Digital imaging of 3D shapes using VL53L0X sensors and MATLAB

Askarov Azizbek Anvarovich
Namangan State Technical University
asqarovazizbek4440@gmail.com

ABSTRACT

This paper proposes a solution for building a 3D scanning system using Arduino and MATLAB. VL53L0X laser distance sensors are mounted on a car steering wheel to generate a 3D point cloud of the surrounding object surfaces. The system operates in real time and visualizes the data through a MATLAB interface. This method enables accurate, stable, and straightforward digitization of shapes using simple components. The proposed solution is low-cost, reprogrammable, and applicable in various fields, including robotics, automotive engineering, and manufacturing technologies.

Keywords: 3D scanning, Arduino, MATLAB, VL53L0X, laser sensor, point cloud, car steering wheel.

Introduction

In recent years, with the advancement of technology, the need to represent the shape and dimensions of objects in digital format has been steadily increasing. In particular, 3D scanning technologies are gaining significant importance in industries such as manufacturing, healthcare, architecture, and robotics. Most commercial 3D scanners are expensive, making them difficult to acquire for small laboratories or educational institutions. Therefore, developing affordable and effective methods for 3D scanning remains a relevant challenge.

This paper discusses a system based on VL53L0X sensors that enables the detection of 3D shapes. These sensors are compact, energy-efficient, and highly accurate, and they can be easily integrated with the Arduino platform. MATLAB is used to visually analyze the scanning results.

System Architecture. The overall architecture of the system is built around VL53L0X sensors, with each sensor mounted in a square arrangement on the end effector of a manipulator. This configuration allows for more comprehensive coverage of the surrounding surfaces around the car steering wheel. The distance data collected by the sensors is transmitted to an Arduino Mega microcontroller. The microcontroller processes each measurement and sends the results to the MATLAB interface.

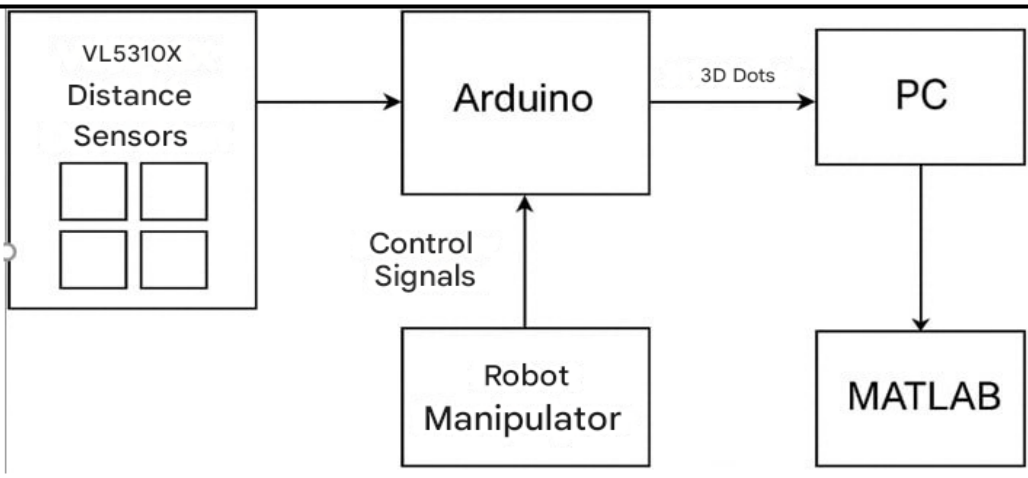

Figure 1. General block diagram of the system.

Software. Communication with the VL53L0X sensors on the Arduino platform is established using the I2C protocol. Each sensor has its own I2C address, and distance measurements are obtained sequentially from each sensor. The collected data is transmitted from the Arduino to the MATLAB application via the UART (Serial) interface.

The MATLAB application converts this data into (x, y, z) coordinates and visualizes it as a 3D graphic representation.

Table 1. Arduino and MATLAB components

Component	Description
Arduino Mega	Microcontroller for controlling the sensors
VL53L0X	Laser-based Time-of-Flight (ToF) distance sensor
MATLAB	Software platform for visualization and analysis
Serial communication	Data exchange between Arduino and MATLAB

Data acquired from the Sensors. Based on the distance data obtained from the VL53L0X sensors, a 3D point cloud was generated in the MATLAB environment. Since the sensors were mounted in a square configuration, the collected points accurately represent the shape surrounding the steering wheel. Each point has its own (x, y, z) coordinates and is displayed in real time through MATLAB.

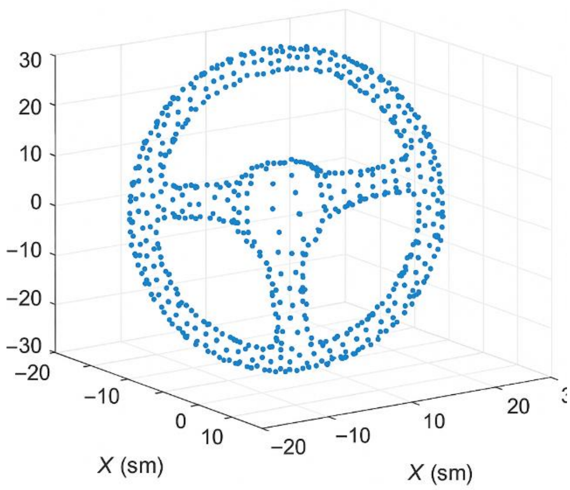

Figure 2. 3D Point cloud generated in MATLAB (Steering wheel model)

MATLAB interface results. Using the MATLAB code provided below, real-time scanning results are visualized as a 3D plot. With each update, new points are added to the plot, gradually forming the shape of the steering wheel.

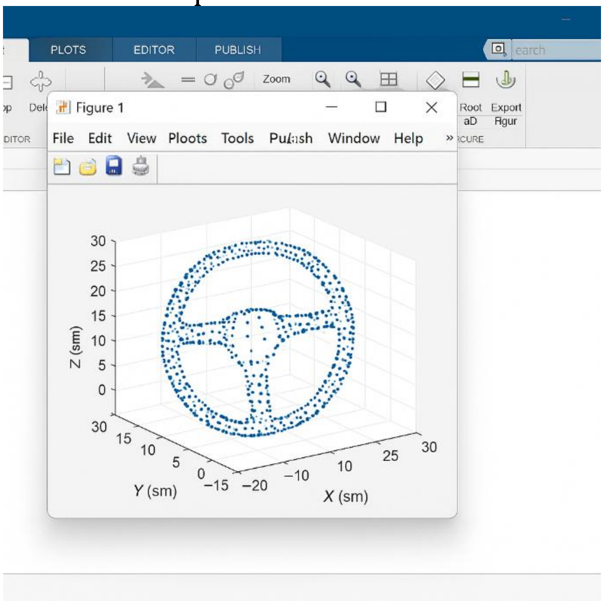

Figure 3. Real-time 3D plot in the MATLAB interface

```
scatter3(X, Y, Z, 40, 'filled');
axis([-50 50 -50 50 0 100]);
xlabel('X (cm)'); ylabel('Y (cm)'); zlabel('Z (cm)');
grid on;
```

Table 2. Sample 3D coordinates

X (cm)	Y (cm)	Z (cm)
-10	-10	45
-10	10	47
10	10	46
10	-10	44

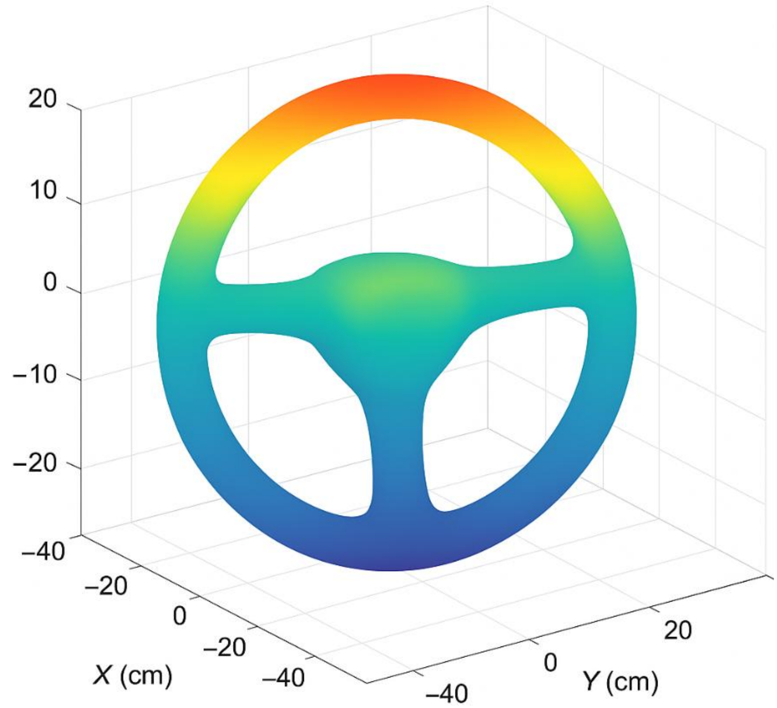

Figure 4. Surface representation of the steering wheel shape based on 3D coordinates (Interpolated model)

Discussion. During the study, the advantages of VL53L0X sensors over conventional ultrasonic sensors became clearly evident. Their laser-based measurement mechanism is less susceptible to light interference, can accurately detect small objects, and, due to their compact size, can be easily integrated into moving robotic manipulators.

Additionally, this system can be applied in automated inspection, digital modeling, and surface detection processes for robotic manipulators.

However, one potential drawback of the system is the possibility of sensor-to-sensor interference. To mitigate this issue, it is necessary to implement sequential activation algorithms for each sensor.

Conclusion

This paper presented an effective and low-cost solution for generating a 3D model of a car steering wheel using VL53L0X laser sensors. The system, built on the ArduinoMega platform, was integrated with the MATLAB software environment to provide real-time visualization.

The simplicity of the system, the accuracy of the sensors, and the flexibility of software integration make it suitable for applications in education, scientific research, and industry. Future work will focus on improving system accuracy, increasing the number of sensors, and implementing automatic shape reconstruction algorithms.

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