

P524: Survey of Instrumentation and Laboratory Techniques Week 9

10/21/2025

Week 9: sensors-2

Distance Measurement:

VL6180X “Time of Flight Distance Ranging Sensor”

- Micro-LIDAR (LIght Detection And Ranging) distance sensor
 - Range: 5-100 mm
- Lux sensor
- I2C communication, I2C address is **0x29**

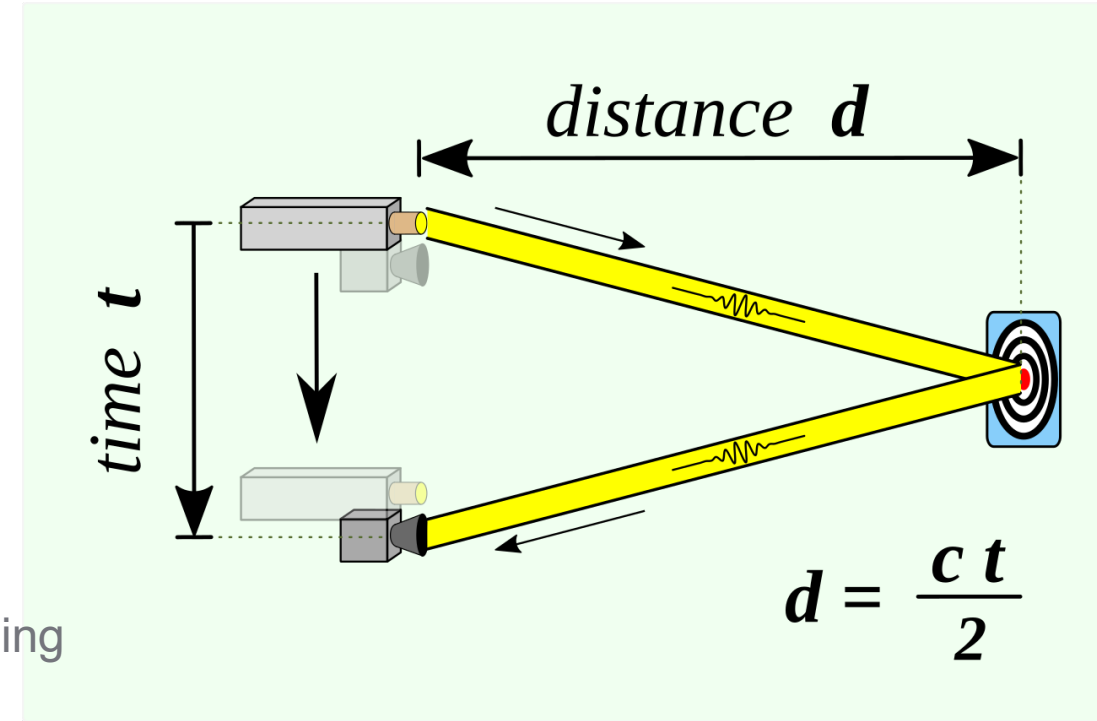


VL6180 sensor chip

VL6180X 3 in 1 proximity sensor
Based on FlightSense™



- The VL6180 from STMicroelectronics is a 3-in-1 package that combines
 - an IR emitter (850 nm infrared laser),
 - a range sensor, and
 - an ambient light sensorcommunicate via an I²C interface.
- Fast, accurate distance ranging
 - Measures absolute range from 0 to above 10 cm (ranging beyond 10cm is dependent on conditions)
 - Independent of object reflectance
 - Ambient light rejection
 - Cross-talk compensation for cover glass



Unlike most distance sensors that rely on reflected light intensity or reflected angles to determine range, the VL6180 uses a precise clock to measure the time it takes light to bounce back from a surface. This offers the ToF Range Finder and VL6180 a great benefit over other methods because it can be much more accurate and more immune to noise.

Difference Types of Distance Sensors

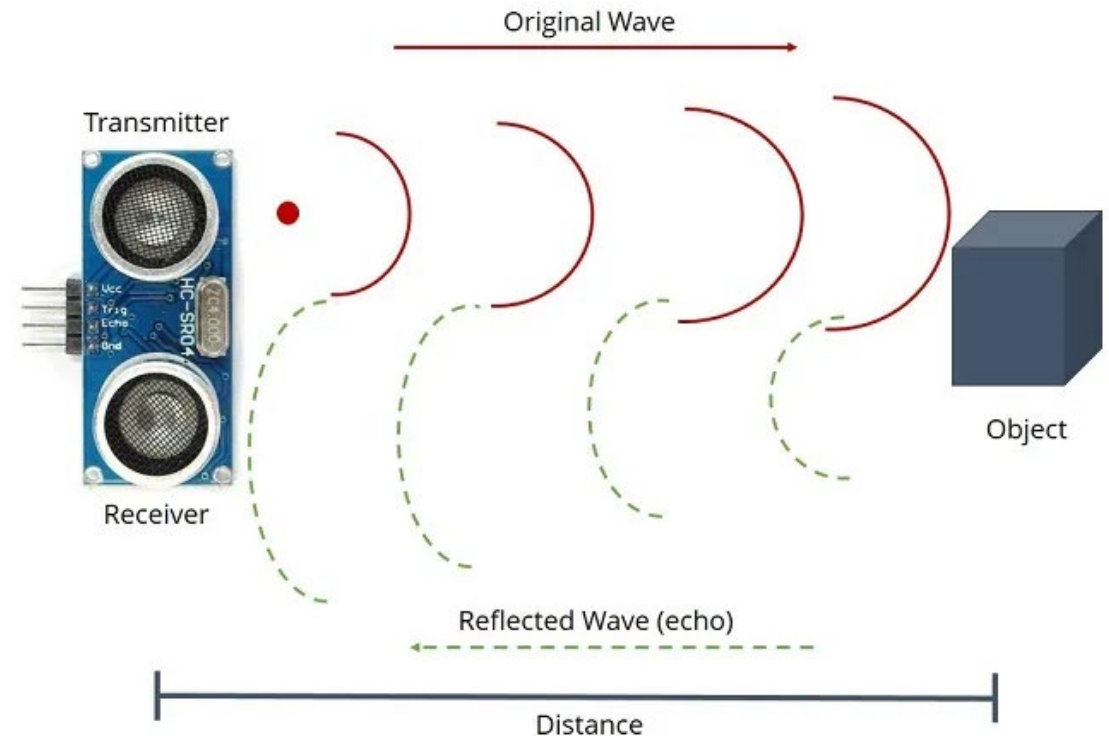
- Ultrasonic Sensor, also known as the Sonar sensor.
 - Emitting high-frequency *sound waves*
 - The wave is reflected by an object nearby.
 - The receiver pick up the reflected wave.
 - Distance = $\frac{1}{2} \times (\text{time delay} / \text{velocity of sound})$.

Advantages of Ultrasonic Sensors

- Not affected by object color and transparency as it detects distance through sound waves
- Works well in places that are bright/dim
- Tend to consume lower current/power

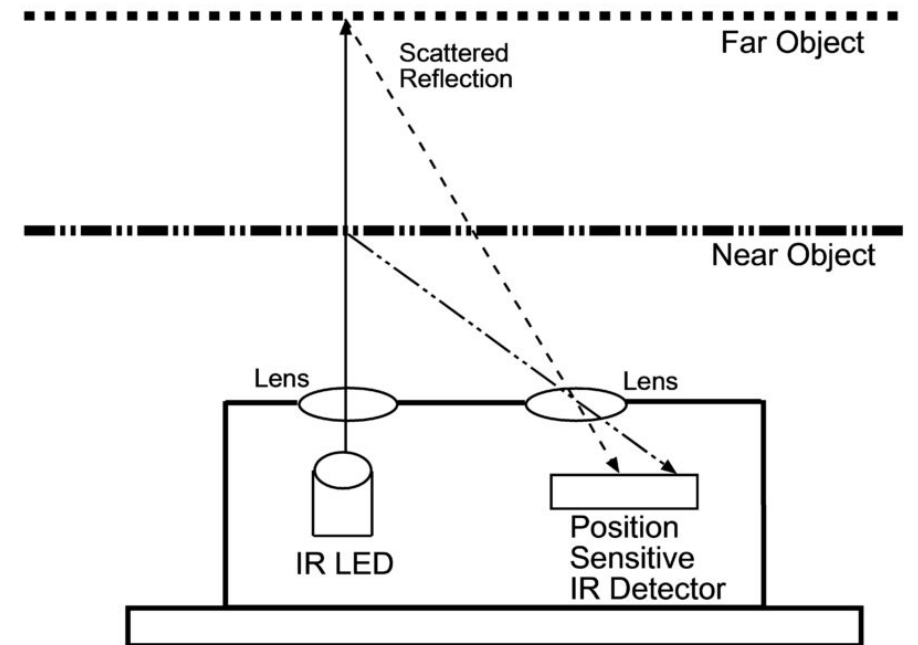
Disadvantages of Ultrasonic Sensors

- Limited detection range
- Low resolution and slow refresh rate, making it not suitable for detection of fast-moving targets
- Unable to measure the distance of objects that have extreme textures/surfaces



Infrared Distance Sensors

- An IR LED emitter lens that emits a light beam
- A position-sensible photodetector (PSD) where the reflected beam will fall onto



Advantages of IR Sensors

- Small form factor; Common IR sensors like the ones from Sharp tend to be smaller in size
- Applicable for daytime and nighttime usages
- Secured communication through a line of sight
- Able to measure the distance of objects that have complex surfaces unlike ultrasonic sensors

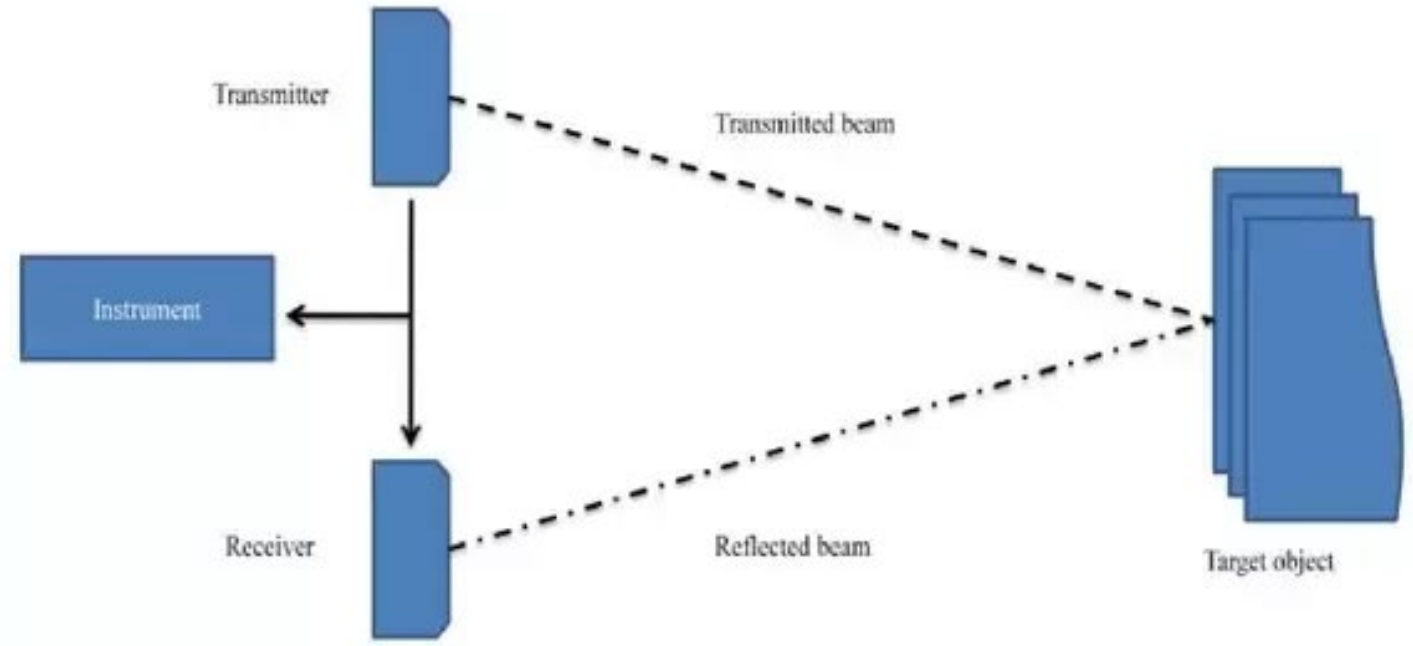
Disadvantages of IR sensors

- Limited measurement range
- Affected by environmental conditions and hard objects

IR vs Ultrasonic distance sensors

Type	IR Sensor	Ultrasonic Sensor
What It Does	Measure distance through reflected light waves	Measure distance through reflected sound waves
How It Measures	Triangulation: Angle of a reflected IR beam is measured	Time taken between transmitting and receiving sound waves are recorded
Human Interactions	Invisible to the naked eye	Unhearable
Object Requirements	Suitable to be used to measure complex objects	Not suitable to measure objects with complex surfaces

Laser Distance Sensors: LIDAR



- **Advantages of LiDAR**

- High measurement range and accuracy
- Ability to measure 3D structures
- Fast update rate; suitable for fast-moving objects
- Small wavelengths as compared to sonar and radar; good at detecting small objects
- Applicable for usage in the day and night

- **Disadvantages of LiDAR**

- Higher cost as compared to ultrasonic and IR
- Harmful to the naked eye; higher-end LiDAR devices may utilize stronger LiDAR pulses which may affect the human eye

LED Time-Of-Flight Distance Sensors

Time-of-flight sensors work similarly to LiDAR sensors, where:

1. The transmitter on the time-of-flight device emits IR waves towards the target object
2. The wave is reflected back upon reaching the target object
3. Distance is then calculated by using the speed of light in air and the time between sending/receiving of the signal

With time-of-flight technology, it provides significant benefits over the other distance sensing methods, including a wider range, faster readings, and greater accuracy.

Advantages of Time-of-Flight Sensors

- Such technology offers high measurement range with accuracy
- 3D imaging capable
- Used in a wide variety of applications due to its ability to identify large objects

Disadvantages of Time-of-Flight Sensors

- Higher costs in general
- Z-depth resolution is still poor with general systems offering a 1cm Z-resolution

Comparison of different distance sensing techniques

Type	Ultrasonic	IR	LIDAR	ToF
Suitablility for Long Range Sensing	No	No	Yes	Yes
High reading frequency	No	No	Yes	Yes
Cost	Low	Low	High	Moderate
Suitability to use for complex objects	No	Yes	Yes	Yes
Sensitive to external conditions	Yes	No	No	No
3D imaging compatible	No	No	Yes	Yes

Both ultrasonic and IR distance sensors are more suited for Arduino projects that require shorter range sensing. While LiDAR and Time-of-flight sensors would be recommended for those that are looking for higher sensing capabilities and 3D imaging

In-class exercise

- Install an Adafruit VL6180X sensor on your breakout board. Get the demo code in the Examples menu running
- Add to the example code to allow the user to specify a distance threshold in the code, and to light the Arduino's on-board red LED whenever the distance is found by the VL6180X to be less than the specified value

Homework (due 10/30)

Modify your program to accept an integer input from the serial monitor's input field and use this on the fly to decide when to illuminate the Arduino's red LED.