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**NTSB Safety Forum – Bosch Pedestrian Protection**

**Sensors for 360 degree surround sensing**

- **Near-range cameras**
  - Detection range: ~25 m

- **Mid-range radar rear/corner**
  - Detection range: ~80 m

- **Ultrasonic sensors**
  - Detection range: ~2.5 m / 4 m

- **Camera (Mono/Stereo)**
  - Detection range: ~120 m

- **Mid-range radar**
  - Detection range: ~160 m

- **Long-range radar**
  - Detection range: ~250 m

- **Near-range cameras**
  - Detection range: ~25 m

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- Dependent on DA functionality, different sensor set necessary (different range, field of view, ...)
- For Pedestrian AEB, target is to have robust and highly reliable sensor set
Distribution of pedestrian crashes in the US

Source: GES 2012 Report prepared by Bosch Accident Research
Pedestrian accidents (n = 66,260) w/ primary collision of passenger car, utility vehicle, van, transporter or light truck.
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Distribution of pedestrian crashes in the US

Based on crash statistics, Bosch is currently focusing on front crossing pedestrian scenarios

Source: GES 2012 Report prepared by Bosch Accident Research
Pedestrian accidents (n = 66,260) w/ primary collision of passenger car, utility vehicle, van, transporter or light truck.
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Radar / Video Standalone

- **Radar:**
  - Precise longitudinal distance and velocity in different weather and light conditions
  - Less exact lateral position
  - Classification as pedestrian based on micro-doppler

- **Video:**
  - Precise lateral position
  - Angles of object edges
  - Less exact longitudinal values
  - Good object type classification
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Radar / Video Fusion

- Fusion
  - Combines the advantages of both sensors
  - Precise longitudinal distance & velocity measurement
  - Precise lateral distance & velocity measurement
  - Robust classification
  - Best possible true/false performance

- Fusion between Radar and Camera required to achieve best possible AEB pedestrian performance
- AEB pedestrian can also be realized with single sensor solutions (may have limitations)
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Evolution Steps Mid Range Radar / Cameras

**MRR (Gen 1)**
- Cost efficient sensor that realizes comfort functions like ACC and safety functions like FCW & AEB
- Fulfillment of EU-NCAP AEB Car requirements 2014/2015

**MRR (Gen 2)**
- Increased lateral FOV for pedestrian and cyclist detection
- Introduction of micro-doppler for radar-based pedestrian classification

**MRR/LRR**

**New Generation**

**MPC1**
- Object detection
- Lane detection
- Road sign recognition
- Auto-high-beam

**MPC2 / SVC2**
- Increased detection range & FOV
- Detection & classification of pedestrians

**Bosch improving sensor technology to realize AEB pedestrian scenarios**
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Object classification w/ Radar

Features for robust and reliable classification on crossing objects (e.g. pedestrian)

Radar Cross Section (RCS)
• ~ 10-20dB difference between car rear and pedestrian

Patterns regarding motion/dynamic of locations

Micro-doppler
• Direct measurement of arm/leg movement

Articulation of pedestrian dummies critical for pedestrian classification with Radar
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Object classification w/ Video

Classification

“Learn patterns and find it”
- Only trained objects are recognized
- Huge training-database is necessary

Optical flow, Structure from Motion

“Compare one image with next”
- Ego-vehicle motion and its precise measurement necessary
- No exact measurement, only estimation

Disparity

“Measure by triangulation”
- Exact measurement of the 3D position for each picture element; also if host vehicle in standstill

Mono

Stereo
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- Bosch has evaluated several artificial test targets
- Some targets are not representative of real pedestrians

- **Realistic appearance, poses and articulation** are critical to ensure robust pedestrian classification.
- A **harmonization** of the pedestrian targets & test procedures between US and EU NCAP could reduce development and testing efforts.

Radar cross section (RCS) of artificial test targets compared to real pedestrians
(Source: ACEA pedestrian target specification and Bosch testing data)
NTSB Safety Forum – Bosch Pedestrian Protection Summary

- Bosch utilizes its Corporate Research activities to identify and develop relevant technologies to **prevent collisions and minimize accident severity**.

- The current development focuses on **front crossing scenarios** which is in line with the recent US NCAP proposal.

- **Harmonization** of test procedures and pedestrian targets with Euro NCAP will ensure the earlier introduction of already available pedestrian protection technologies to the US market.

- Scenarios with a turning vehicle require additional technologies and further research to realize robust systems.

- Bosch’s vision is **Accident-free Driving**.