Automotive Lidars in foggy environment

In cooperation with the CEREMA and the LAMP

What is a Lidar ?

LIght Detection And Ranging

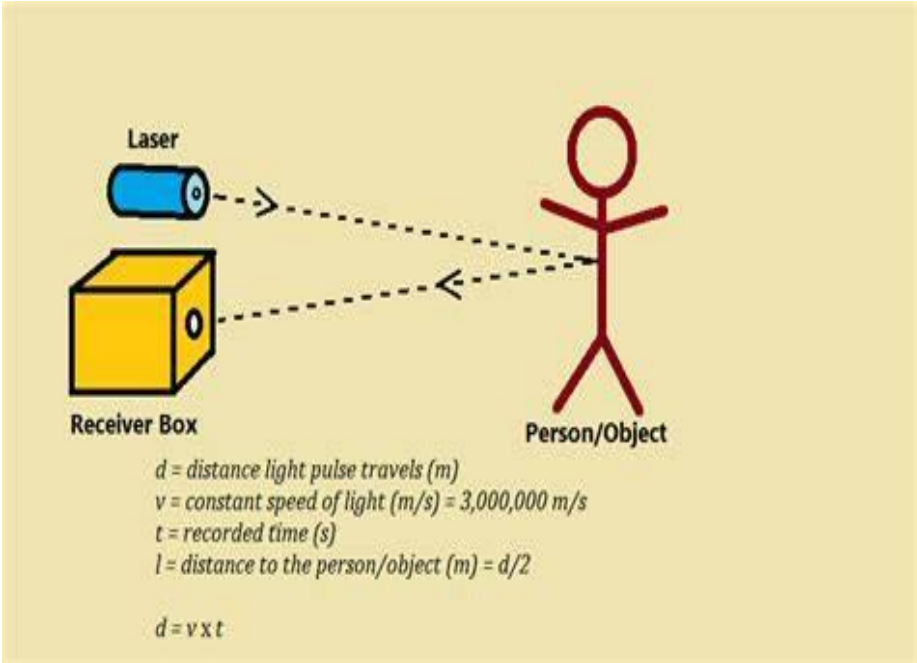
Goal: Give the distance to the obstacle or map the surroundings

Lidars' principle

Use of TOF Lidars

Main equation:

$$R = \frac{1}{2n} c\Delta t$$



The fog

Appears when visibility < 1 km
In France, on the road the limit is 400 m

The fog

Appears when visibility < 1 km
In France, on the road the limit is 400 m

Two types of fog:

The fog

Appears when visibility < 1 km
In France, on the road the limit is 400 m

Two types of fog:

- Radiation fog
  Due to temperature inversion and the condensation of the humidity caused by a cooling of the air near the ground

The fog

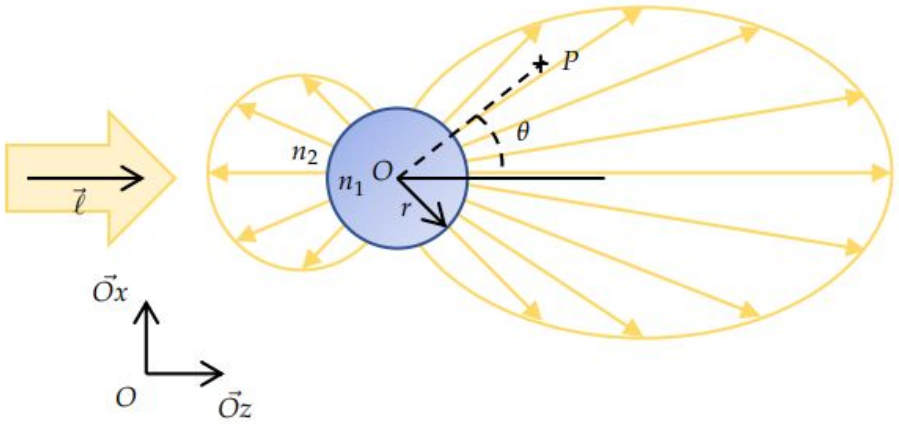
Appears when visibility < 1 km
In France, on the road the limit is 400 m

Two types of fog:

- Radiation fog
  Due to temperature inversion and the condensation of the humidity caused by a cooling of the air near the ground

- Advection fog
  Due to a contact between a warm and humid air and a colder surface

Fog's effects on Lidars



Scheme of a droplet and its scattering by Mie theory

Droplets will disturb the signal

=> backscattering and scattering effects

This effects give the equation of Lidars :

$$P(r)r^2 = C_0\beta(r)\exp\left[-2\int_0^r \alpha(r')dr'\right]$$

where

$$C_0 = P_0\frac{c\tau}{2}A$$

r the distance to the object
A the telescope aperture
τ the laser pulse length
Po the power transmitted by the laser
β(r) the backscatter
α(r) the extinction coeffcient

Autonomous cars

Future generation of vehicles

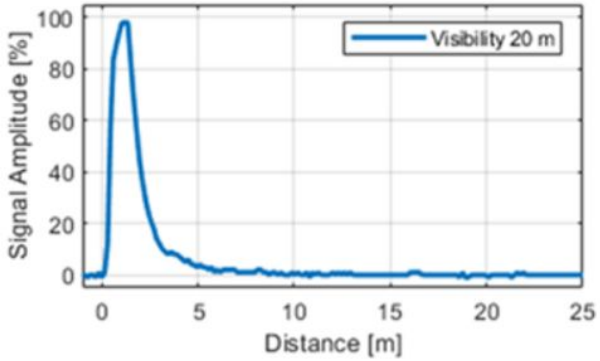
Use of many sensors likes cameras, radars and Lidars

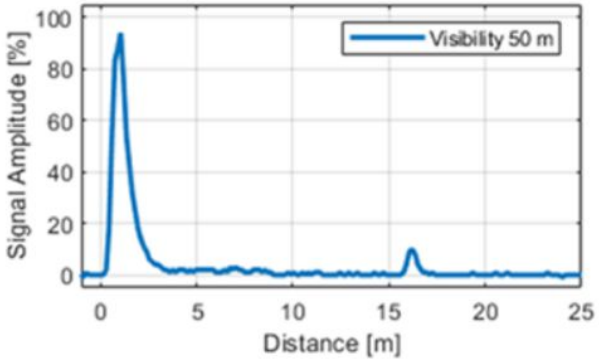
Lidars to detect obstacles and to improve the vehicle security

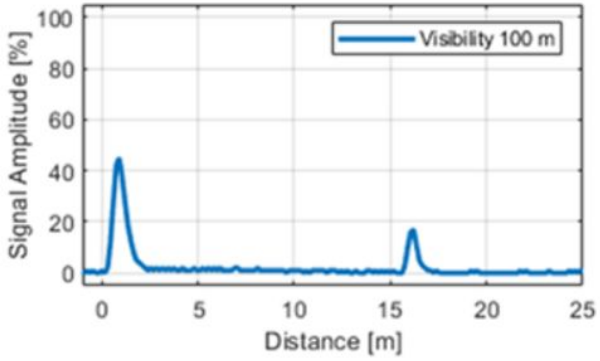
Not currently useable => many improvements have to be made

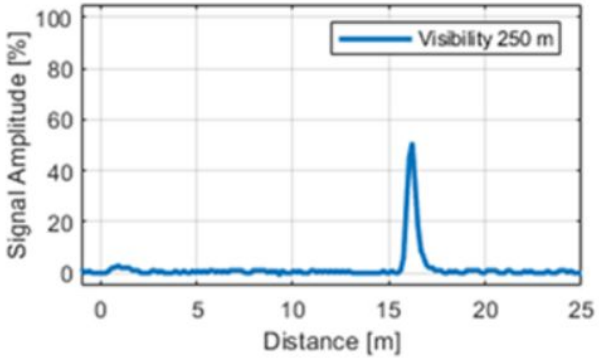
Navya Shuttle project

Problems with fog conditions









Main steps

- Understand the principle of Lidars, fog and the application on autonomous vehicles

Main steps

- Understand the principle of Lidars, fog and the application on autonomous vehicles

- Work with Mie Theory and Monte Carlo algorithm

Main steps

- Understand the principle of Lidars, fog and the application on autonomous vehicles

- Work with Mie Theory and Monte Carlo algorithm

- Use the LAMP model for spatial Lidars and transform it into a model for automotive Lidars

Main steps

- Understand the principle of Lidars, fog and the application on autonomous vehicles
- Work with Mie Theory and Monte Carlo algorithm
- Use the LAMP model for spatial Lidars and transform it into a model for automotive Lidars
- Simulate this model on different conditions of fog visibility

Main steps

- Understand the principle of Lidars, fog and the application on autonomous vehicles
- Work with Mie Theory and Monte Carlo algorithm
- Use the LAMP model for spatial Lidars and transform it into a model for automotive Lidars
- Simulate this model on different conditions of fog visibility
- Make conclusions on these results to help the advance on the construction of the autonomous vehicle

Thank you for your attention

Back up

Mie Theory

- Theory which deals with light scattering on spheres here droplets
- Allow to calculate the backscatter and extinction coefficients
- The wavelength and the size of the particle must be similar
- Rayleigh should be use when the size of the particle is much lower than the wavelength

Monte Carlo algorithm

- Numerical method to simulate random events based on a probabilistic model
- Perform random repetitions of a process to compute a numerical estimate
- Based on recording photon's histories as they are scattered and absorbed using optical properties of the medium
- Allow to optimize lidars parameters

Velodyne Lidar

Information on Velodyne Ultra Puck:

- TOF Lidar
- range 200m (80% reflectivity)
- accuracy 5 cm
- 360° HORIZONTAL
- 40° VERTICAL
- 0.2° horizontal angular resolution
- 0.3° vertical angular resolution
- 903 nm
- Max scanning speed 20 Hz

Navya Shuttle project

- Goal is to create an autonomous bus which will be able to circulate in the city center
- It is also built to be fully electrical
- Its capacity should be 15 people
- Autonomy of 9h and a max speed of 25 km/h

Other autonomous vehicles projects

- Waymo an autonomous taxi-car build by Google
- Tesla FSD (Full Self-Driving) with more advanced driver assistance
- Cruise a field of General Motors working on 2 projects: a commercial ride-hailing service and an electric car with self-driving technology
- Mobileye a field of Inter Corporations to create a robotaxi service in Tel Aviv

Questions that I have to answer

- Why using Monte Carlo algorithm instead of the Lidar equation in this subject ?
- How the Velodyne detect an object precisely ? Where does this low accuracy come from ?
- What is the microphysic of the fog ?
- Why do Lidars only use 2 different wavelengths 905 and 1550 nm ?
- What is the impact of fog on Lidars measurements ? What is the limit ?