: Impact protection

Active Safety: Accident prevention
Delivered during the past decade, as Veoneer and as part of Autoliv, the number of airbag ECUs and crash sensors is for a longer period.
Net Sales
2022: ~2 BUSD

Sales by Product
- Active Safety: 58%
- Restraint Control Systems: 38%
- Brake Systems: 2%
- Other: 2%

Sales by Customer
- Daimler: 18%
- Chinese Domestic: 17%
- Ford: 10%
- Other: 9%
- Volvo: 9%
- GM: 9%
- FCA: 7%
- Subaru: 7%
- Honda: 6%
- Hyundai/Kia: 5%
- RNM: 5%
- Other: 5%

Sales by Region
- Americas: 34%
- Asia: 28%
- Europe: 38%
Global Footprint

6,400 ASSOCIATES
11 COUNTRIES
5 PRODUCTION PLANTS
19 TECH CENTERS
Consolidation and restructuring of automotive suppliers

- Spin-off from Autoliv 2018
- SW arm purchased by Qualcomm 2022
- Active Safety purchased by Magna 2023
UPC cooperation 1
Development of a solid-state Lidar
Limitations of early Lidar
Moving parts and precision optics do not match well

- 2015 Lidar were sensitive to vibration, shock and thermal variations
- Vertical resolution insufficient
  - Example: Velodyne HDL-64E S3 (64 channels)
  - Measurement Range: Up to 120 m
  - Vertical Field of View: 26.9° -> Vertical angular resolution: 0.42°

*Velodyne spec
Lidar must handle all kinds of disturbances
Both night & day, background light limits performance

Source: 3M
Signal levels depend on obscurants in the atmosphere

How much degradation can we allow? How severe conditions? Will determine system specifications (how much laser power we need to emit).
UPC-CD6 has helped us with assessing different options

Example optical link budget trade off:

$$N_{\text{phot}} = \frac{1}{4} \cdot \frac{\lambda}{hc} \cdot \frac{A_{\text{pix}} FF}{A_{\text{array}}} \left( \frac{f}{z \cdot F\#} \right)^2 \cdot P_E T_{\text{pulse}} \cdot \rho \cos \Theta \cdot k$$

- \( N_{\text{phot}} \): the number of photons per frame that in pinges on a detector pixel
- \( \lambda \): Wavelength
- \( h \): Planck's constant
- \( c \): Speed of light
- \( A_{\text{pix}} \): Pixel area
- \( A_{\text{array}} \): Array area
- \( FF \): Fill factor of pixel
- \( f \): Focal length of detector optics
- \( z \): Object distance
- \( F\# \): F-number of optics
- \( P_E \): Emitted laser power
- \( \rho \): Reflectance of object
- \( \Theta \): Angle of incidence for object
- \( k \): Optical attenuation in the light path
- \( T_{\text{pulse}} \): (Integrated) active pulse time during frame

Assumptions:

- object modelled as a Lambertian diffuser
- the illuminated area is exactly covering the imaging detector

Adverse weather effect
Sensor fusion
Using several sensors is complex to match

- Several sensors required for redundancy and to cover the different failure modes
- Parallax error when fusing sensors at different positions
- Different sensor geometries and update frequencies
- Transform Lidar points into camera image
  - Alignment transformation distance dependent
  - Motion of objects between different sensors
Lessons learnt:

- Poor patent attorney: Almost lost US patent
Development and integration of customized lidar prototypes

Co-located Lidar & cameras for improved sensor fusion
UPC cooperation 2: EU project for AEBS based on Night Vision (EU proposal)
Many pedestrian fatalities in darkness

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>EU</th>
<th>China</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian fatalities</td>
<td>4,884*</td>
<td>7,000</td>
<td>24,500</td>
<td>1,884</td>
</tr>
<tr>
<td>% of total traffic fatalities</td>
<td>12%</td>
<td>14%</td>
<td>25%</td>
<td>32%</td>
</tr>
<tr>
<td>% at night time</td>
<td>71%</td>
<td>47%</td>
<td>-</td>
<td>68%</td>
</tr>
</tbody>
</table>

* http://www.iihs.org/iihs/topics/t/pedestrians-and-bicyclists/fatalityfacts/pedestrians
Pedestrians
Cadillac Night Vision

Night Vision Image in Center Cluster Display

Night Vision camera
Animal Accidents Can Be Deadly
Main driving force for Night Vision 2(2)

Many animal accidents in darkness & twilight

<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deer/Vehicle Accidents</td>
<td>1,090,000</td>
<td>500,000</td>
</tr>
<tr>
<td>Human Fatalities</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>Human Injuries</td>
<td>26,647</td>
<td>30,000</td>
</tr>
<tr>
<td>Property Loss</td>
<td>3.5 B$</td>
<td>1.0 B€</td>
</tr>
</tbody>
</table>

Sources: (1) State Farm, (2) Langley, et al 1995-2004, (3) Center for Disease Control and Prevention 2001-2002
Night Vision with Marking Light
Animal Detection with Marking Light System: BMW interface
Animal Detection
UPC cooperation 3
Sensing for automated driving
UN Regulation extends automated driving up to 130 km/h in certain conditions

- Revised UNECE regulation R157 for Automated Lane Keeping Systems (ALKS) entered into force on 1 Jan 2023 for all contracting countries (42).
  - Allows OEMs to legally provide customers with ALKS (SAE Level 3 up to 130 km/h for “Minimum forward detection range”)
  - “A passable object is such an object, that may be driven over without causing an unreasonable risk to the vehicle occupants or other road users regardless of whether the tyre of the ALKS vehicle comes in contact with the object or not.”
  - ALKS can only operate in conditions that allow bigger than “passable object” to be detected

\[ V = 130 \text{ km/h} \]
Summary:

Benefits of UPC cooperation
Summary

Cooperation with UPC

• Benefit
  • Access to technology (IP)
  • Evaluate technological options
  • Search for solutions (e.g., sensing, compute) for emerging challenges

• Conduct
  • Skilled
  • Professional
  • Flexible
  • Uncomplicated/unbureaucratic
  • Fast prototyping
Our Purpose
Creating Trust in Mobility