Overview of 2D LiDAR System | TEAM UTKARSH

Introduction: LiDAR (Light Detection and Ranging) technology is a key enabler for precise mapping, navigation, and environmental awareness. This report presents a cost-effective solution to design a 2D LiDAR system, fulfilling the requirements outlined in the Build-A-Bot 2.0 competition. The design incorporates accuracy, simplicity, and innovation, ensuring accessibility to researchers, hobbyists, and educators.

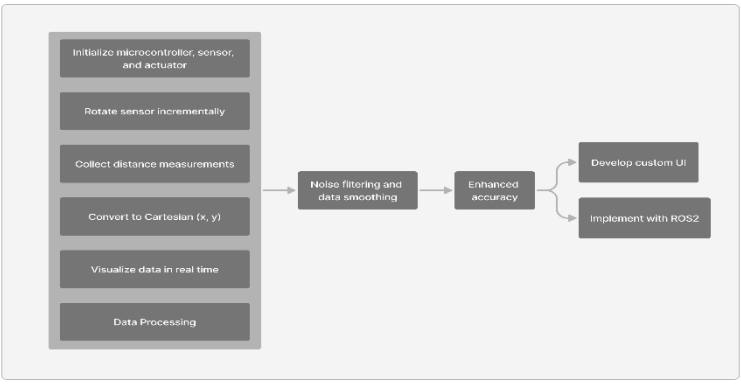
Solution Overview: The proposed 2D LiDAR system features:

- **Accurate Detection and Mapping:** Real-time acquisition of 2D data for surroundings.
- **Interactive User Interface:** Visualization via a lightweight UI or ROS2 with Rviz2.
- **Innovative Design:** A compact and robust structure optimized for portability and reliability.

The 2D LiDAR bot integrates key components for optimal performance:

1. **Hardware Components:**
    - **Microcontroller:** ESP32 for its processing power, wireless connectivity, and low cost.
    - **Sensor:** Time-of-Flight (ToF) sensor for precise distance measurement.
    - **Actuator:** Servo motor for smooth and controlled rotation of the sensor.
    - **Power Supply:** USB breakout board (5V supply).
    - **Chassis:** Lightweight Styrofoam for cost-effective and portable design.
2. **Software Integration:**
    - **Algorithm Design:** Efficient data collection, processing, and visualization.
    - **ROS2 Compatibility:** Seamless data streaming and visualization using Rviz2.
    - **Interactive UI:** Real-time data plotting with options for CSV export.

Design Details:



1. **Mechanical Design:**
    - **Chassis:** A circular Styrofoam base holds the microcontroller, actuator, and sensor securely. The base design ensures minimal vibration during operation.
    - **Actuator Mount:** A stable mount for the servo motor ensures precise rotation and alignment of the sensor.
2. **Electrical Design:**
    - **Circuit Schematic:**
        - ESP32 connected to the ToF sensor via I2C.
        - Servo motor interfaced with ESP32's PWM pins.
        - Power supplied through a 5V USB breakout board.
    - **Wiring:** Short and well-organized wiring minimizes noise and ensures reliability.
3. **Software Design:**
    - **Algorithm Workflow:**
        - **Step 1:** Initialize microcontroller, sensor, and actuator.
        - **Step 2:** Rotate the sensor incrementally across the scanning range.
        - **Step 3:** Collect distance measurements at each angle.
        - **Step 4:** Convert polar coordinates to Cartesian (x, y).
        - **Step 5:** Visualize data in real time via ROS2 or a custom UI.
    - **Data Processing:** Noise filtering and data smoothing for enhanced accuracy.

Challenges and Solutions: Optimization

1. **Challenge:** Sensor alignment affecting accuracy.
    - **Solution:** Precise calibration using a reference object.
2. **Challenge:** Noise in distance measurements.
    - **Solution:** Apply median filtering and outlier removal.