Automotive Radar and Radar Based Perception for Driverless Cars

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Auditorium, Ben-Gurion University of the Negev
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Radar Team DNA
More than 15 years of field (Product) experience, and now

“Radar is in all platforms at DAIMLER”
Radar 4 driverless driving Team-DNA

First automotive ESR

360°-76GHz Radar-Net

Mercedes Benz Cars

Autonomous BUS
Active Safety EvoBus

Autonomous Tuck
Active Safety Truck
Sites of the driverless-activities

- Peking, China
- Sunnyvale, California
- Immendingen, Germany
- Sindelfingen, Germany
- Berlin, Germany (Affiliated Institute: DCAI)
- Böblingen, Germany
- Ulm, Germany (Affiliated Institute: driveU)
- Ulm, Germany (Affiliated Institute: driveU)
- Immendingen, Germany
Introduction
Driver less driving: A Trend at Hype peak?

"Autonomous vehicles are not the stuff of science fiction. The technology has existed for years, and recent research has elevated the field from experiment to near-commercial readiness."

Ryan C.C. Chin, MIT Media Lab

2016 Start-ups, new players and Car-OEMs flooded the autonomous driving arena

... and they all heavily use Radar

If you are in „Wikipedia“ and things like „How Stuff works,“ you have reached public societal awareness
Drvless driving – How we approached it

How do we see the drvless future,

... that´s how our future began in 2013
Bertha-Tour 2013:
Bertha-vehicle appears like a normal S-Class
Bertha-Tour-2013:
... and Radar had been intensively used as backbone and innovation enabler
Performance Status
Truck Active Brake Assist – Radar-Based Function
COLLISION PREVENTION ASSIST PLUS

COLLISION PREVENTION ASSIST uses radar to constantly monitor closing speeds between your Mercedes-Benz and the moving vehicles around it. If the system determines that a collision is likely, it can help you apply the ideal level of braking.
The new E-Class 2016

Active Brake Assist with cross-traffic function: The system can detect crossing traffic at junctions and, if the driver fails to respond, applies the brakes autonomously. It is possible to completely avoid accidents at speeds up to 100 km/h or substantially reduce the severity of accidents at speeds above this level.
PRE-SAFE® impulse side: The system inflates an air chamber in the side bolster of the front seat backrest nearest the side of the imminent impact in a fraction of a second, thus increasing the distance between occupant and door and, at the same time, reducing the forces acting on the occupants.
Present E-Class: Drive Pilot

Following a lane with only occasional driver input
Changing lanes at the push of the indicator lever
Industrialization Challenges
Radar enables Style Icon like designs
Hence, Radar vehicle-integration is science for sake of artworks
Typical construction of a bumper

Cross-section of a standard multi-layer painting structure

For each layer we need the characteristic RF-parameters:
- Thickness
- Permittivity $\varepsilon_R$
- Dielectric loss angle $\tan(\delta)$
Radar- und Microwave-Measurement set-up
Drvless Challenges to Perception
Urban City - Next Radar Challenge

See also: https://www.researchgate.net/profile/Juergen_Dickmann
Traffic Challenges
Complexity, sudden appearance and diversity of Urban Scenarios

- Large area crossings
- Crossing traffic

- Non cooperative weather conditions

- Unpredictable, surprising obstacle positions and object movement

- Manifold object types
  - Hooded or partly covered objects
The Automation Dilemma

Wish for dissipation, relaxing and opportunity of parallel activities
Expected extremely high safety level to autonomous systems

Present automation practice
- Accidents caused by limitations of human driver
  - Reduce some accidents caused by human drivers
- Know your neighbour
- Know the relevant object

Future automation expectation
- Humans perform more right than wrong if driving
  - Additional task: Automating tasks that humans do right
  - Know your neighbourhood
  - Know what is what
  - Motion Prediction as future estimate
Radar Perception Paradigm
Radar perception paradigm
Transvision-Use the physical nature of mmWaves

You can only react on what you can see and what you can properly assess.

On my lane?
Radar perception paradigm
Full 360° FoV coverage and global representation

You can only react on what
You can see and what
You can properly assess
Radar development directions
Radar paradigm
Use ultra high resolution in space and time

Represent and classify dynamic objects comprehensively
Radar perception plan

Represent the static world comprehensively
Radar-perception plan

Bring both worlds into context to each other
Radar paradigm
Adopt machine learning and AI to radar
Achievements on our way
High resolution Radar
360° Global Object Map
Occupancy and other Radar-Grid Maps
High Definition Radar enables all weather capability.

Far Range Track prediction also in snow (with white lane markings in white snow 😊)
Instantaneous motion prediction

azimuthal doppler distribution
High Definition Radar perception and classification for moving objects
Localization support from Radar

CRR: Characteristic-Radar-Regions
Localization: Radar may help with landmarks
Simultaneously representation of static and dynamic world
Interpretation of the environment
Machine learning helps
Automotive Radar Future
Deep Learning for Cognitive Radar Grid-Maps

1. Radardata
2. Grid-Mapping
3. Clustering
4. Klassifikation
5. Labeled-Mapping
Classification (connected components) in Radargrids as input in CNN

<table>
<thead>
<tr>
<th></th>
<th>Classified as vehicle</th>
<th>Classified as non-vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>True vehicle</td>
<td>94.2% ±0.3%</td>
<td>5.1% ±0.2%</td>
</tr>
<tr>
<td>True non-vehicle</td>
<td>1.4% ±0.5%</td>
<td>98.6% ±0.7%</td>
</tr>
</tbody>
</table>

A lot of staff to do…

![car](image)
Deep Learning for Cognitive Radar Grid-Maps
Localisation with Radars (SLAM) and understand your detections
THx, Questions?