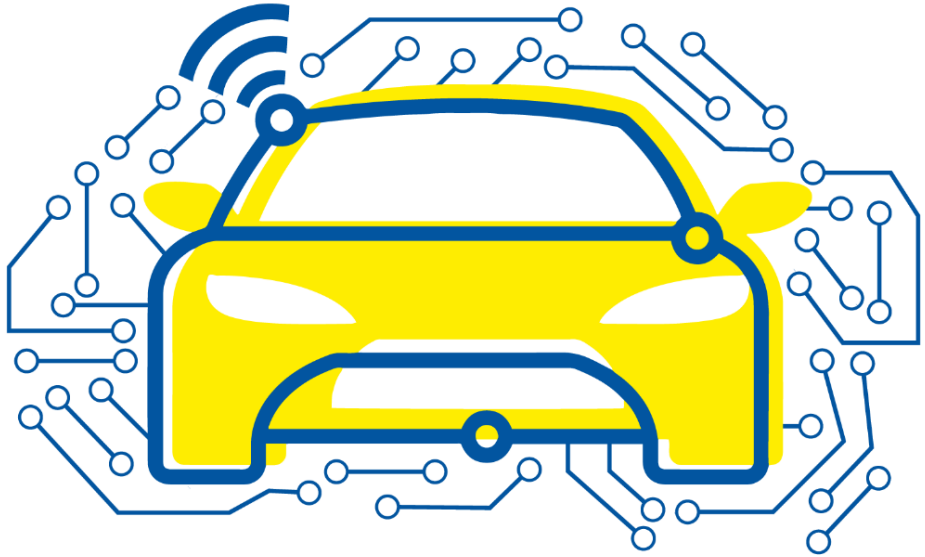
Automated and Connected Driving Challenges

Section 2 – Sensor Data Processing

Object Detection

Introduction



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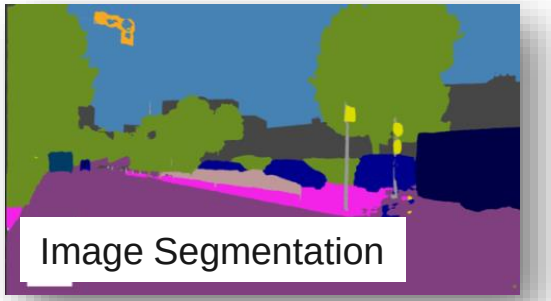
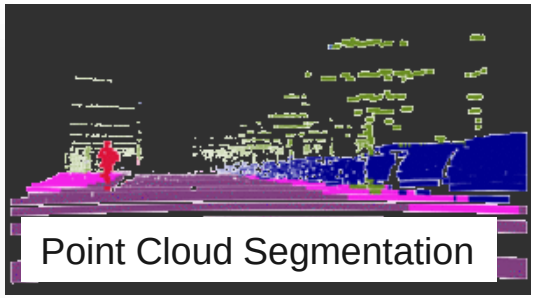
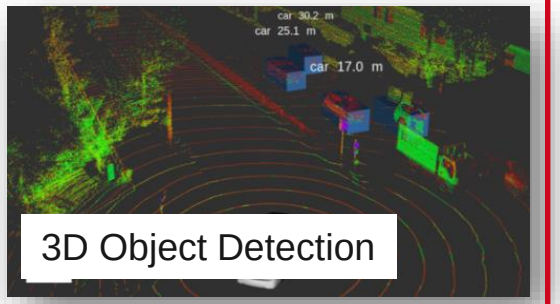
Object Detection - Introduction

Computer Vision Approaches

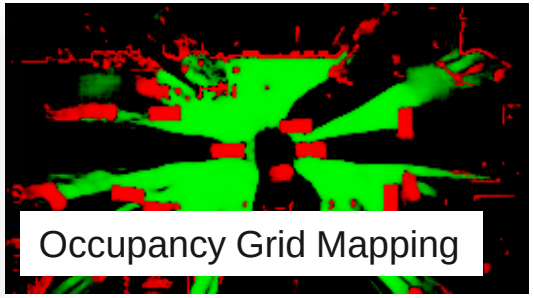




Single Object



Multi Objects

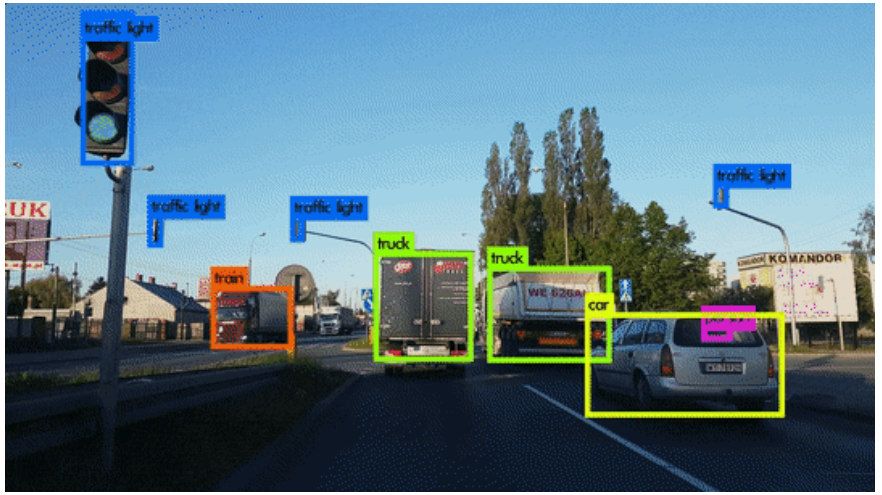


Images: ika, fka, ieee

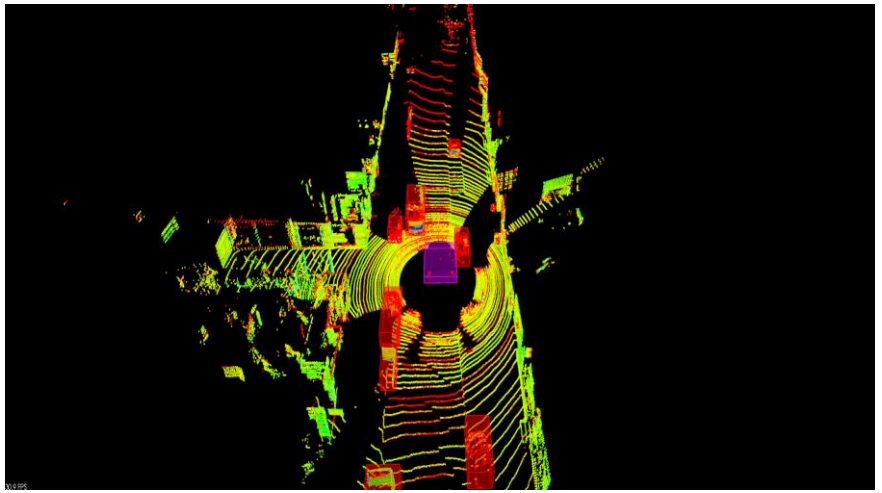
Object Detection - Introduction

Overview

- **Goal**: Find all objects and assign a class from a fixed set of classes
- Solve multiple tasks simultaneously
  - **Localization** of objects
  - **Classification** of objects
- Detect **multiple** objects
- An Object is represented by
  - **Bounding box** (e.g. position, dimension, orientation)
  - **Classification** (e.g. car, pedestrian, truck)
  - ...
- **Different** sensor modalities for input **data**
  - **2D** camera **images**
  - **3D** LiDAR **point clouds**



Video: gfycat



Video: github

Object Detection - Introduction

Main Challenges

- **Class ambiguity** (fixed set of classes)
- **Class imbalance**
- **Intra**-class and **inter**-class **variance**
  - Illumination
  - Object pose or sensor viewpoints

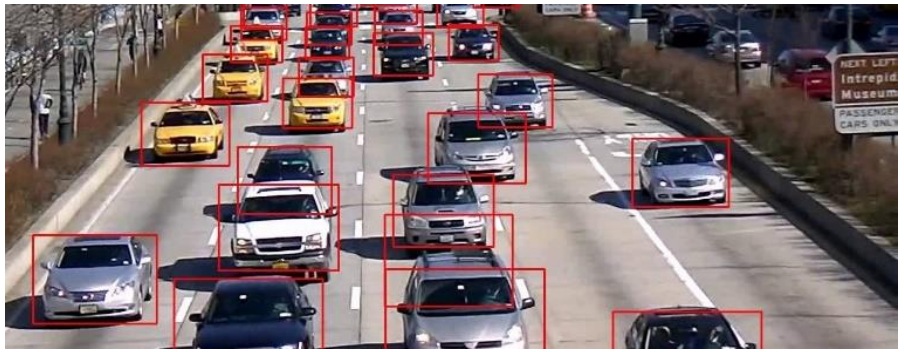


Image: becominghuman

Object Detection - Introduction

Main Challenges

- **Class ambiguity** (fixed set of classes)
- **Class imbalance**
- **Intra**-class and **inter**-class **variance**
  - Illumination
  - Object pose or sensor viewpoints
- **Overlapping**, **occluded**, **truncated** objects
- **2D** camera images
  - No 3D information (estimation required)
  - Glare, reflection, distortion
- **3D** LiDAR point clouds
  - Unstructured point representation (sparse, variable size)
  - Only intensities instead of RGB

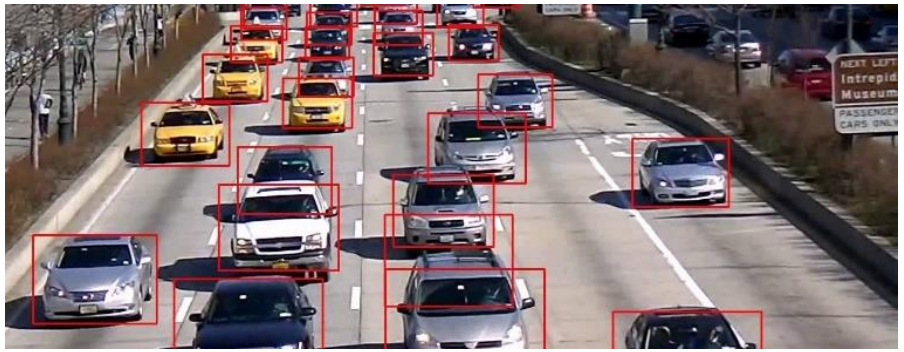


Image: becominghuman

Image: sony

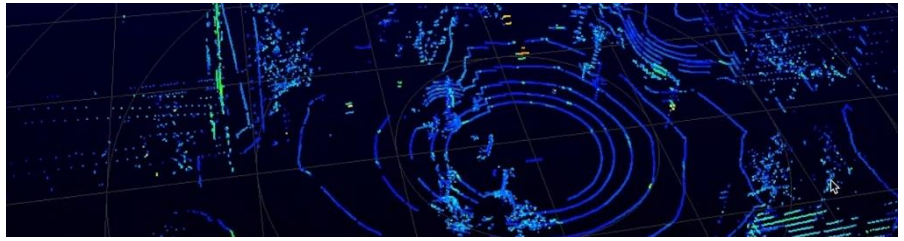
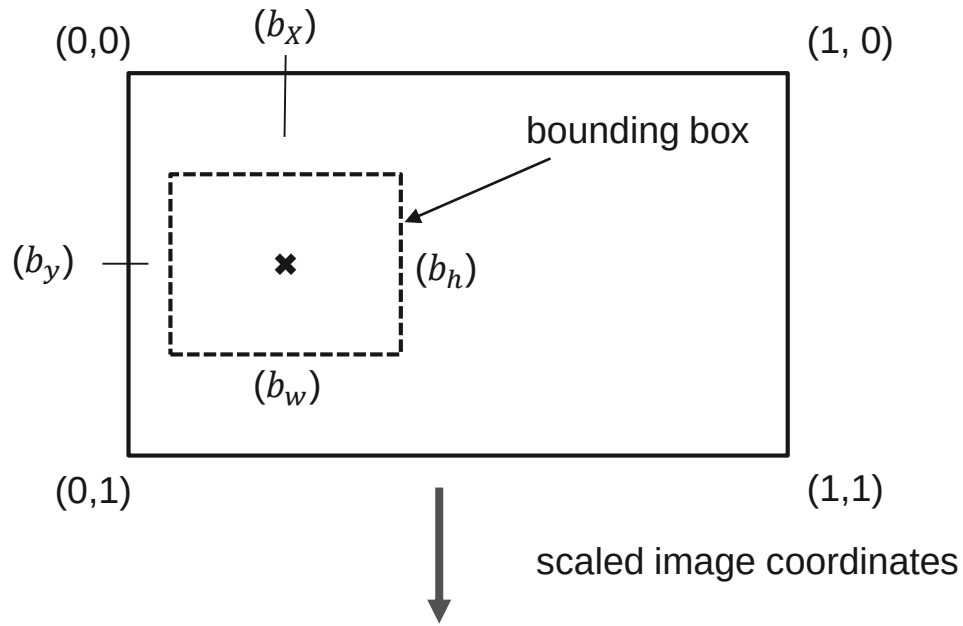


Image: techniexpert

Object Detection - Introduction

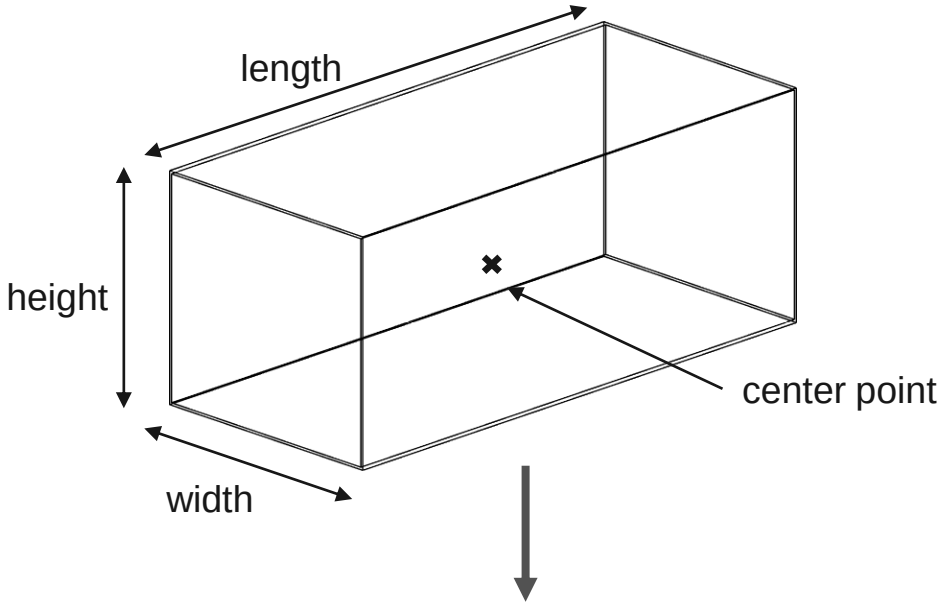
Bounding Box Representation

- **Center** of bounding box and **dimensions** as **scaled image coordinates**



$$b_x = 0.2$$
$$b_y = 0.5$$
$$b_h = 0.5$$
$$b_w = 0.3$$

- **Center** of bounding box, **dimensions** and **orientation** as **3D absolute world coordinates**



$$b_X = 0.5 \quad b_y = 0.25 \quad b_z = 0.5$$
$$b_l = 0.5 \quad b_w = 0.3 \quad b_h = 0.2$$
$$\phi = 0.25$$

Object Detection - Introduction

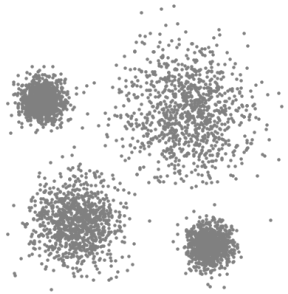
Approaches

- Focus here:

3D Multi Object Detection in LiDAR Point Clouds

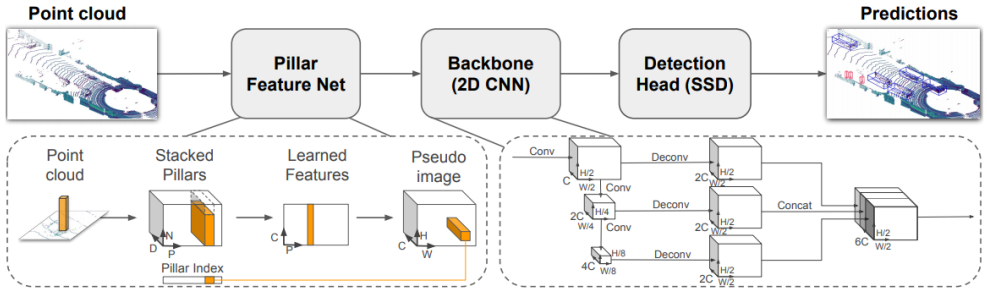
  - 3D bounding boxes enables direct usage in environment model
  - LiDAR point clouds provide accurate 3D environment information
  - Object detection is most intuitive way of identifying objects in 3D space

- Unsupervised clustering algorithms
  - k-mean clustering
  - DBScan



Video: towardsdatascience

- **Supervised deep learning approaches**

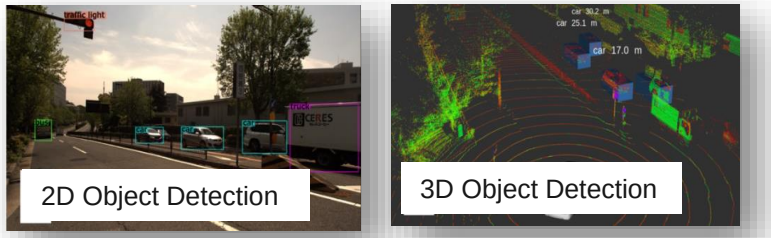


Source: Lang et al. 2019

Object Detection - Introduction

Summary

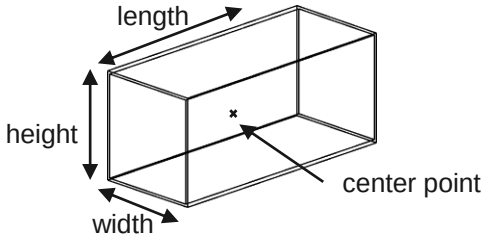
- **Localization** and **classification** of objects



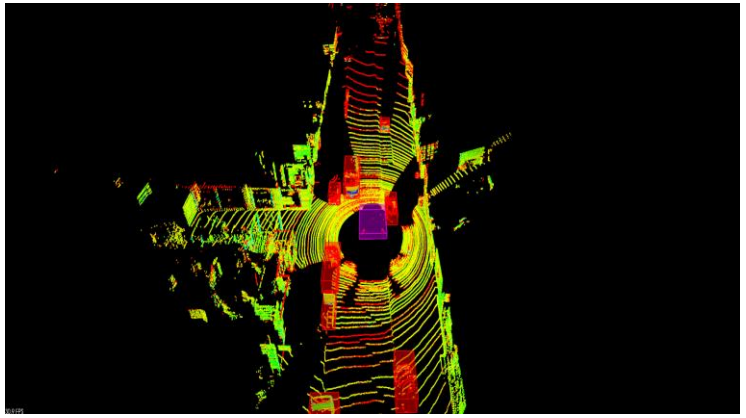
Images: ieee

- Main **challenges** (e.g. occlusion, multiple instances / classes, illumination effects)

- **Bounding box** representation



- **Different approaches** for solving the task



Video: github