Design and Implementation of LIDAR System for Distance Measurements

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Abstract

LIDAR (Light Detection and Ranging) is an optical remote sensing system that can measure the distance to a target by shining light on the target. LIDAR technology is used in robotics to recognize the environment and classify objects. The ability of LIDAR technology to provide a 2D elevation map of the terrain, a highly accurate distance to the ground, and an approach speed allows robots and manned vehicles to land accurately and safely. LIDAR consists of a transmitter that illuminates the target with a laser beam and a receiver that can detect light components that are substantially coaxial with the transmitted beam. The receiver sensor calculates the distance based on the time it takes for the light to reach and return to its destination. A mechanical mechanism with a mirror uses a rotating nodding mirror to pan the light beam and cover the desired scene in one plane or even in 3D. LIDAR can measure distances up to 40 meters, making this system suitable for urban environments. The rider was mounted on a stepper motor and covered the entire area. This paper describes the design and implementation of LIDAR for distance measurement.

Keywords: Arduino Nano, LIDAR, VL53L0X sensor, Servomotor.

1. Introduction

LIDAR is a method for determining ranges (variable distance) by targeting an object with a laser and measuring the time for the reflected light to return to the receiver. The LIDAR system consists of a VL53L0X far distance sensor, an Arduino Nano board, and a servo motor. Unlike current technologies, the VL53L0X is a new generation Time-of-Flight (ToF) laser-ranging module contained in the smallest compact on the market today, providing accurate distance measuring regardless of target reflectance. It is capable of measuring absolute distances of up to 2metres. Arduino Nano is a small board based on the ATmega328P.It is equipped with 30 male I/O headers.MG90S is a micro servo motor with metal gear. This compact, light servo has high output power, making it suitable for RC planes, quadcopters, and robotic arms. LIDAR works with lasers that have a significantly shorter wavelength than radar's radio waves. The LIDAR is an appropriate sensing device for an urban-related emergency, safety, and comfort systems, such as Pedestrian Detection, Traffic Jam Assist, Collision Warning and Avoidance, and Adaptive Cruise Control, because it meets the following requirements: high speed of distance measurement, high accuracy, and ability to function well in most weather.

1.1 Literature survey

(A. Davies et al., 2017)segmented the points using Radially Bounded Nearest Neighbour (RBNN). The algorithm is efficient in the real-time segmentation of 3D data. The algorithm assigns all points within a distance threshold to a point in one cluster, thus more points can be assigned to a cluster which speeds up the iterative process of visiting all points in the point set. The more points that can be assigned at one look-up to a cluster the faster the algorithm runs. This mainly depends on the distance threshold; too big a value may result in underfitting, too small in over-fitting, and yield a longer processing time.

(B. Templeton et al., 2017) used a spatial-temporal approach to solve the problem of the segmentation and classification in one step. They segmented not just the current scan, but rather gathered several scans in which reoccurring objects can be detected and also the moving objects can be easily recognized using spatial-temporal features of the detected clusters.

(Kwak etal., 2014) used Extended Kalman Filter to detect the breakpoints between segments. The edge was detected by comparing the range estimate and the range measurement. By searching boundaries of the objects scanned by a laser. They solve the problem of boundary detection as a classification problem, where the boundary either exists or not between the consecutive points.

(**ShengboEben, Li et al., 2018)** showed how to make an array of ultrasonic detectors with an Arduino board for sensing moving things. For precise measurement, both the object's effective area and its shape were considered. The angle of rotation to the center line, on the other hand, ranged from -60° to *60°. This project attempts to build and implement an ultrasonic distance measurement system utilizing an Arduino board for distances up to 100 meters and has a covering range of (0 to 180) and (180 to 0) degrees.

(Huthaifa Ahmad Al Issa, et al., 2016) used a combination of three sensors and a PIC l6F877A microcontroller to create a smart device that may be used for a variety of purposes. Nonetheless, the results of distance measurements do not mention the distance between the object and the device, instead focusing on the measurement error.

1.2 Methodology

In this study, Arduino Nano, Vl53L0X sensor, and the servo were important components. An Arduino Nano was used to link and control these. The servo motor rotates the VL53L0Xsensor while the sensor sends lasers. USB connector, microcontroller, analog input pins, power port, digital pins, crystal, oscillator reset switch, USB interface chip, and TX RX LEDs make up the Arduino Nano. It serves as a controller and provides a coding environment; therefore it necessitates a direct computer connection for processing software.

1.2.1 Existing method with block diagram

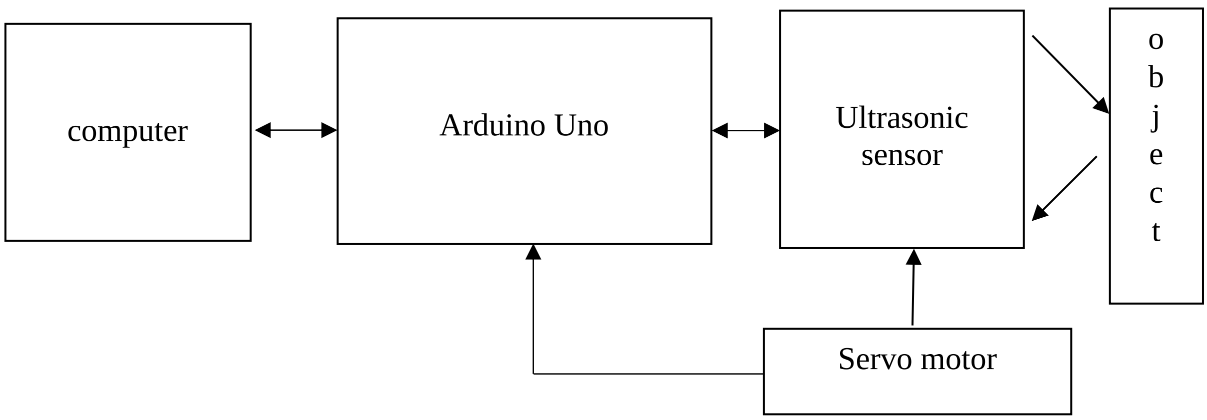

Figure 1.2.1: Existing Block Diagram of Ultrasonic Radar System

1.3 Problem identification

Unlike radar, the LIDAR does not suffer so much from interference due by other LIDARs in its surroundings. Additionally, it can provide a more accurate position of the obstacle with a higher range and angular resolution compared to radar.

1.3.1 Proposed method with block diagram

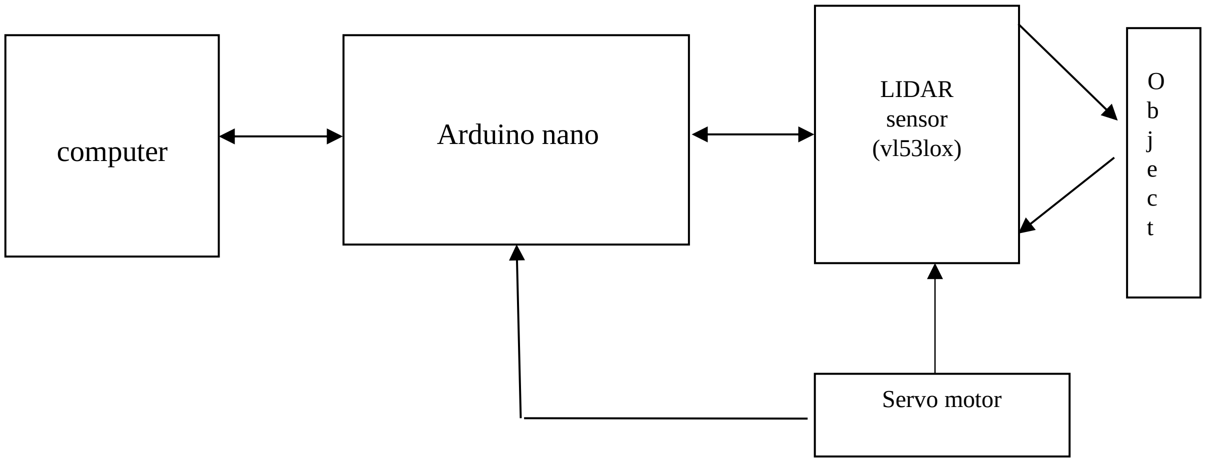

Figure 1.3.1: Proposed Block Diagram of LIDAR System

As shown in figure 1.3.1, Arduino Nano receives a power supply from the computer. Then microcontroller sends signals to the other components: the VL53L0X sensor and servo motor. The response from these components is sent back to the microcontroller. The VL53L0X sensor has a transmitter to emit the light rays and a receiver to catch the reflected light rays. The total traveling of this light ray is the distance.

2. Hardware and Software Requirements

2.1 Arduino Nano

Arduino Nano is one type of microcontroller board, and it is designed by Arduino. cc. It can be built with a microcontroller like Atmega328. However, this Nano board is different in packaging. It doesn't have any DC jack so the power supply can be given using a small USB port otherwise straightly connected to the pins like VCC & GND.

Technical specifications of Arduino Nano:

a) ATmega328P Microcontroller is from the 8-bit AVR family
b) The operating voltage is 5V
c) Input voltage (Vin) is 7V to 12V
d) Input/output Pins are 22
e) Analog i/p pins are 6 from A0 to A5
f) Digital pins are 14
g) Power consumption is 19 mA

h) DC at I/O pins is 40 mA
i) Flash memory is 32 KB
j) SRAM is 2 KB
k) EEPROM is 1 KB
l) CLK speed is 16 MHz
m) Weight is 7 g
n) The printed circuit board is 18 x 45mm in size and supports three types of communications: SPI, IIC, and USART.

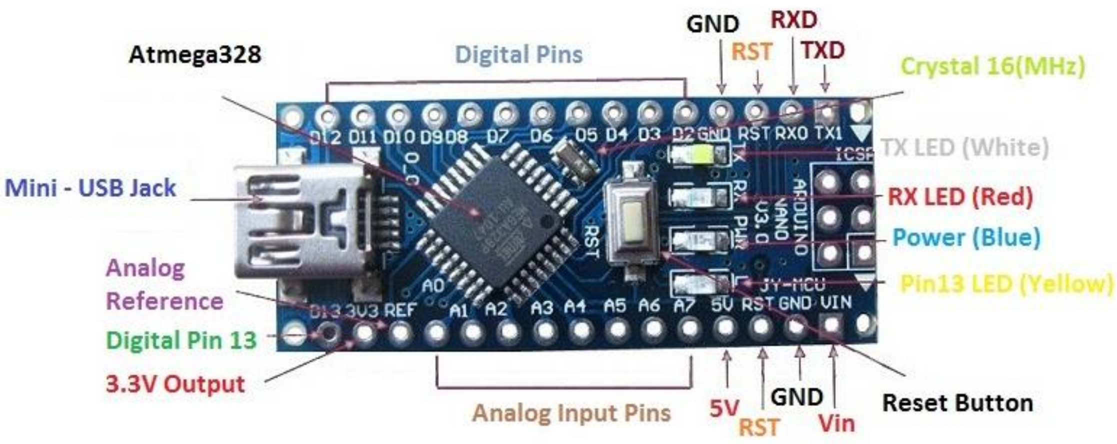

Figure 2.1: Arduino Nano Board Details

2.2 VL53L0X LIDAR Sensor

- **Fully integrated miniature module**
  - 940 nm laser VCSEL
  - VCSEL driver
  - Ranging sensor with an advanced embedded microcontroller
  - 4.4 x 2.4 x 1.0 mm

- **Fast, accurate distance ranging**
  - Measures absolute range up to 2 m
  - The reported range is independent of the target reflectance
  - Advanced embedded optical cross-talk compensation to simplify cover glass selection
  - Single reflowable component

Figure 2.2:VL53L0XLIDAR Sensor Board Details

2.3 MG90 Servo Motor

The Towerpro MG90S Micro Digital Servo is a 360° rotation servo. It's a Digital Servo Motor that accepts and processes PWM signals much more quickly and efficiently. Internal circuitry is complex, allowing for good torque, holding power, and rapid updates in response to external pressures.

Features of MG90 Servo motor

a) High resolution
b) Accurate positioning
c) Fast control response
d) Constant torque throughout the servo travel range
e) Excellent holding power

Figure 2.3:MG90 Servo Motor

2.4 Software component

2.4.1 Arduino IDE

The Arduino Integrated Development Environment **(**IDE) is a cross-platform application (for Windows, macOS, and Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino-compatible boards.

Figure 2.4.1: Arduino IDE

3. Experimental setup

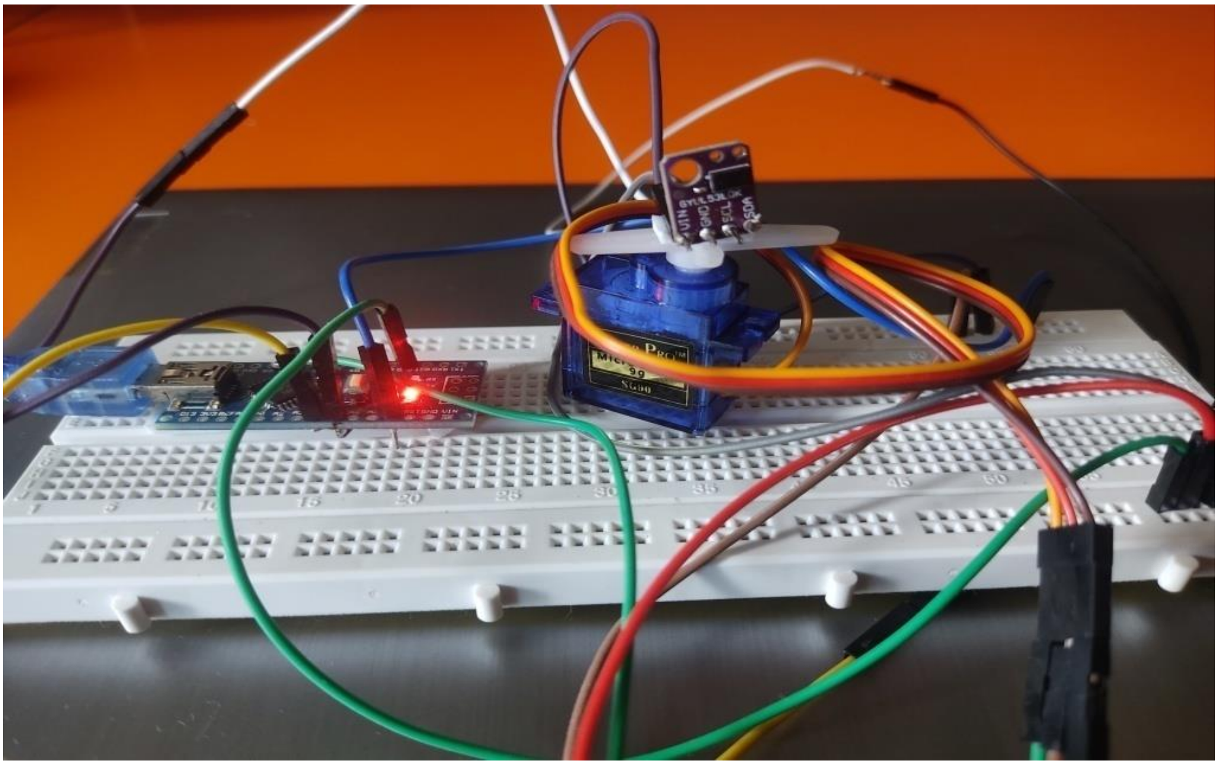

Figure 3: Experimental setup

Figure 3 shows the practical implementation of the overall LIDAR system. The system was able to experimentally detect the objects. The outcome of the practical implementation was analyzed in the following sections.

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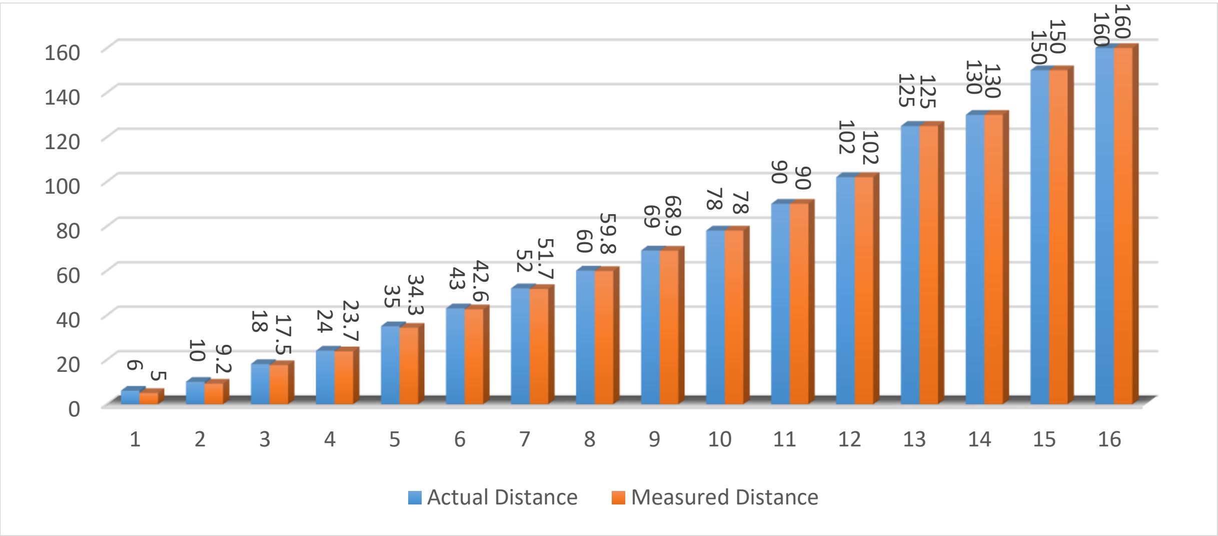
3.1 Results

S.No	Actual distance(cm)	Measured distance(cm)	Efficiency (%)
1	6	5	83.33
2	10	9.2	92.00
3	18	17.5	97.22
4	24	23.7	98.75
5	35	34.3	98.00
6	43	42.6	99.06
7	52	51.7	99.42
8	60	59.8	99.66
9	69	68.9	99.85
10	78	78	100.00
11	90	90	100.00
12	102	102	100.00
13	125	125	100.00
14	130	130	100.00
15	150	150	100.00
16	160	160	100.00



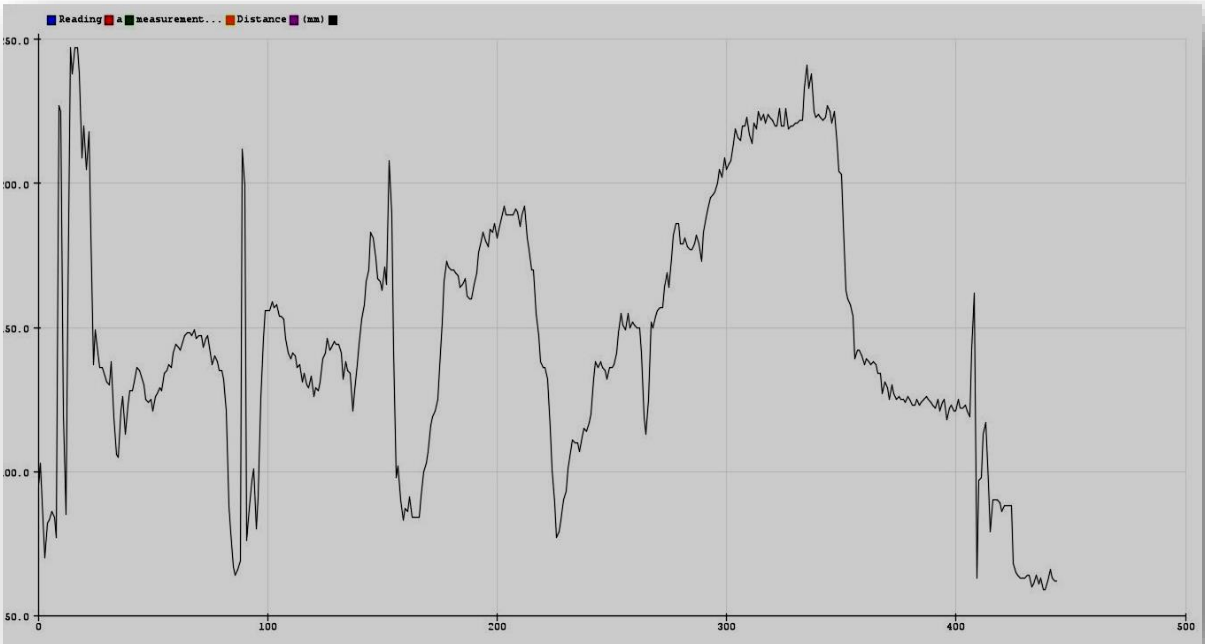


Figure 3.1: Serial plotter output of Arduino IDE

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