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Objective

The purpose of this project is to design and develop a LiDAR-like optical sensing system using a **VL53 distance sensor** combined with a **reflective mirror**. The goal is to achieve **360-degree omnidirectional object detection** with a measurement range of up to **10 cm**. The system is intended for **close-range sensing applications**, with no strict precision requirements.

Introduction

This project explores the working principles of **LiDAR technology** and applies the optical engineering concept that **the angle of incidence equals the angle of reflection** to design a LiDAR-like system with a simplified mechanical structure. The system utilizes a **VL53 distance sensor** and strategically placed **reflective mirrors** to achieve **360-degree omnidirectional object detection** within a **10 cm range**.

The main challenge of this project is to ensure that the reflected laser paths are properly controlled to cover a full path from VL53 through mirror to the detected object. By leveraging **optical principles and practical engineering techniques**, this project aims to create a functional yet simplified LiDAR system that serves as a stepping stone for deeper learning in **LiDAR technology**.

Analysis

In traditional rotational LiDAR systems, both the emitter and receiver modules rotate together, making the mechanical and electrical design **complex and expensive**. The system requires **slip rings** to ensure stable electrical transmission while continuously rotating, which significantly increases the cost. To address this issue, this project adopts a **rotating mirror scanning mechanism** where only the mirror rotates, keeping the electronic components stationary. This method reduces mechanical complexity and overall cost, making it a more accessible alternative for LiDAR applications.

The selection of the **VL53 distance sensor** is purely based on **cost-effectiveness**. The primary goal of this project is to **validate the feasibility of using a rotating mirror for LiDAR-like scanning**, rather than achieving high-precision sensing results.

During the design process, several challenges were encountered:

1. **Limited budget constraints** prevent the use of a **DC motor with encoder feedback**. Instead, a **servo motor** is used to perform discrete step scanning.
2. **Software limitations** make it difficult to visualize the scanned data effectively.
3. **Degradation in VL53 measurement accuracy and range** is observed after reflection from the mirror. This is suspected to be caused by the **low surface quality of the mirror**, affecting the laser reflection.

Prototype Description

The prototype consists of four key components: **a servo motor, a reflective mirror, a VL53 distance sensor, and an ESP32 microcontroller**. The **servo motor** is responsible for rotating the reflective mirror, which is mounted on a **3D-printed gear mechanism** to ensure controlled movement.

The **ESP32 microcontroller** controls the servo motor, instructing it to rotate to a specific angle. At each predefined angle, the ESP32 reads the **VL53 distance sensor** data and records the measured value. This process continues as the servo motor sweeps back and forth, enabling **a 360-degree scanning capability**.

The main challenges in the prototype include ensuring **accurate mirror**

alignment for consistent reflection and addressing the **degradation in VL53 accuracy** due to mirror imperfections. Software improvements are also needed to provide **a better visualization** of the scanned data.

Conclusion

The current prototype successfully achieves **rotation and distance measurement**, demonstrating the feasibility of using a rotating mirror for LiDAR-like scanning. However, a significant issue was observed—**the VL53 sensor's accuracy and range are greatly reduced** after reflecting off the mirror.

Throughout this project, valuable insights were gained in **the fundamental principles of LiDAR, basic programming, and the mechanical design of a reflective scanning system**. The implementation highlights both the advantages and limitations of using low-cost components for LiDAR applications.

For future improvements, given more **time and budget**, replacing the servo motor with a **DC motor equipped with an encoder** would allow for more precise and continuous rotation, enhancing the scanning resolution and overall system performance.