Vivekanand Education Society's
Institute of Technology
(Autonomous Institute Affiliated to University of Mumbai, Approved by AICTE & Recognised by Govt. of Maharashtra)
NAAC accredited with 'A' grade

Semester: VI

Title of the Project:
Distance Measurement Using Laser Sensor [VL53L0X]

Subject : Sensor Lab

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Introduction to Project

- Measuring distance accurately is a critical requirement in modern technologies like robotics, automation, and IoT devices. This project explores the use of the VL53L0X laser sensor for precise, contactless distance measurement.
- The VL53L0X is a Time-of-Flight (ToF) laser-ranging sensor that measures how long it takes for a laser beam to bounce back from a target, providing highly accurate distance data.
- This project utilizes the sensor's capabilities to develop a system that can detect objects and measure their distance with precision, even in challenging environments.
- By leveraging the sensor’s compact size, low power consumption, and I2C communication, the system is ideal for real-time applications in robotics, obstacle detection, and IoT-based smart solutions.
- With the VL53L0X, we aim to build a reliable and efficient distance measurement system that can enhance automation and intelligent decision-making in embedded applications.

Objectives of the project

The objective of the project is to develop a compact and reliable distance measurement system using the VL53L0X Time-of-Flight laser sensor for accurate object detection in real-time applications.

- **Accurate Distance Sensing**: Implement the VL53L0X sensor to measure distances precisely, even in low-light or reflective environments.
- **Real-Time Object Detection:** Design a system capable of detecting objects instantly and responding to distance changes in real time.
- **Easy Microcontroller Integration:** Interface the sensor with platforms like Arduino using I2C communication for smooth and flexible operation.
- **Compact and Low Power Design:** Develop a lightweight, energy-efficient solution suitable for portable or embedded systems.

Requirements of the system (Hardware, software)

HARDWARE REQUIREMENTS

- **VL53L0X Time-of-Flight Sensor** – Measures distance using laser-based ToF technology.
- **Arduino Uno/Nano (Microcontroller)** – Acts as the main controller to interface with the sensor.
- **Jumper Wires** – Connects all components electrically for signal and power transmission.
- **Breadboard** - Provides a platform for temporary circuit assembly and testing.
- **USB Cable / Power Supply** - Powers the microcontroller and the connected components.
- **LCD Display** - Displays real-time distance readings from the sensor.

Requirements of the system (Hardware, software)

SOFTWARE REQUIREMENTS

- **Arduino IDE –** Used to write, compile, and upload code to the Arduino board
- **VL53L0X Arduino Library –** Facilitates communication with the VL53L0X sensor for distance measurement:
- **LiquidCrystal (or LiquidCrystal_I2C) Library –** Needed for interfacing with LCD displays to show real-time distance data.

Literature Survey

Sr.No	Title	Author	Publish Date	Description
1]	Application of low-cost VL53L0X ToF sensor for robot environment detection	Nikola Laković; Miodrag Brkić; Branislav Batinić; Jovan Bajić; Vladimir Rajs; Nenad Kulundžić	20 May 2019	•The paper explores the use of the VL53L0X Time-of-Flight sensor for robot environment detection. •Testing includes different surface materials and lighting conditions (including low light) to assess sensor consistency. •The VL53L0X provides precise distance measurements up to 2 meters. •The paper concludes that the sensor is ideal for proximity sensing, object detection, and robot odometry due to its stable performance and low cost.
2)	Real-time simulation of time-of-flight sensors	Andreas Kolb,M. Keller, and R. Koch	May 2009	▪ The paper presents a real-time simulation model for Time-of-Flight (ToF) sensors, focusing on the Photonic Mixing Device (PMD) type. ▪ The simulation accounts for real-world effects like motion blur, flying pixels, and deviation errors, using a physics-based approach for realistic sensor behavior. ▪ The system leverages GPU acceleration to provide interactive, real-time feedback and control during the simulation.

Literature Survey

Sr.No	Title	Author	Publish Date	Description
3]	Study of arduino microcontroller board	Alisher Shakirovich Ismailov,S. Anwar and A. Rehman	March 2022	•Explains the working principle of Arduino microcontrollers. •Highlights Arduino's use in education and research, especially sensor-based projects. •Arduino is easy to learn and program using the free Arduino IDE. •IDE includes built-in libraries to simplify coding. •Discusses different types of Arduino boards and their applications. •Arduino offers a low-cost, fast solution for small-scale electronics projects.

Proposed System

- **Study of Sensor and I2C Communication:**
  Understood the working of the VL53L0X Time-of-Flight sensor and its communication via the I2C protocol.

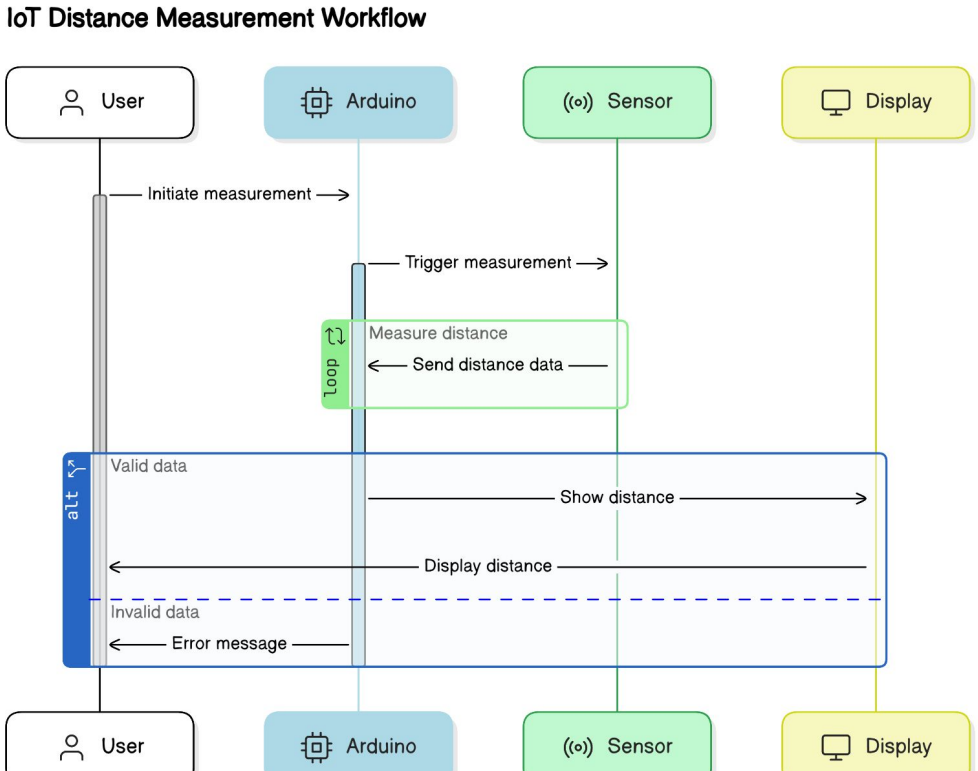
- **Interfacing with Arduino Uno:**
  Connected the VL53L0X sensor to the Arduino Uno R3 using SDA and SCL pins and installed necessary libraries.

- **Displaying Values on LCD:**
  Using a 16x2 LCD with an I2C Module to display real time distance values.

- **Circuit Design and Wiring:**
  Built the circuit on a breadboard using jumper wires and ensured all connections were correct.

- **Code Development and Testing:**
  Wrote and uploaded the Arduino code for sensor reading and LCD display, followed by testing for accuracy.

Proposed Design

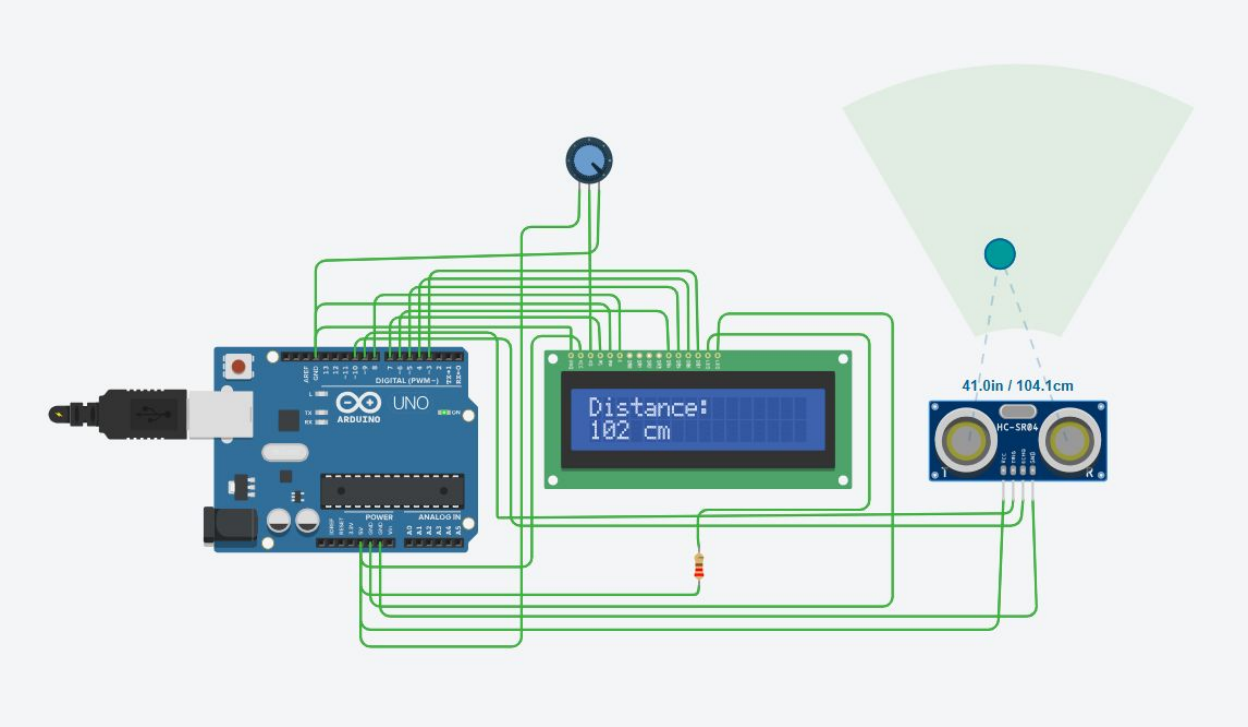


Proposed Design [Flowchart]

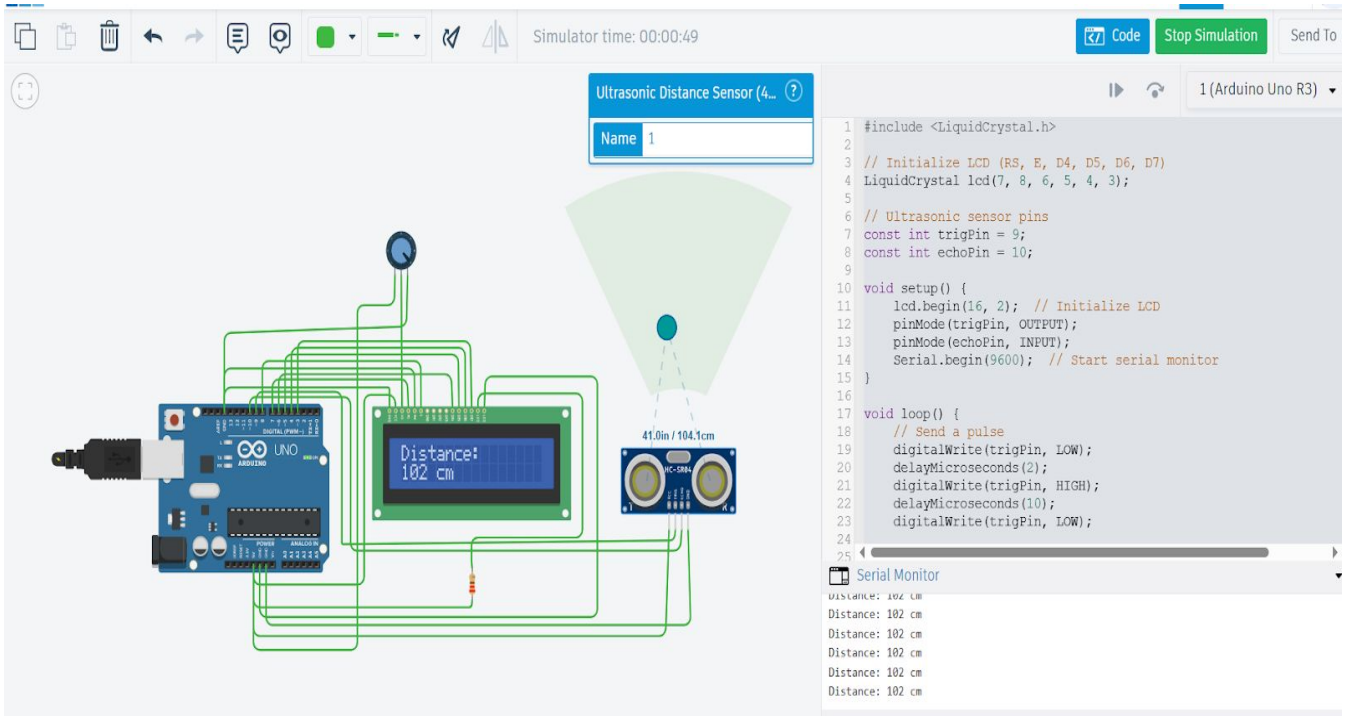
PROJECT FLOWCHARTS

https://docs.google.com/document/d/1aHWsdv4VMCf6ffHWh82PdK8TEwIAr5xafE9ROrQzpT8/edit?tab=t.0

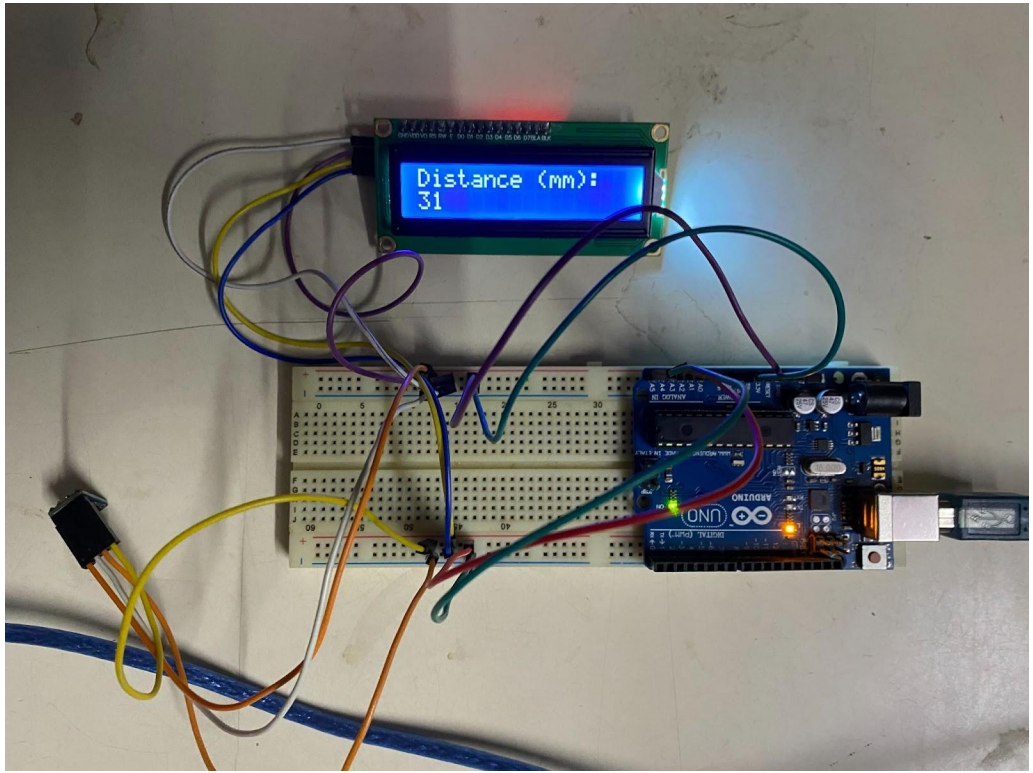
Simulation



Simulation


Simulator time: 00:00:49
Code
Stop Simulation
Send To
Ultrasonic Distance Sensor (4...
Name 1
1 (Arduino Uno R3)
#include <LiquidCrystal.h>
// Initialize LCD (RS, E, D4, D5, D6, D7)
LiquidCrystal lcd(7, 8, 6, 5, 4, 3);
// Ultrasonic sensor pins
const int trigPin = 9;
const int echoPin = 10;
void setup() {
lcd.begin(16, 2); // Initialize LCD
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
Serial.begin(9600); // Start serial monitor
}
void loop() {
// Send a pulse
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
Distance:
102 cm
41.0in / 104.1cm
Serial Monitor
Distance: 102 cm
Distance: 102 cm
Distance: 102 cm
Distance: 102 cm
Distance: 102 cm
Distance: 102 cm

Implementation



VL53L0X

- **VCC → 5V on Arduino**
- **GND → GND on Arduino**
- **SDA → A4 on Arduino**
- **SCL → A5 on Arduino**

LCD (I2C)

- **VCC → 5V on Arduino**
- **GND → GND on Arduino**
- **SDA → A4 on Arduino**
- **SCL → A5 on Arduino**

Result Analysis

- The VL53L0X sensor provided accurate distance measurements within its specified range (30 mm to 2 meters). Test results showed reliable readings when objects were placed at varying distances, with minimal error margin.
- The 16x2 LCD displayed the distance values in real-time, effectively reflecting the sensor's output. The system updated the readings smoothly, showing no significant lag.
- The Arduino microcontroller processed the sensor data without issues, and the I2C communication worked seamlessly with the sensor and the display. There was no significant delay between sensor reading and display output.
- The circuit design and code proved to be robust during multiple test iterations. The sensor and display worked consistently, ensuring the system is reliable for continuous operation.

Conclusion

- The VL53L0X Time-of-Flight sensor, when integrated with an Arduino microcontroller, successfully measures distances in real-time with high accuracy within the range of 30 mm to 2 meters.
- The system provides reliable and consistent distance readings, displayed effectively on an LCD screen.
- The project demonstrates the potential of using laser-based sensors in embedded applications, with the system being compact, efficient, and suitable for various real-time distance measurement tasks, including object detection and obstacle avoidance.
- Further improvements could enhance the system's range and robustness, making it adaptable for more complex applications in robotics and automation.

References

[1] N. Laković, M. Brkić, and B. Batinić, “Application of low-cost VL53L0X ToF sensor for robot environment detection,” Proc. 18th Int. Symp. INFOTEH-JAHORINA, East Sarajevo, Bosnia and Herzegovina, pp. 1–5, Mar. 2019.

[2] M. Keller, A. Kolb, and R. Koch, “Real-time simulation of time-of-flight sensors,” Proc. Int. Symp. Signals, Circuits and Systems, Iasi, Romania, pp. 1–4, Jul. 2007.

[3] S. Anwar and A. Rehman, “Study of Arduino microcontroller,” ResearchGate, 2022. [Online]. Available: https://www.researchgate.net/publication/359502443_Study_of_arduino_microcontrol