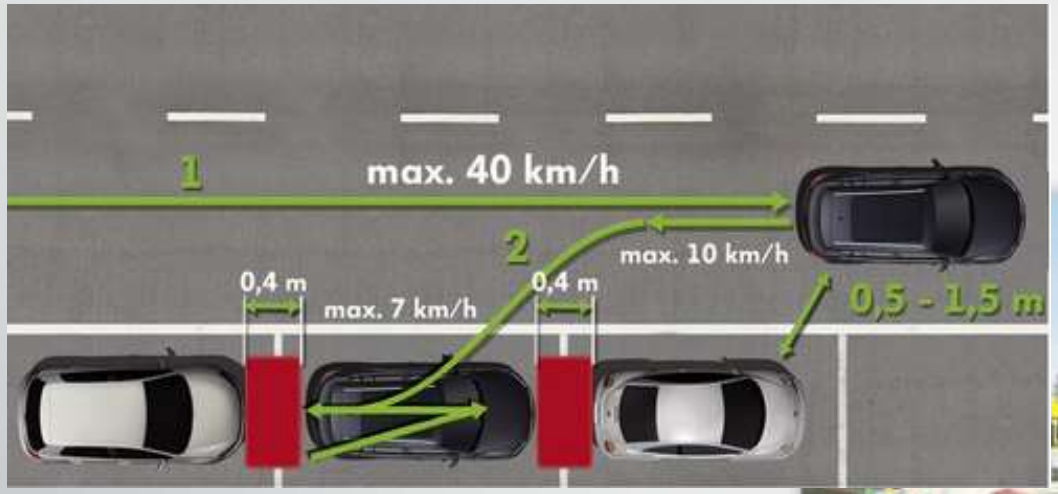
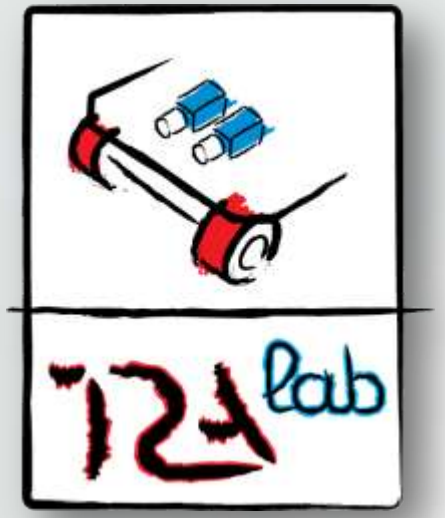
A few sensor failure modes





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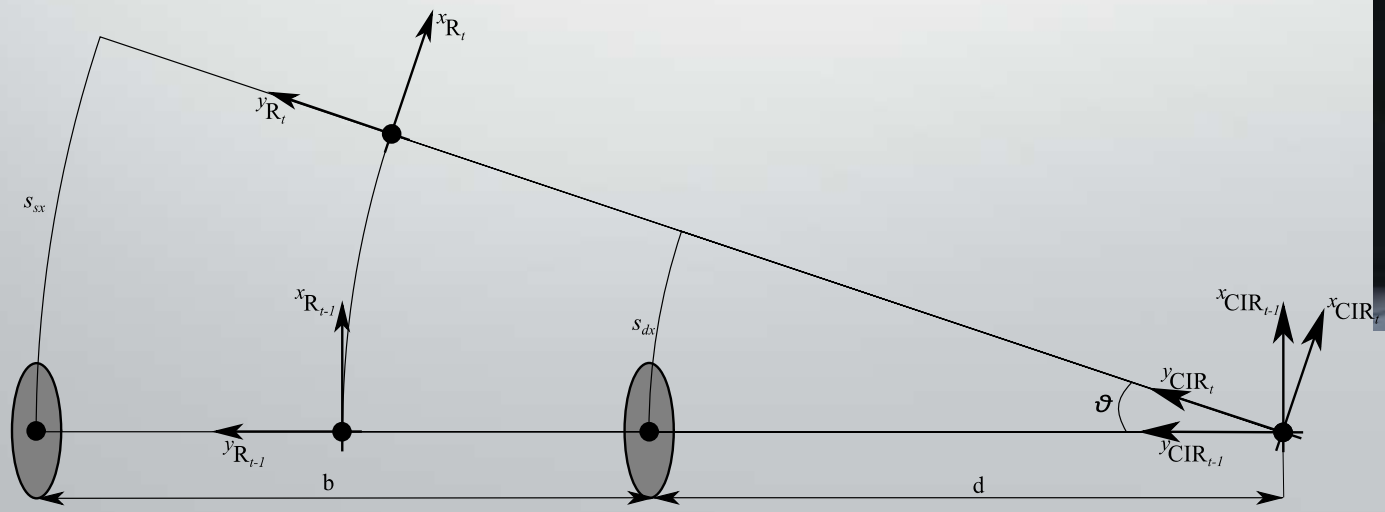
Università degli Studi di Milano - Bicocca

A short review of failure modes of sensors used in ADAS and autonomous driving

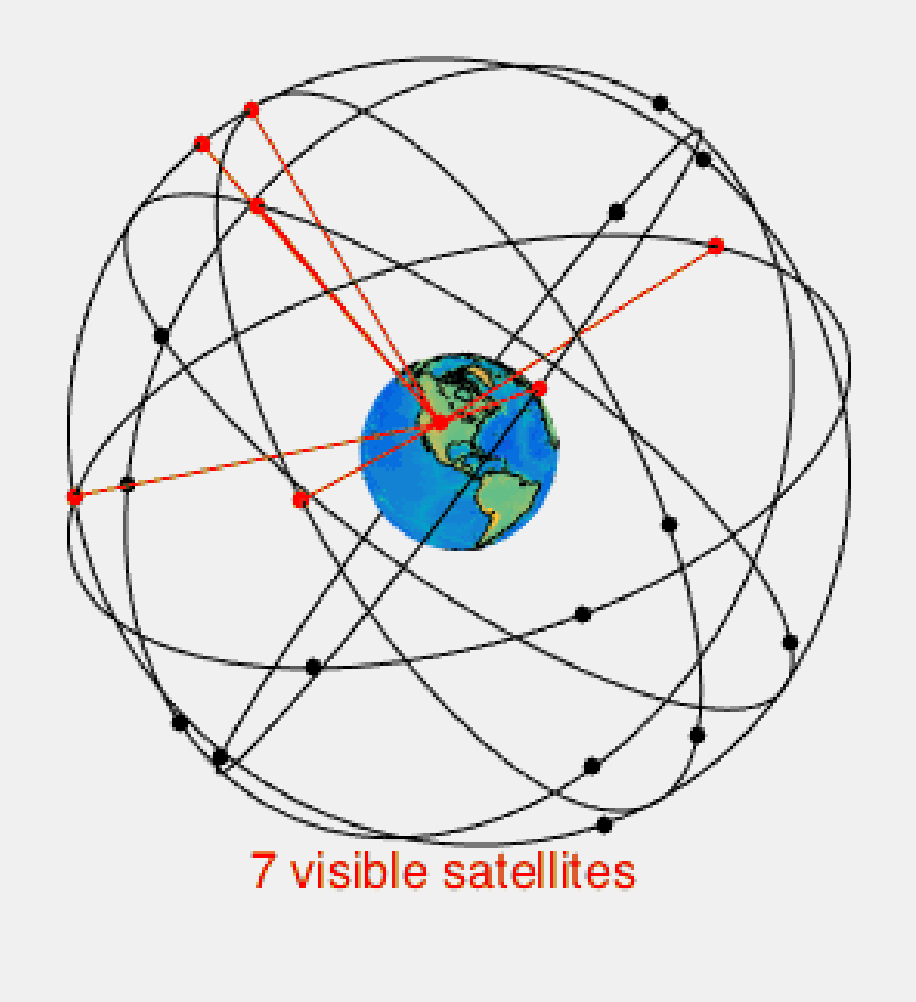
Index

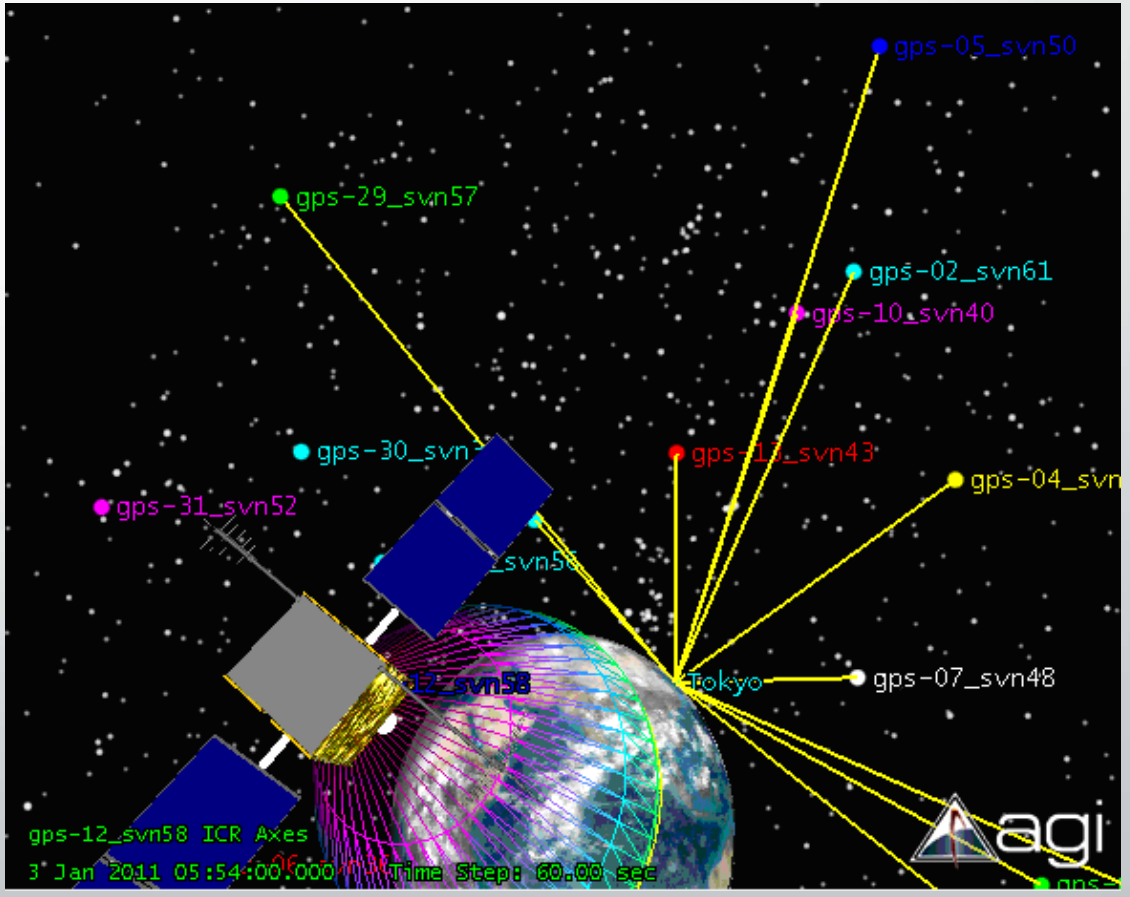
- Simplest idea: proprioperception.
- Position estimation based on propriopercetion is not enough.
- Global localization.
- Global localization is not enough.
- Sensors for observing the world outdside the robot (car), for localization and world modeling.

Proprioperception of motion



GNSS: GPS, Galileo, Glonass, Beidu





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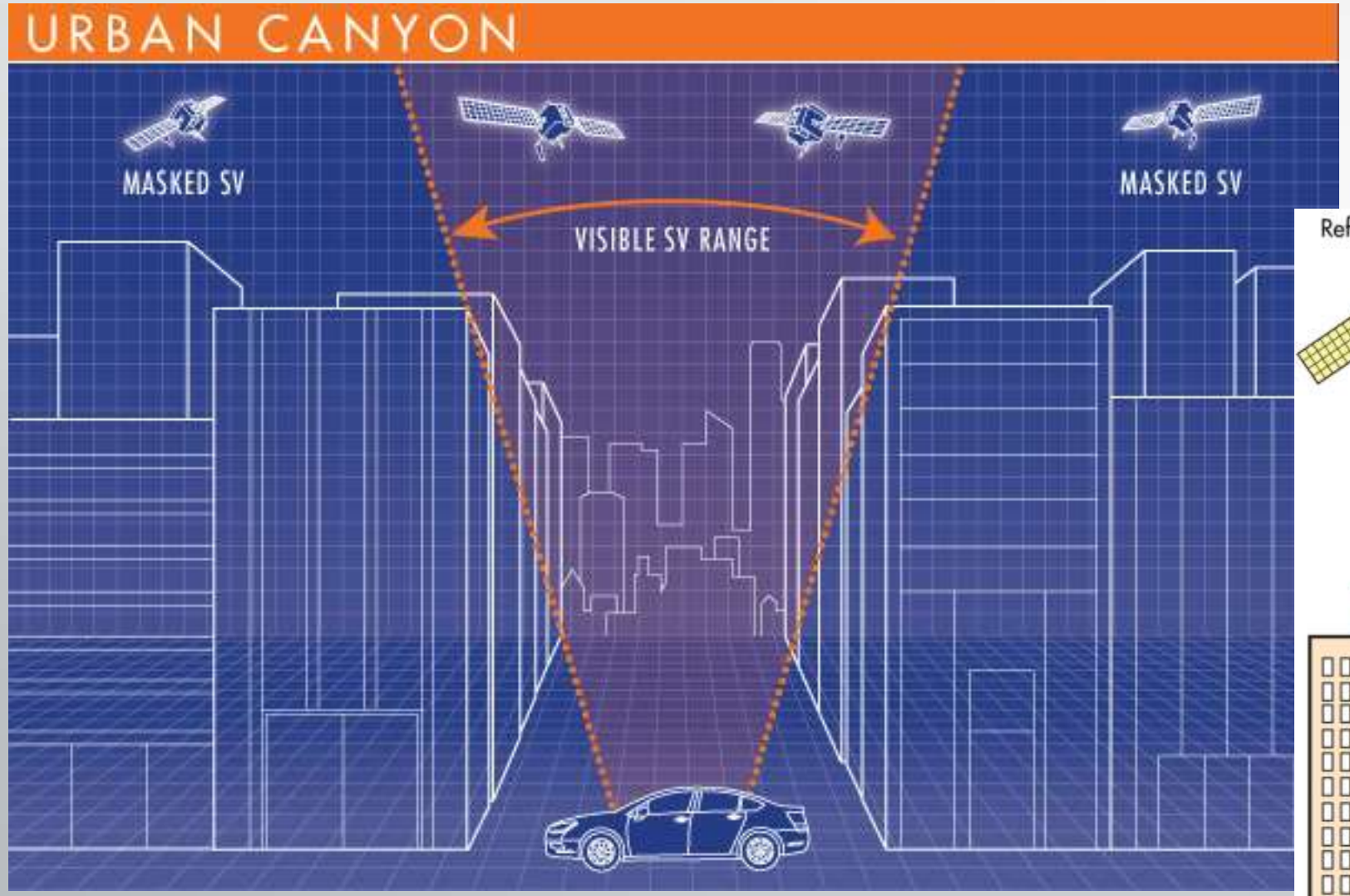

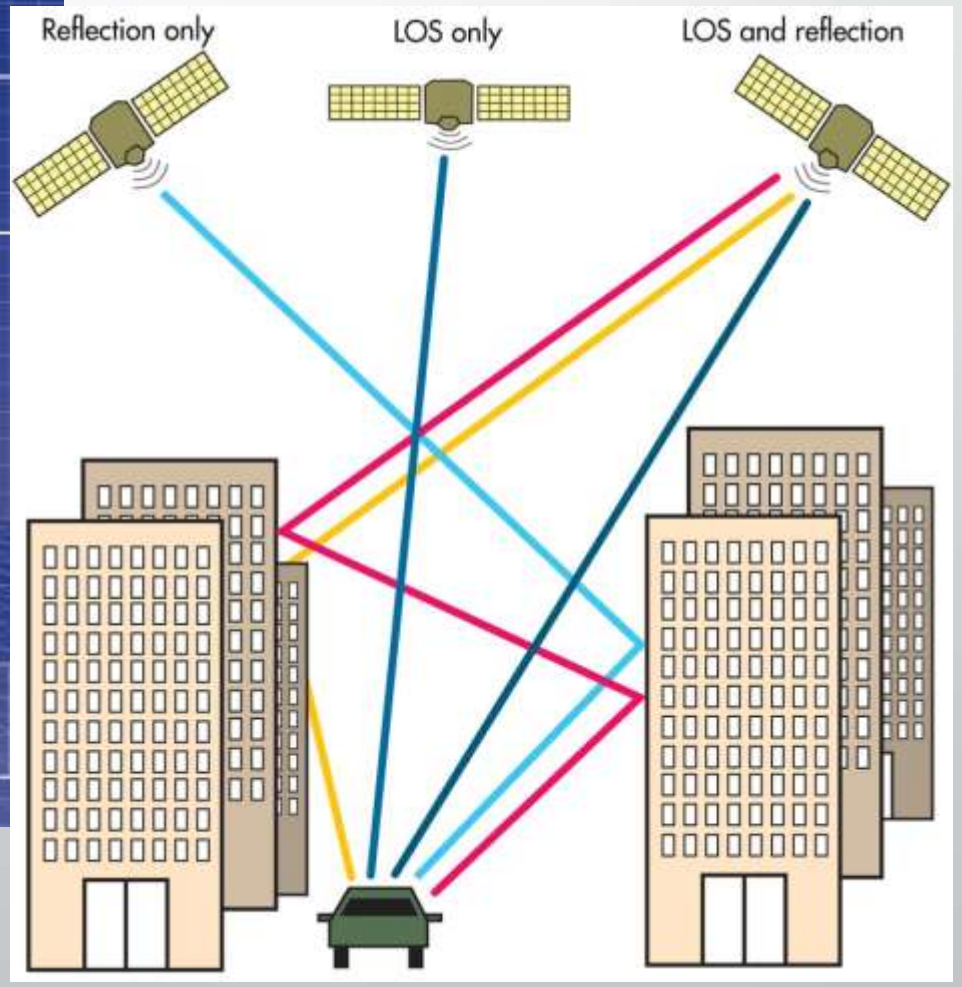

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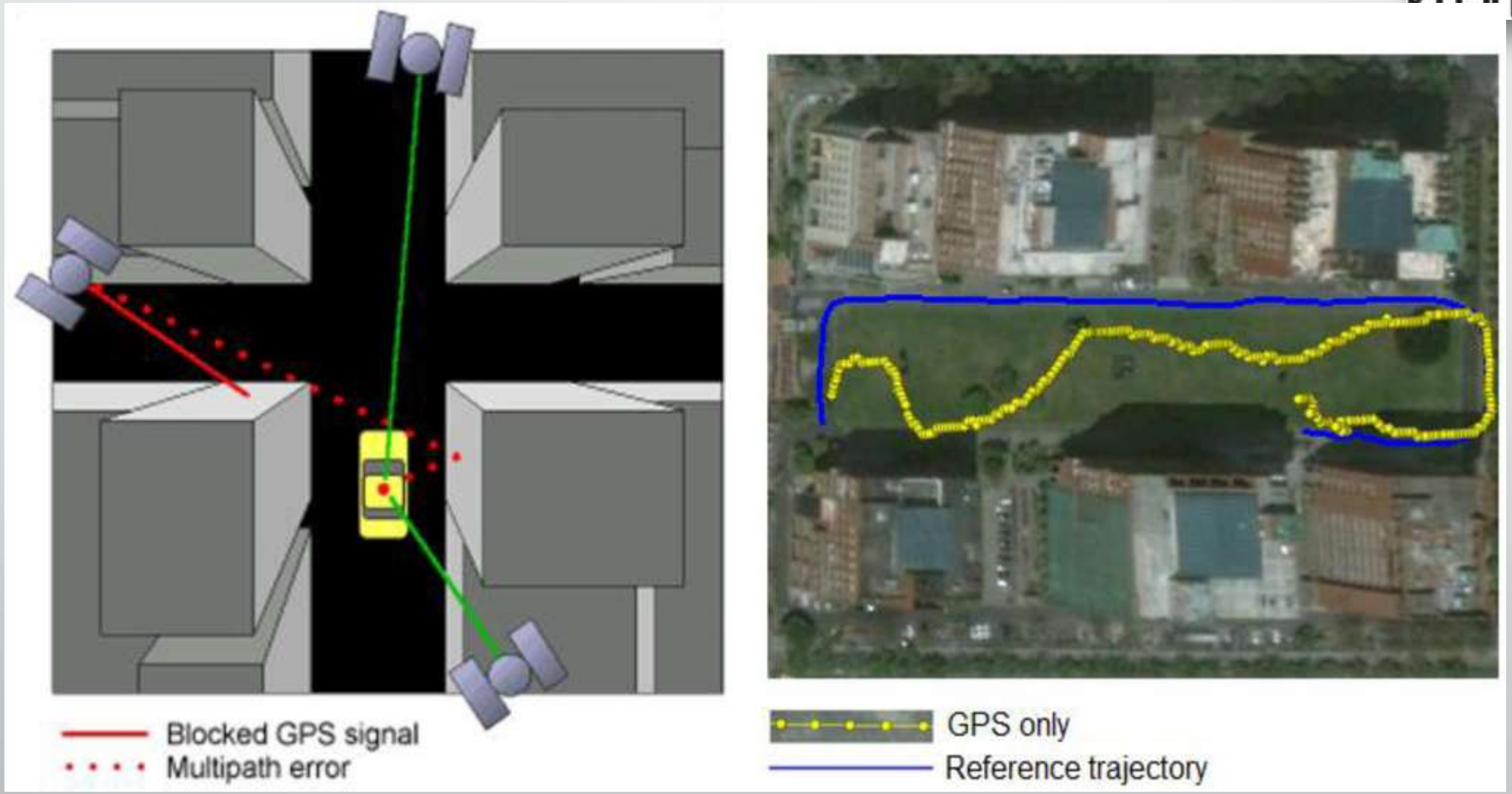


Necessari sensori a bordo robot

Sensors

- In ADAS and in autonomous driving the robotcar builds a model of the world.
- This means the car perceives the world around it by means of its sensors and processing the data from the sensors.

Sensors

- Sensors are the union of sensor hardware, electronic signal conditioning, conversion in computer treatable format, software processing and settings for the software parameters

Sensors

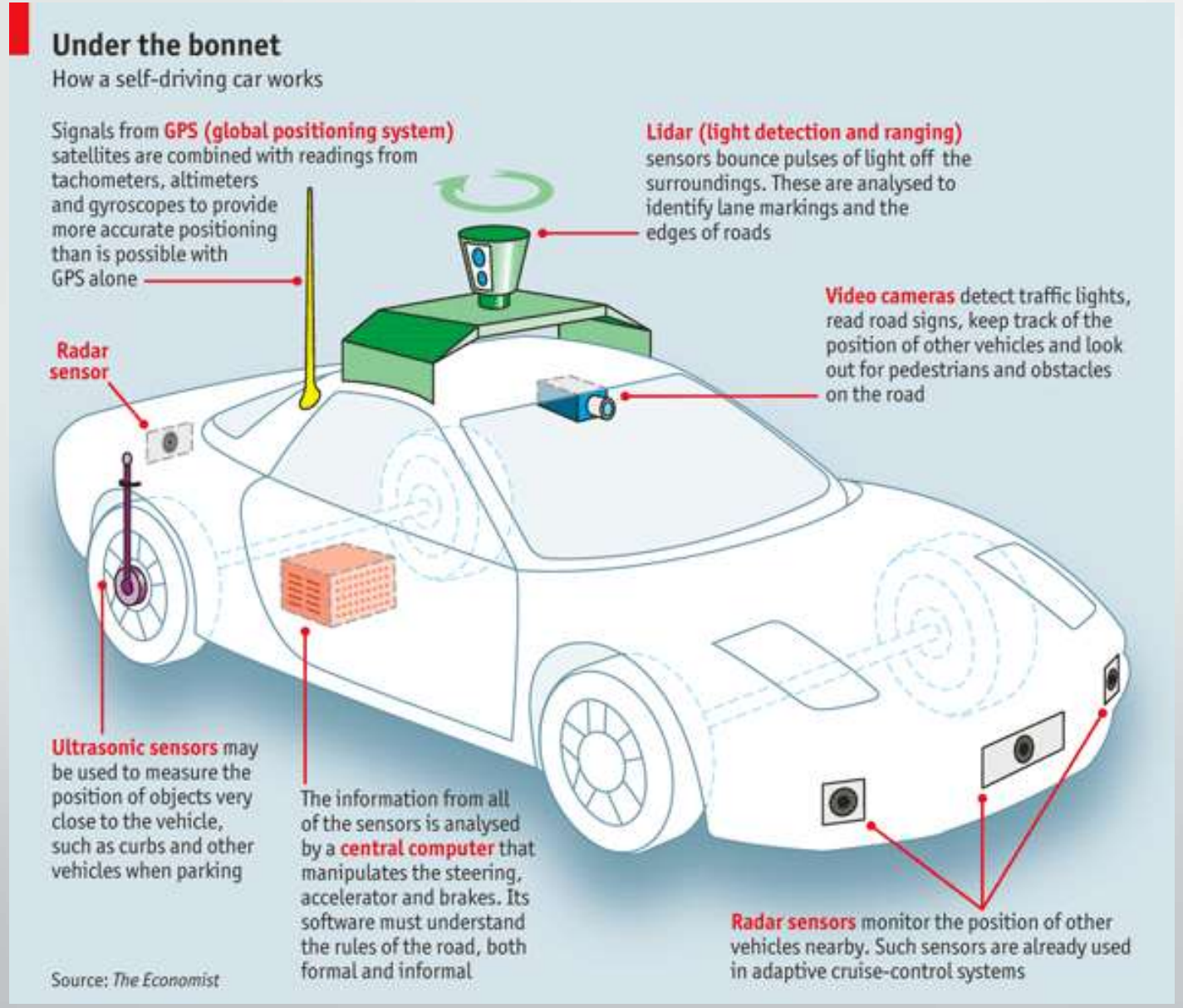
- Perception is never 100% perfect.

Sensors

- Failures
  - HW limits
  - Processing errors

Most used sensors

- RADARs
- LIDARs
- Cameras



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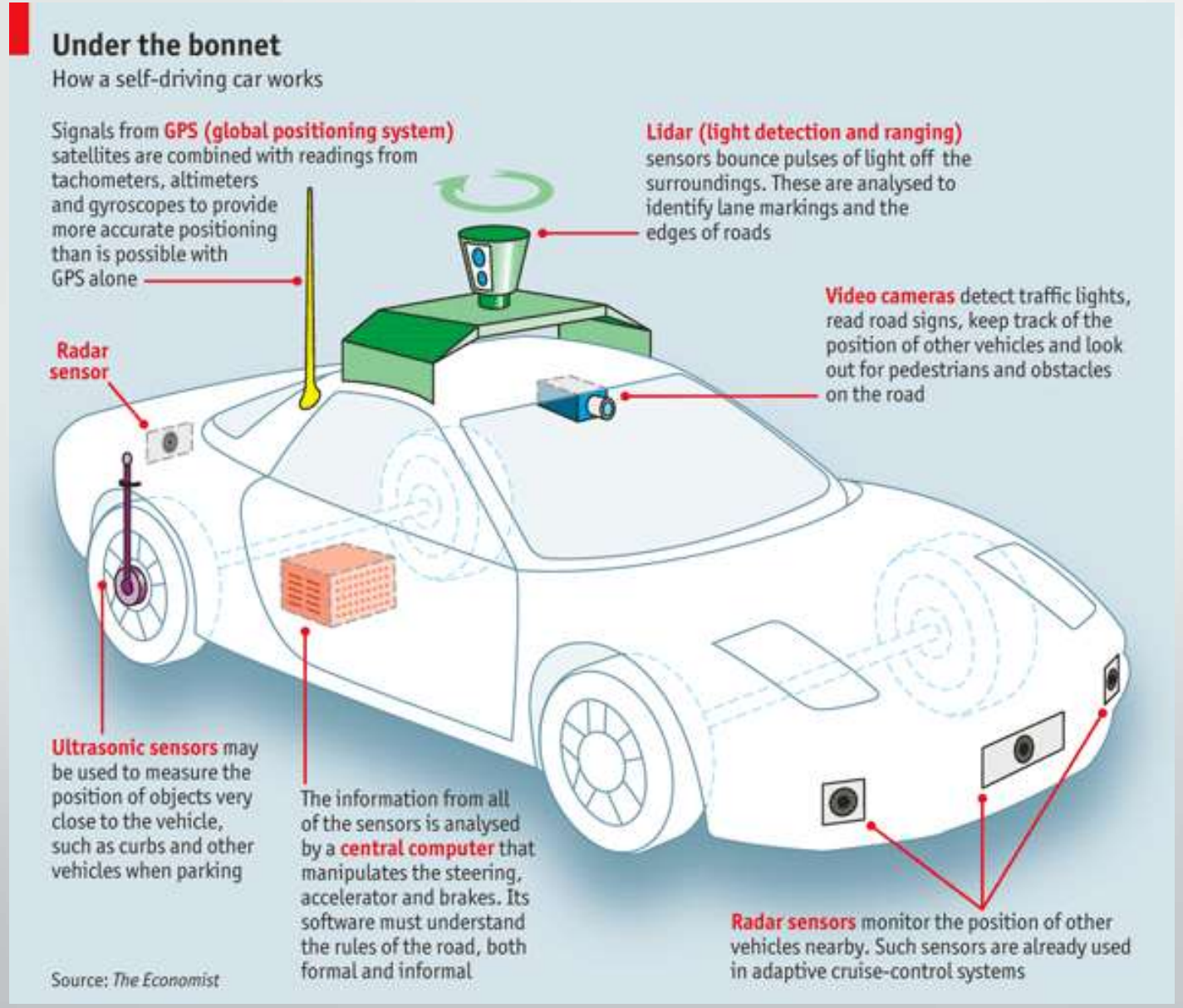


Physics of cameras and LIDARS

- Electromagnetic waves
  - Visible
  - NIR
  - Visible + NIR
  - FIR
  - Multi-spectral
  - etc.

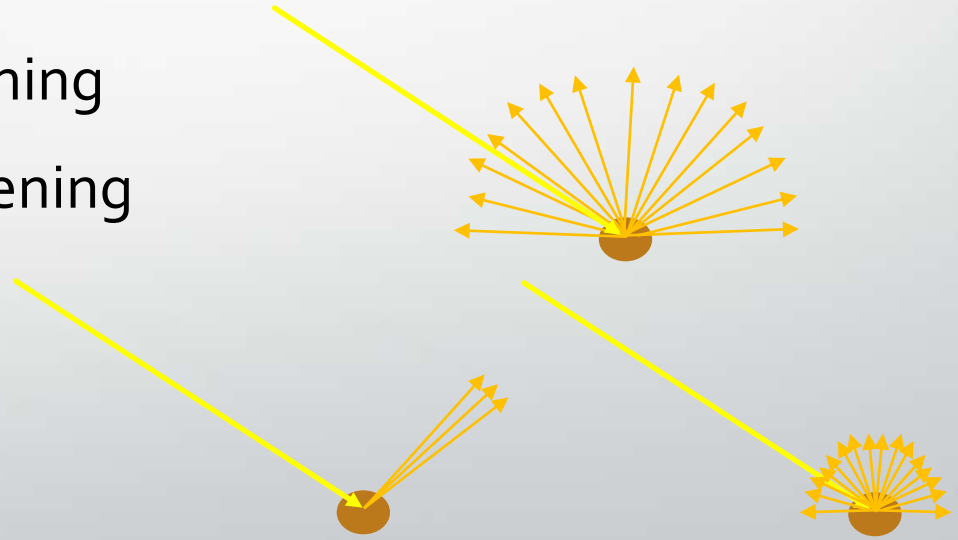
- Cameras all bands
- LIDAR quite often NIR

- LIDAR: active
- Camera systems: quite often passive

- Active lightening
- Passive lightening

Electromagnetic waves →

- Absorption
- Re-emission
- Reflection
- Refraction



Camera defects

- Sensor
  - Smearing
  - Not enough dynamic range
  - Defective pixels
  - Etc.
- Lenses
  - Chromatic aberrations
  - Geometric distorsions
  - Vignetting
  - Etc.

Smearing (blooming)

- Sensor
  - Smearing
  - Not enough dynamic range
  - Defective pixels
  - Etc.
- Lenses
  - Chromatic aberrations
  - Geometric distorsions
  - Vignetting
  - Etc.

Dynamic range

- Sensor
  - Smearing
  - Not enough dynamic range
  - Defective pixels
  - Etc.

Defective pixels

- Sensor
  - Smearing
  - Not enough dynamic range
  - Defective pixels
  - Etc.
- Lenses
  - Chromatic aberrations
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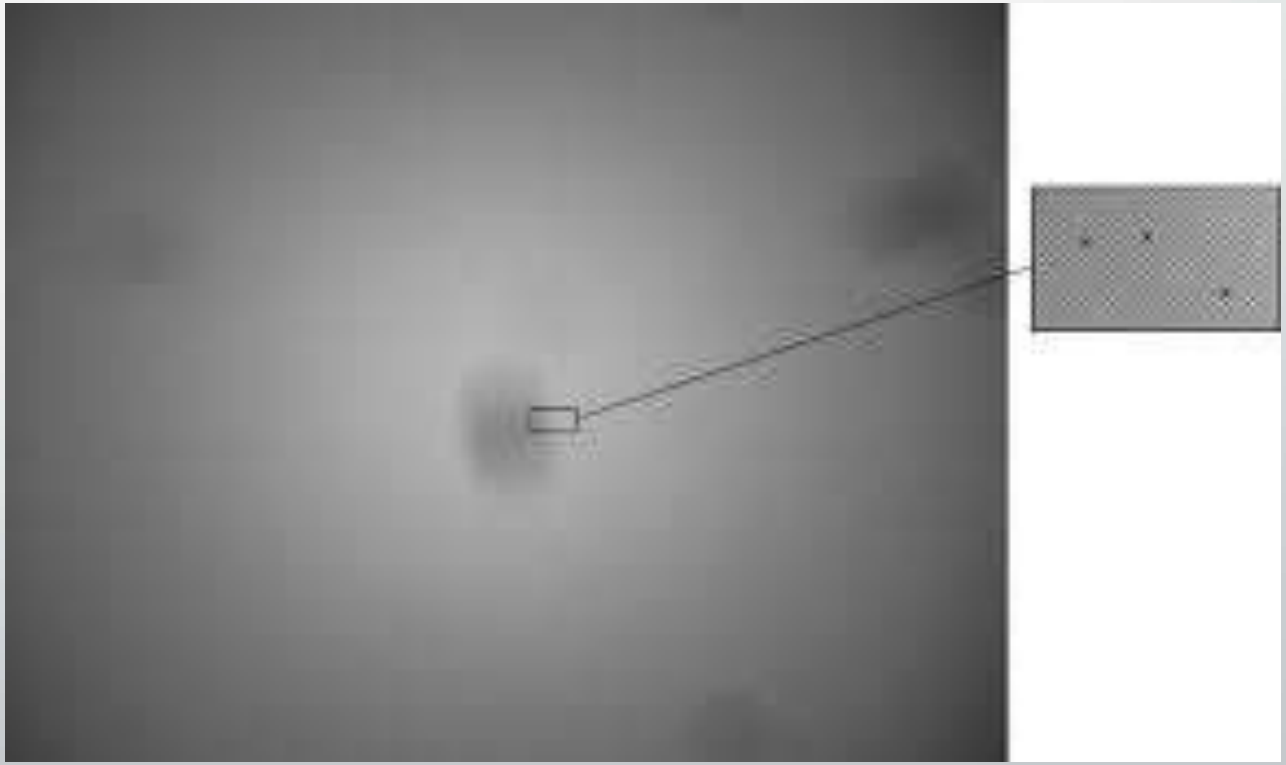
  - Etc.



Chromatic aberrations

- Sensor
  - Smearing
  - Not enough dynamic range
  - Defective pixels
  - Etc.
- Lenses
  - Chromatic aberrations
  - Geometric distorsions
  - Vignetting
  - Etc.

Geometric distorsions

- Sensor
  - Smearing
  - Not enough dynamic range
  - Defective pixels
  - Etc.
- Lenses
  - Chromatic aberrations
  - Geometric distorsions
  - Vignetting
  - Etc.

Vignetting

- Sensor
  - Smearing
  - Not enough dynamic range
  - Defective pixels
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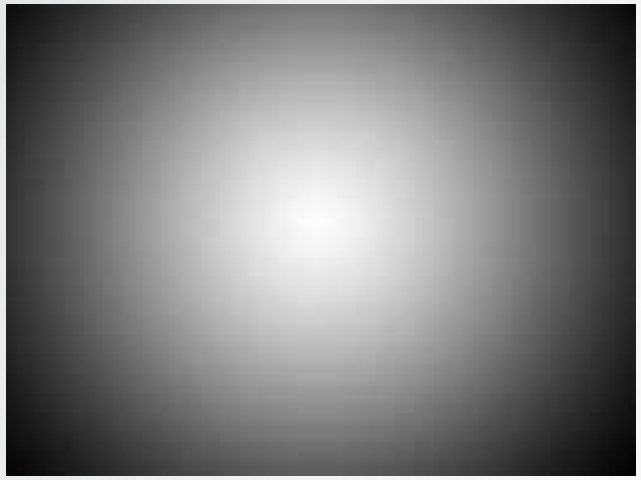

Software and its parameters for cameras and LIDARS

- Thresholds
  - For edges / lines
  - For segmentation
  - Classification
  - etc.
- Algorithms

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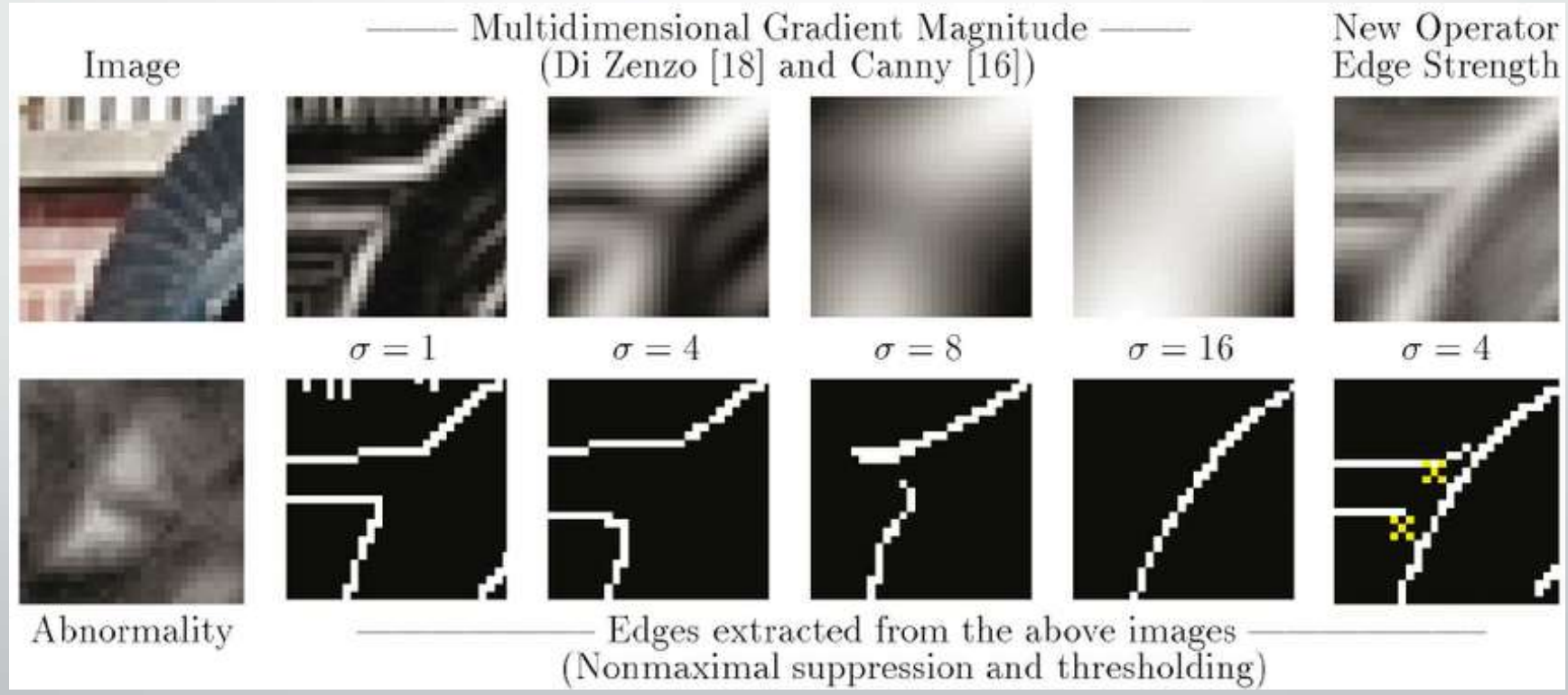
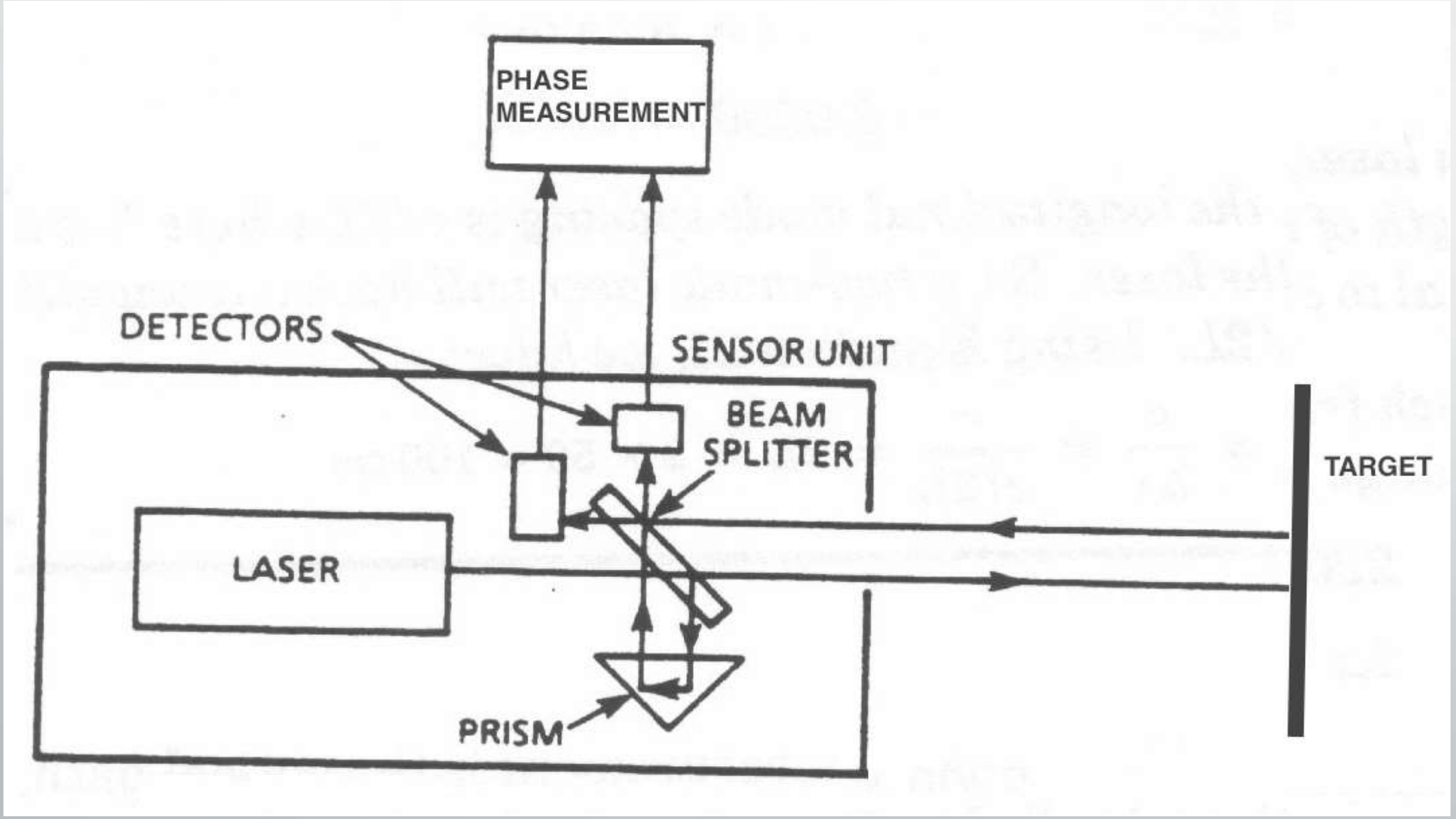
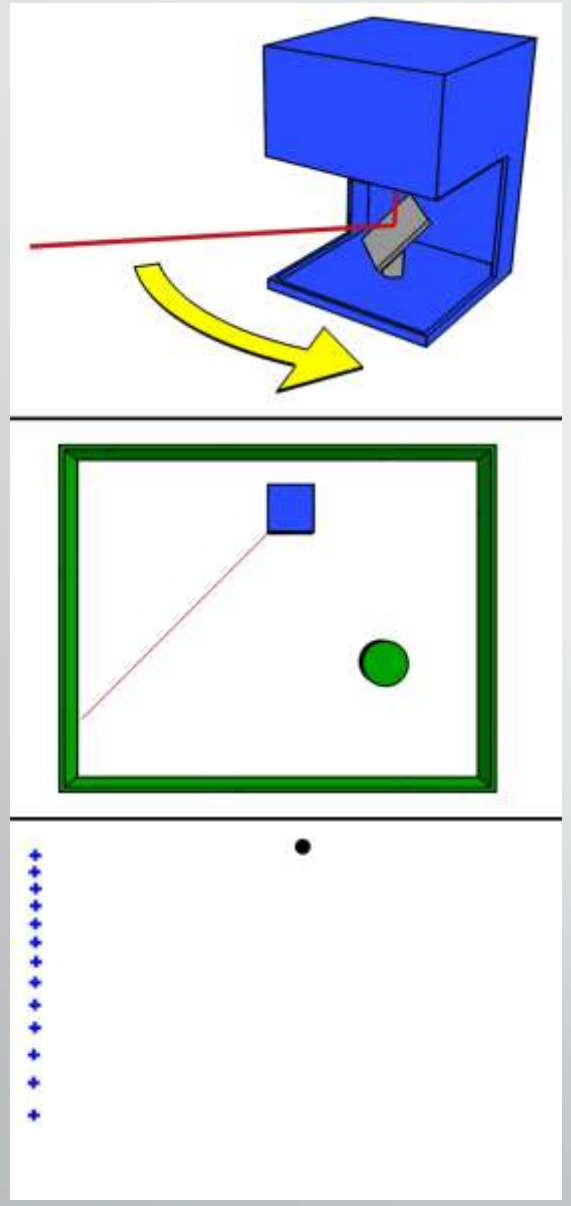


Physics of LIDARS

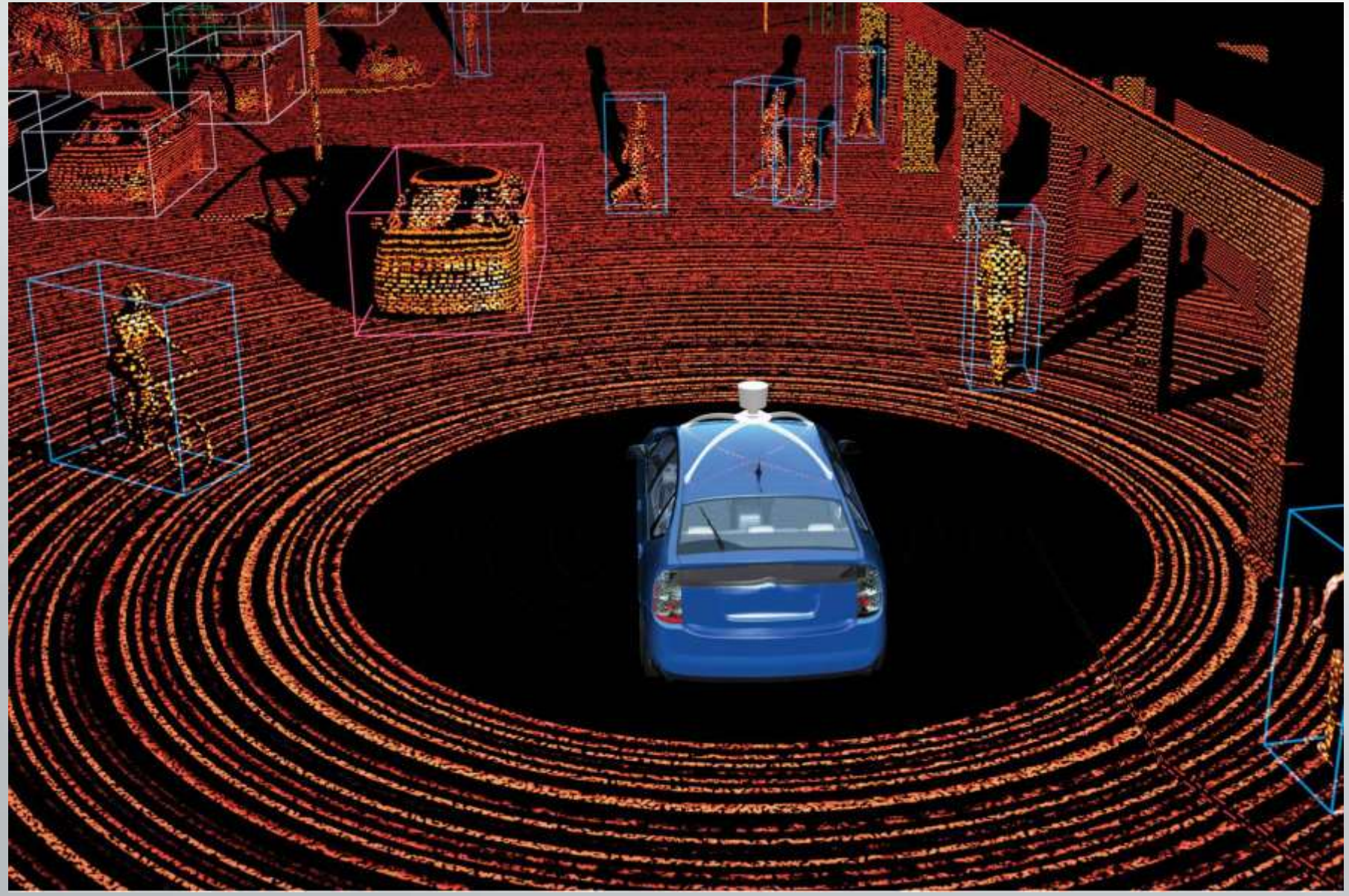


Physics of LIDARS



- Beam steering
  - Solid state (phased array)
  - MEMS mirrors

LIDARS



How to deal with all these complications?

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Correct model of the probability of each error

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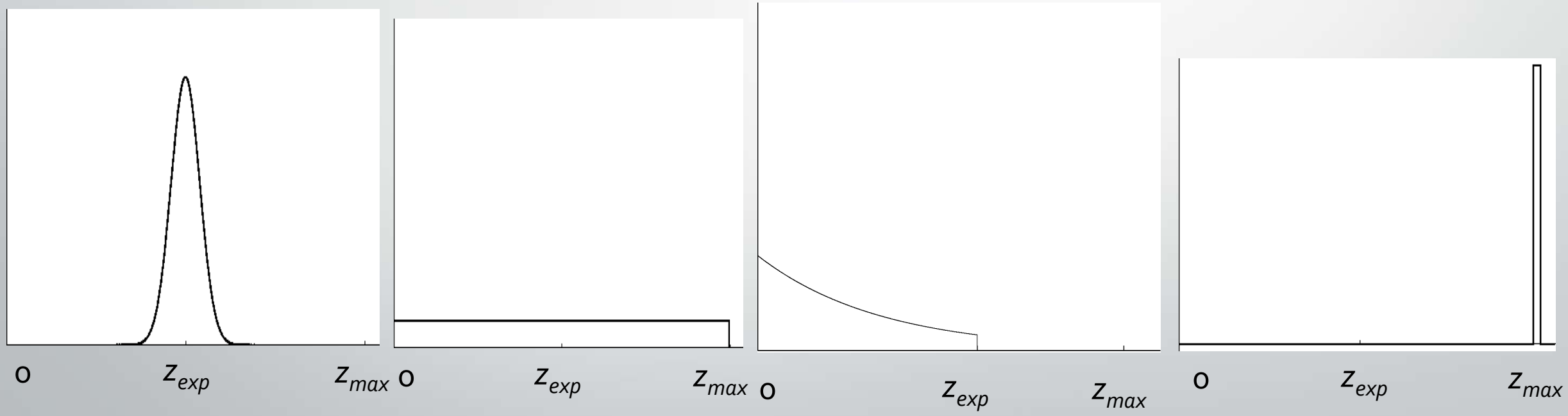
Correct model of the probability of each error

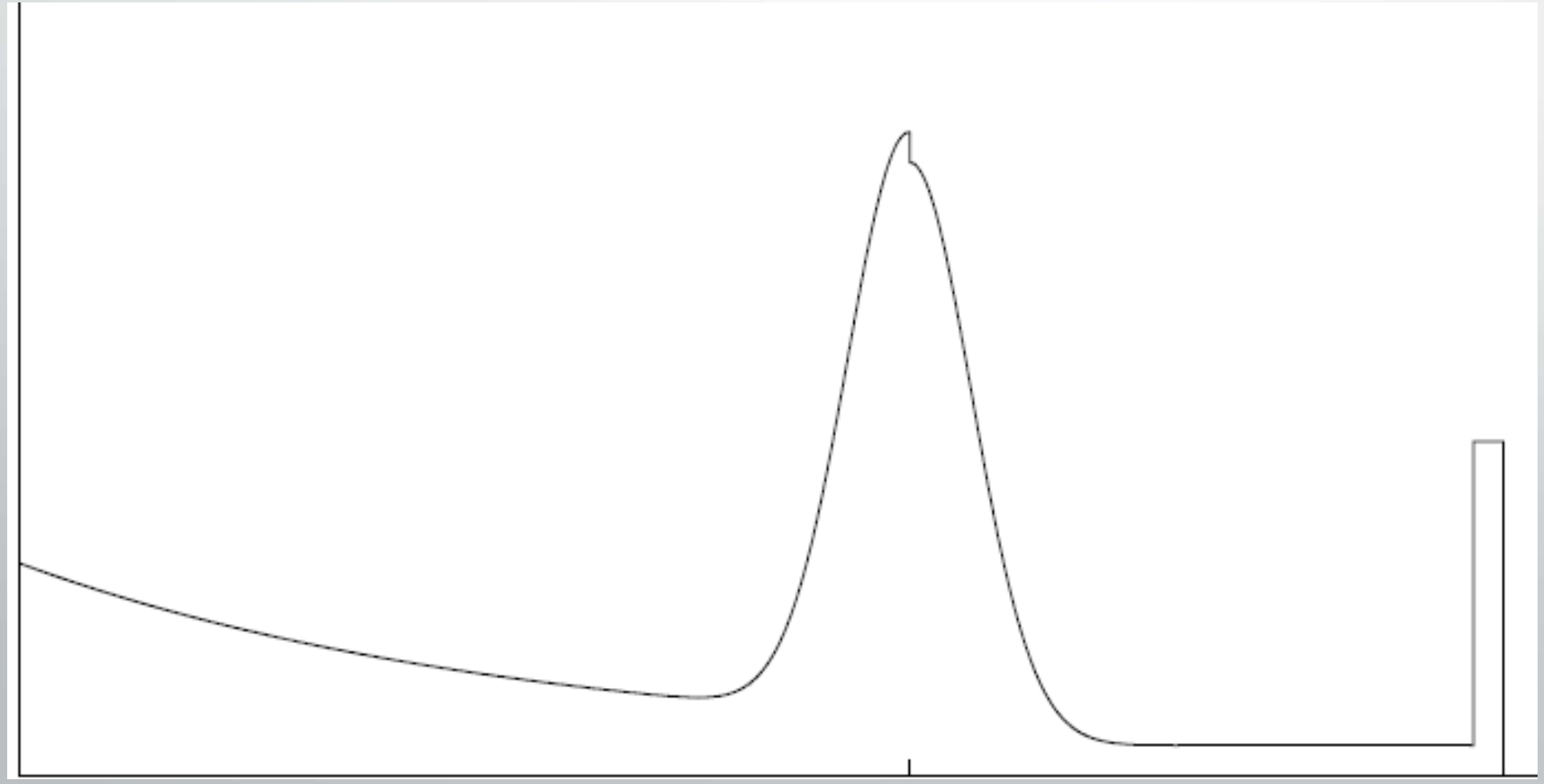
RANGE MEASUREMENTS



How to deal with all these complications?

Correct model of the probability of each error

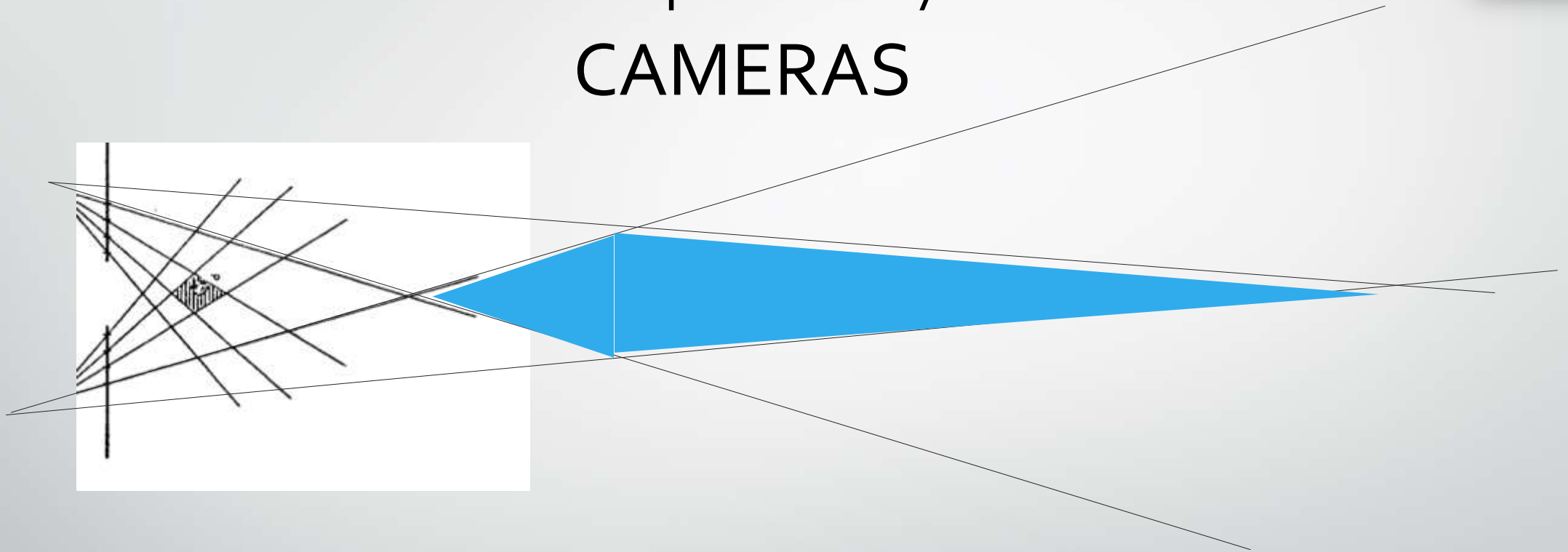
RANGE MEASUREMENTS: BEAM MODEL



How to deal with all these complications?

Correct model of the probability of each error

CAMERAS



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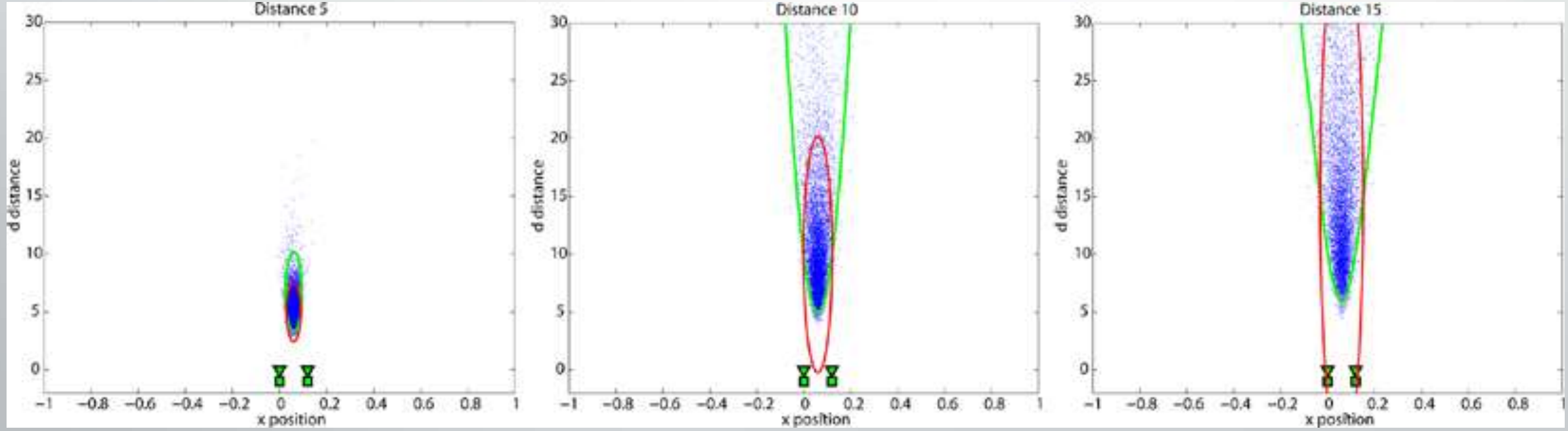
CAMERAS



THANKS FOR YOUR ATTENTION