DRIVES

Development and Research on Innovative Vocational Education Skills

SENSOR FUSION EXPERT

SFE.U4.E1 - LIDAR, RADAR AND CAMERA

Data and Sensor Fusion Applications, Use Cases and Real-Life Examples

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LEARNING OBJECTIVES

The student is able to …

SFE.U4.E1.PC1	The student can describe Lidar, Radar and Camera and their particularities.
SFE.U4.E1.PC2	The student understands and distinguishes the different sensors.
SFE.U4.E1.PC3	The student knows the different use cases of each type of sensor.
SFE.U4.E1.PC4	The student is able to combine and synchronize different sensors according to specific conditions.

LIDAR, RADAR AND CAMERA SENSOR

Introduction

- LIDAR, RADAR and CAMERA sensors are used in sensor fusion for many applications, in particular for autonomous driving.
- We've covered sensors before, however, we'll look at them in a little more detail.

LIDAR SENSOR

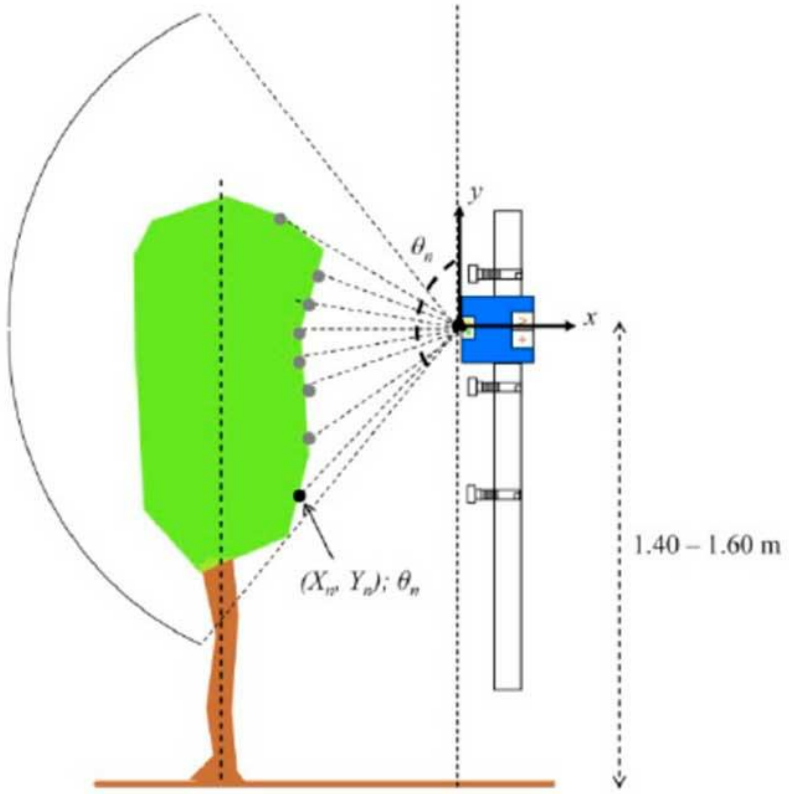
Introduction

- LIDAR - Light Detection And Ranging
- It can be found by another name, LADAR
- Have been used for a long time
- Serve to measure distances between objects
- Its main benefit is the accuracy of the generated calculation
- It is very useful in topographic studies
- It is hoped that along with augmented reality the renderings will be better

LIDAR SENSOR

Which is?

- It is a pulsed laser system;
- It can measure and get the real distance between objects;
- Can be used to define measurements;



LIDAR SENSOR

How it works

- Measure distances through light
- When there is a lack of light (dark environments) the process is merely the same as the light source comes from infrared lasers;
- This sensor is able to model the environment in three dimensions
- The more beams your sensor has, the greater its range

LIDAR SENSOR

How it works

- LIDAR can combine the Global Navigation Satellite System (GNSS) and the Inertial Navigation System (INS).
- The sensor converts time into distance, based on the speed of light. The value is associated with the placement information. The result will show the 3D coordinates of the object.

LIDAR SENSOR

Applications and Uses

- Geodesy
- Architecture
- geography
- Geology
- Geomorphology
- Seismology
- Forest engineering
- coastal oceanography
- Remote and physical detection of the atmosphere
- autonomous driving
- Augmented Reality

RADAR SENSOR

Introduction

- RADAR - Radio Detection and Ranging
- Determine the relative speed and relative position of detected obstacles
- Get accurate measurements in the most extreme conditions
- It is one of the best known sensors in autonomous systems

RADAR SENSOR

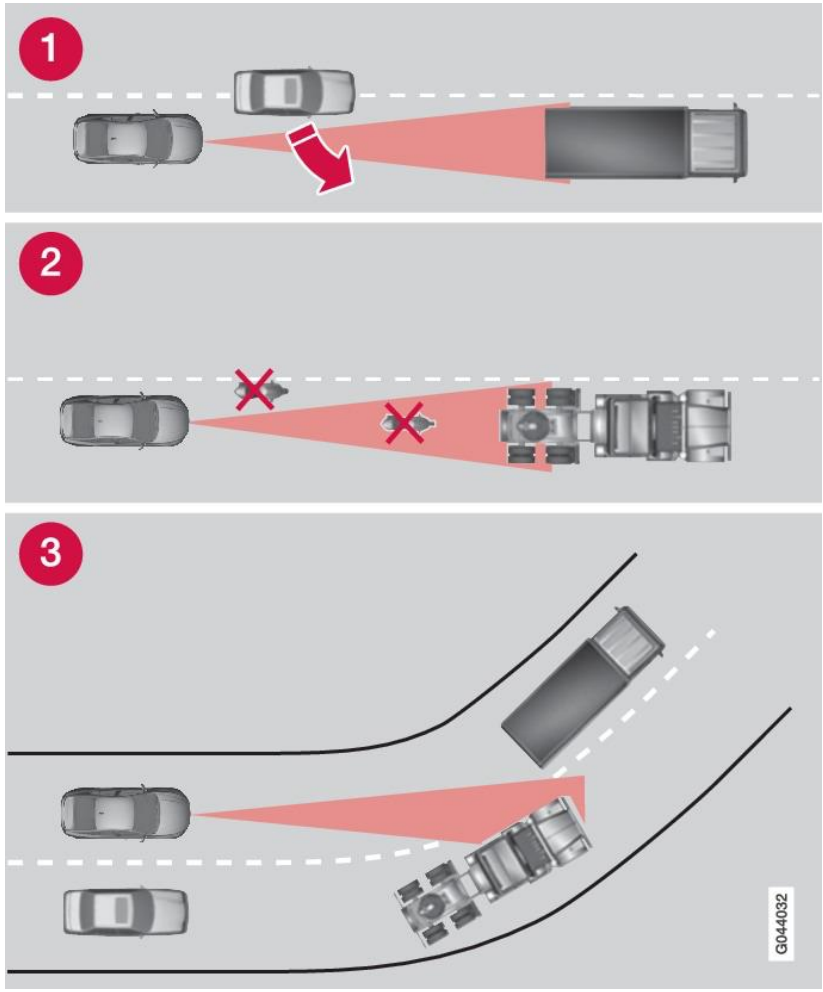
How it works

- Use Doppler Shift
  - Variations or shifts in wave frequency due to relative motion between a source wave and its targets.
  - When the frequency of the received signal increases it is when the target moves towards the radar system

RADAR SENSOR

How it works in autonomous driving

- 1) Radar sensor may detect vehicles at short distance too late
- 2) Motorcycles or vehicles that do not drive in the middle of the carriageway may remain undetected.
- 3) When cornering, the radar sensor can detect a wrong vehicle or lose sight of a detected vehicle.



Advantages and disadvantages

- Provides additional information such as the speed of detected moving obstacles
- Can perform mapping in short, medium or long range, depending on the configuration
- As a rule, it is not suitable for object recognition applications because of its coarse resolutions compared to cameras.

CAMERA SENSOR

Introduction

- A camera works to detect lights emitted from the surroundings on a photosensitive surface through a lens.
- are cheap
- In autonomous driving it is used to generate boundary lanes, lane line positions, detect traffic light colors and traffic signs.
- It's a 2D sensor and it's great for classifying objects and understanding a scene.

CAMERA SENSOR

How it works

- An autonomous vehicle may have cameras:
  - Monoculars
  - Binoculars
  - A combination of the two.

CAMERA SENSOR

How it works

- **Monoculars**
  - This type of camera uses only one camera to create a series of images
  - They are usually more limited than binoculars and lack native depth information.
  - In most cases they are installed side by side to form a binocular camera

CAMERA SENSOR

How it works

- Binoculars
  - They are known as stereo
  - They mimic the depth perception found in animals
  - They hold two image sensors separated by a line that provides a distance between the image sensors.
  - This line has the name of baseline

CAMERA SENSOR

How it works

- Binoculars
  - The disparity maps that are calculated from the stereo camera images can allow the generation of depth maps.
  - This happens when using epipolar geometry and triangulation methods.

COMBINE AND SYNCHRONIZE DIFFERENT SENSORS

How to combine these sensors

- Using sensor fusion, the LIDAR, RADAR and CAMERA sensors can be combined and thus the processing of these data can result in:
  - Shapes
  - speeds
  - Distances
- Sensor data inputs are fed by an artificial intelligence computer
- This happens to increase reliability and less redundancy in the data.

COMBINE AND SYNCHRONIZE DIFFERENT SENSORS

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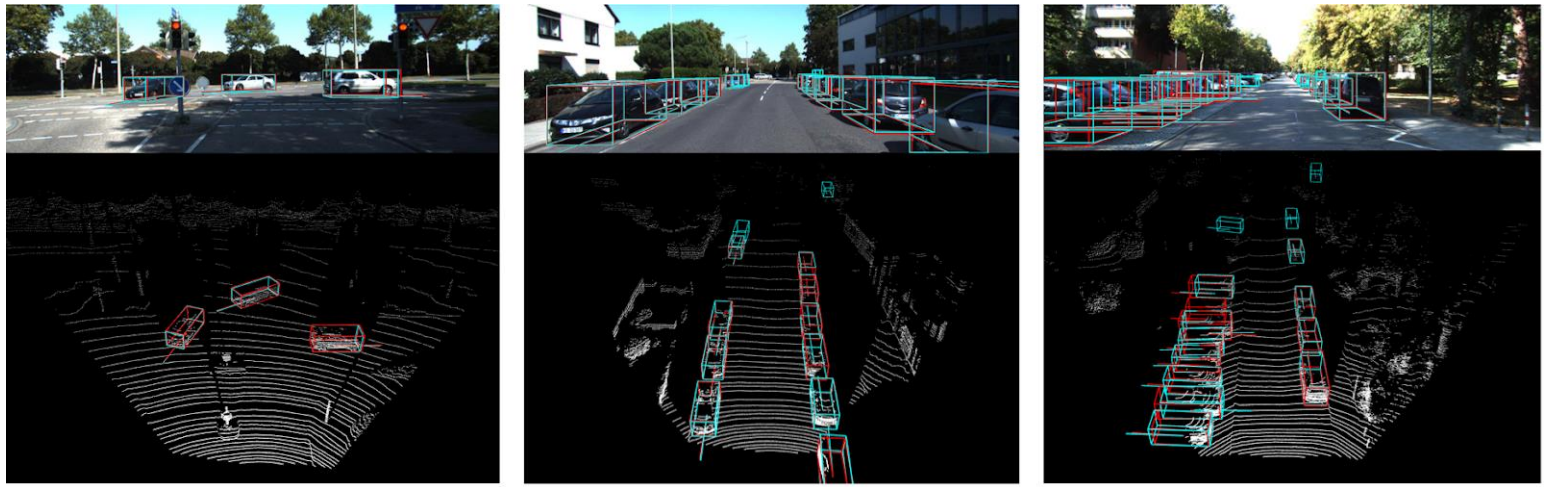
Example

- Let's imagine a car that detects a 3D obstacle.
- With the LIDAR sensor, two approaches can be used:
  - Naive Approaches - Use Machine Learning 3D without supervision
  - Deep Learning Approaches – Using Algorithms
- With Camera you use:
  - Understanding of projection values (intrinsic and extrinsic calibration)
  - Deep Learning
  - Vehicle size and orientation must be known.

Example

- IOU Matching in Space
  - If the CAMERA and LiDAR bounding boxes overlap, in 2D or 3D the obstacle can be considered to be the same.



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Thank you for your attention

DRIVES project is project under **The Blueprint for Sectoral Cooperation on Skills in Automotive Sector**, as part of New Skills Agenda.

The aim of the Blueprint is **to support an overall sectoral strategy and to develop concrete actions to address short and medium term skills needs.**

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