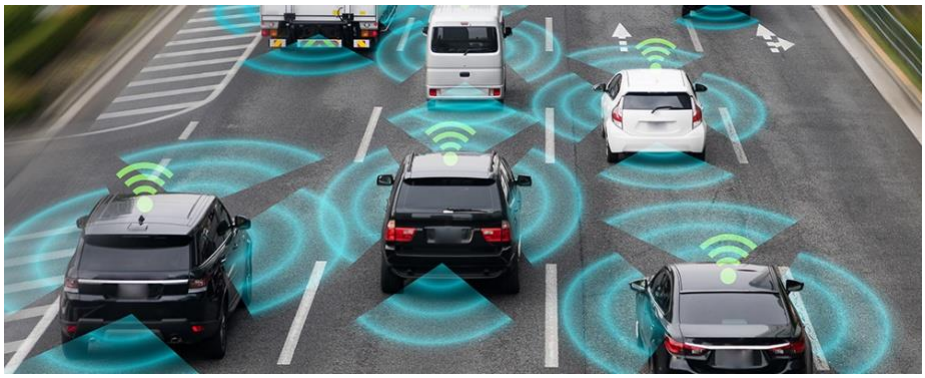
1. What are the different sensors that are typically used to obtain The data which is fed into the navigation stack for autonomous Systems? What are the advantages and disadvantages associated .With these sensors? When do we use which? What about sensor Fusion? (Answer in around 200 words. Be clear and concise. Use Diagrams if required.)

Self autonomous vehicles sensors are critical to the perception of the surroundings and localization of the vehicles for path planning and decision making essential precursors for controlling the motion of the vehicle photo remove vehicle primarily utilizes multiple vision cameras radars lidar sensors and ultrasonic sensors to perceive it environments are devices that map the detected events or changes in surroundings to a quantitative measurement for further processing in general sensors are classified into two classes based on their operational principle .



- proprioceptive sensors or internal state sensors captured dynamical state and measures the internal value of a dynamic system example force ,angular rate, wheel load, battery voltage etc.
- examples of the proprioceptive sensors include inertia measurement units (IMU) ,encoders, inertial sensors garage scopes and magnetometers and positioning sensors GPS receivers.
- The extroceptive sensors or external state sensors sense and acquire information such as instance measurements or light density from the surrounding of the system.
- cameras radio detection and ranging radar light detection and ranging lidar and ultrasonic sensors are examples of exteroceptive sensors additionally sensors can either be passive sensors or active sensors passive sensors receive energy emitting from the surrounding to produce outputs example vision cameras .
- conversely active sensors emit energy into the environment and measures the environmental reaction to that energy to produce outputs such as with lidar and radar sensors.

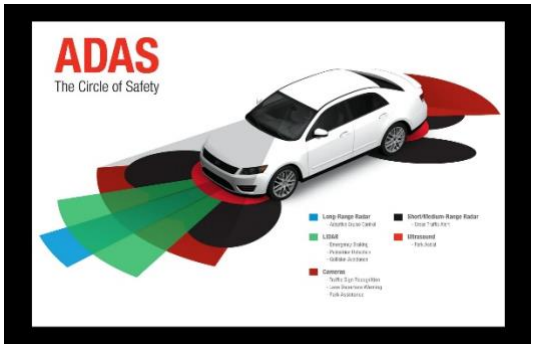
In autonomous vehicles sensors are critical to the perception of the surroundings and localization of the vehicles for path planning and decision making essential precursors for controlling the motion of the vehicle autonomous vehicles primarily utilizes multiple vision cameras radar sensors lidar sensors and ultrasonic sensors to perceive its environment

Additionally other sensors including the global navigation satellite system(GNSS), IMU and vehicle odometry sensors are used to determine the relative and absolute position of the vehicle.

Placement of sensors for environment perception on typical Evie applications their coverage and applications are shown in the figure below .

this section reviews the advantage and shortcomings of three primary sensors cameras, lidars and radars for environment perception in autonomous vehicle applications.

Cameras



Cameras are one of the most adopted technology for perceiving the surroundings a camera works on the principle of protecting lights emitted from the surroundings on a photosensitive surface through a camera lens mounted in front of the sensor to produce clear images of the surrounding

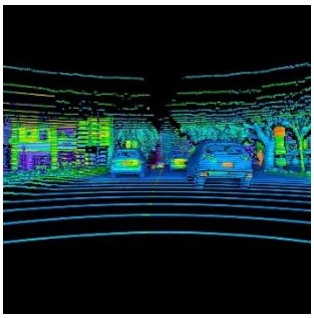
advantages of using camera

- Cameras are relatively inexpensive and with appropriate software can detect both moving and static obstacles within their field of view
- Cameras provides high resolution images of the surroundings

Disadvantages of using cameras

- The deviation in lens symmetry from the idea or nominal geometry will result in image distortion
- The quality of images captured by the cameras magnificently affected by lightning and adverse weather conditions
- Large computation power while in analysing the image

Lidars



Lidar is a remote sensing technology that operates on principle of emitting pulses in infrared beams or laser light which reflect off targets objects these reflections are detected by the instrument and the interval taken between emission and receiving of the light pulse enables the estimation of distance

Advantages

- Accuracy lidar technology offers incredibly accurate consistent results the short wavelength can even detect small objects and create exact 3D models making it possible to determine what the objects are whether it's a tree person or ball
- Speed the sensors send out laser pulses and receives them back in NS making it possible to scale large area in a fairly short period of time and still get a high volume of data
- Places that are inaccessible such as high mountains dense forest and hard to reach areas can be easily mapped with lidar technology.

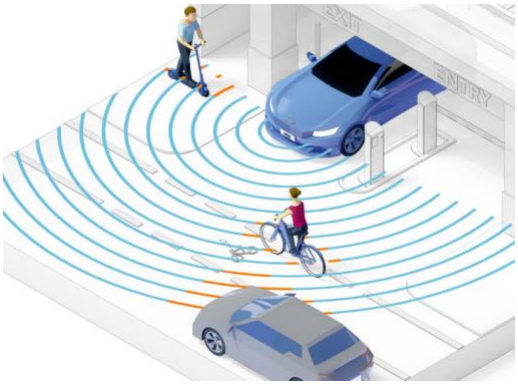
Disadvantages

- Lidar sensors do not provide color information over surroundings compared to the camera systems and this is one of the reasons that PC is often fused with data from different sensors using sensor fusion algorithms.
- It takes previous surveying experience to take check shots run base stations and check in to benchmarks the lidar is complex in nature and requires a deep understanding of the sensors
- purchasing high end ladder sensors are costly

Sensor Fusion !!!- what is this ?

Each sensor type or modality has inherent strengths and weaknesses. Sensor fusion is the process of bringing together inputs from multiple sensors to form a single model or image of the environment around a platform the resulting model is more accurate because it balances the strength of the various sensors sensor fusion brings the data from the heterogeneous set of sensors modality together and uses software algorithms to provide a more compressive and therefore accurate environmental model.

Radars



Radio detection and ranging operates on the principle of radiating electromagnetic waves within the area of interest and receiving the scattered waves of targets for further signal processing and establishing range information about the targets .

Advantages of radars

Radars are valuable sensors in autonomous systems as they provide reliable and precise perception of obstacles in day and night because of its capability to function irrespective of elimination and adverse weather conditions

It provides additional information such as speed of the detected moving obstacles and can perform mapping in either short, medium or long range depending on the configuration mode

Disadvantages

Prodders however is not generally suitable for object recognition applications because of their quartz resolution compared to cameras.