Science Module: Sensors for Automated Vehicles

Describes the key sensor technologies used by automated vehicles for navigation.

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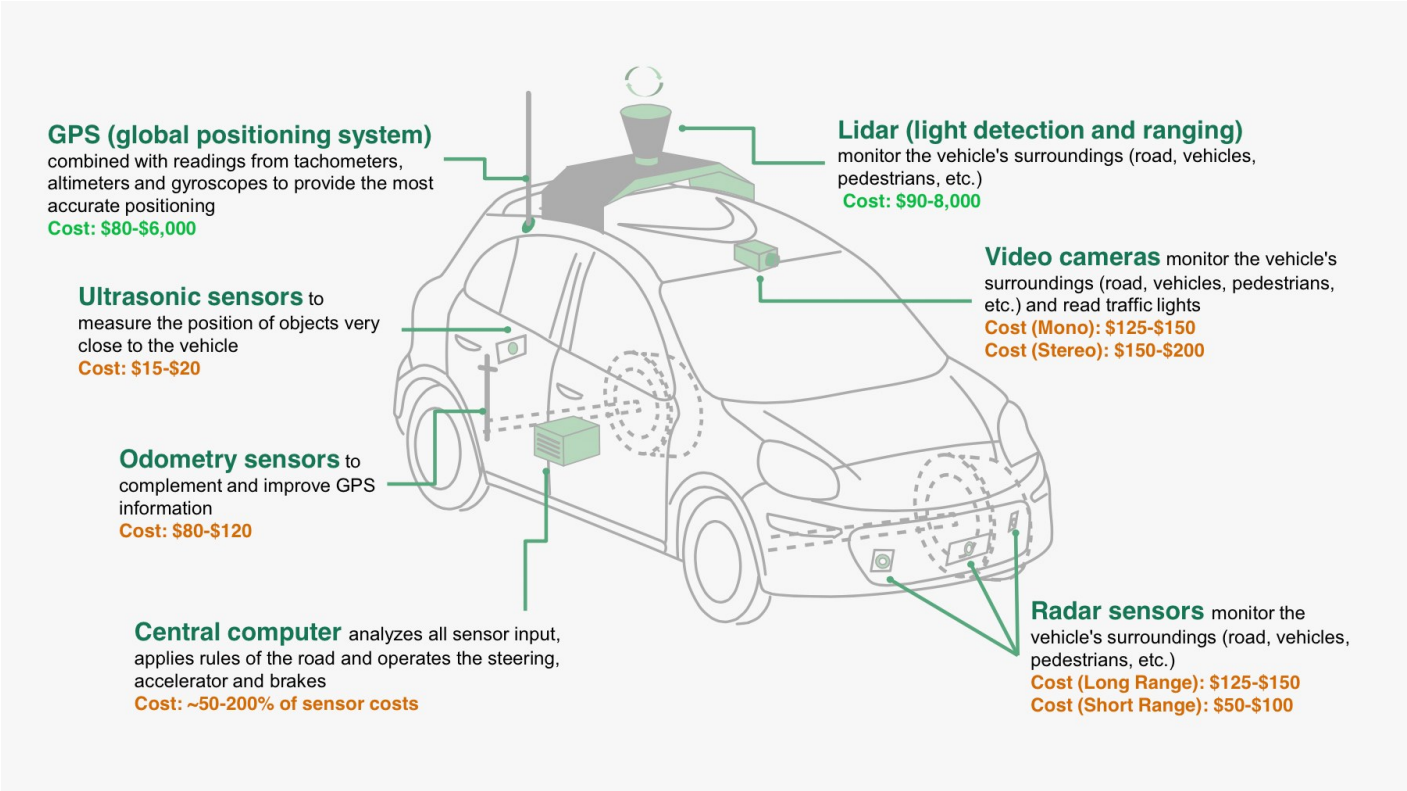
HAL Humans and Autonomy Lab

WHAT IT DOES

Broadly defined, a sensor is a device that detects measurable properties in the physical environment and converts them to data that can be processed by another system or device. In the context of automated driving systems, sensors are used to create and maintain a perception of objects within a vehicle's surroundings. Most current autonomous vehicles are equipped with different combinations of four main types of sensor technology, including cameras, radar, lidar, and ultrasonic sensors.

RELEVANT SCIENCE

The four main types of sensors, in addition to location-based sensors, currently used by automated vehicles are illustrated in the figure below.



- *Camera* sensors visually detect objects around the vehicle. Cameras are advantageous for object recognition because they detect light and color, but struggle with depth perception and suffer from impaired functionality under weather conditions that

reduce visibility, such as rain and fog.

- *Radio detection and ranging* (RADAR) detects surrounding objects by sending out electromagnetic waves that reflect off objects and provide information about how far away the object is and how fast it is moving. Short range radars are located on the side of the vehicle, while long range radars are located on the head and rear of the vehicle to detect other vehicles moving in front of and behind it. These signals allow vehicles to see hundreds of feet away in vision-impairing conditions, but most cannot detect height and only provide 2-D representation of objects.
- *Light imaging detection and ranging* (LIDAR) produces a monochrome 3-D map of the surrounding world by using scanning lasers to measure the distance between the vehicle and other objects. Current LIDAR sensors use laser beam flashes, but LIDAR sensors that use continuous laser beams are under development. These sensors are the most effective for identifying obstacles but are currently too expensive for commercial production.
- *Ultrasonic sensors* function by measuring sound waves reflecting off solid objects. These sensors have a very short range but are very effective for three-dimensional mapping with accuracies within a centimeter, outperforming radar at close range.
- *Global Positioning Systems* (GPS) are used to calculate vehicular location data. GPS determine the vehicle location by analyzing signals received from multiple satellites. A direct line of sight between the vehicle and satellites is required for maintaining accurate location data. This means that signals can fail in locations where the signals are blocked, such as in deep canyons or in covered parking decks.
- *Inertial Measurement Units* (IMU) are used to collect vehicular motion and rotation data to localize the vehicle relative to its surroundings. Such systems supplement GPS systems in instances where satellite data is unavailable; they cannot determine absolute vehicular position but can help determine the location of a vehicle relative to its starting point.

Sensor Fusion

Since each type of sensor has independent strengths and weaknesses, the driving system combines the incoming data it receives from individual sensors to form the most optimal “view” of its environment. This process, known as sensor fusion, allows the vehicle to overcome the shortcomings of individual sensors caused by malfunction or condition-related impairments. For example, if the driving system must navigate through heavy rain or fog, its camera sensors may not detect objects clearly, while its radar sensors would maintain full ability to accurately measure the distance between itself and other objects. Therefore, sensor fused systems can improve accuracy, provide redundancy, and better equip the driving system to address suboptimal circumstances.

BACKGROUND

Further reading:

- http://www.thedrive.com/tech/8657/heres-how-the-sensors-in-autonomous-ca...
- https://driverless.wonderhowto.com/news/different-driverless-sensors-see...

PRIMARY AUTHOR

Nicole Kastelic

EDITOR(S)

Michael Clamann, PhD, CHFP

RECOMMENDED CITATION

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