Project Sunflower: Dual-Axis Solar Tracking System

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1. Introduction

Solar energy is one of the most abundant and sustainable sources of energy available. The efficiency of solar panels can be significantly improved by ensuring they are always oriented towards the sun. Project Sunflower is a dual-axis solar tracking system designed to maximize solar panel efficiency by automatically aligning the panels with the sun's position throughout the day.

2. Objectives

The primary objectives of Project Sunflower are:

- To build a cost-effective solar tracking system using readily available components.
- To maximize the energy generation of solar panels by maintaining optimal orientation to sunlight.
- To develop a modular and easily replicable system suitable for small-scale solar setups.

3. System Components

3.1 Hardware

- **Arduino Uno**: Used as the main controller to process LDR data and control servo motors.
- **Light Dependent Resistors (LDRs)**: 5 LDRs are used to detect the intensity and direction of sunlight.
- **Servo Motors (MG996R)**: Two high-torque servo motors are used for dual-axis movement (horizontal and vertical).
- **3D-Printed Parts**: Custom-designed petals to hold solar panels and the LDR base.
- **PVC Board Frame**: Sturdy and lightweight structure to support the tracking system.
- **Power Supply**: An old mobile phone charger repurposed for powering the Arduino and servos.

3.2 Software

- **Arduino IDE**: Used for writing, compiling, and uploading the control code.
- **Servo Library**: To manage servo movements smoothly.

4. Working Principle

4.1 Light Detection

The system uses five LDRs strategically positioned to detect the direction of the brightest light. These are arranged as follows:

- **Center LDR (M)**: Measures direct light intensity.
- **Left LDR (L)**, **Right LDR (R)**, **Up LDR (U)**, **Down LDR (D)**: Measure relative light intensity in respective directions.

4.2 Movement Mechanism

- The difference between the central LDR and directional LDRs is calculated to determine the movement direction.
- The servo motors adjust their angles to orient the solar panel towards the brightest light source.

4.3 Code Logic

- Continuously read the values from all five LDRs.
- Compare the central LDR with each directional LDR.
- Adjust servo position incrementally to minimize the light difference.
- Introduce a small delay for smooth and controlled movements.

5. Mechanical Design

The entire frame is designed using PVC boards, offering both durability and lightweight properties. The petal structures, which can hold solar panels, are designed using 3D printing, allowing for precise and modular construction.

6. Implementation

6.1 Assembly

- Attach the servo motors to the PVC frame.
- Fix the 3D-printed petals onto the motor shafts.
- Position the LDRs on the central hub for accurate light detection.
- Connect the Arduino to the servo motors and LDRs as per the circuit diagram.

6.2 Code Upload

- Connect Arduino to the PC.
- Open the code file in Arduino IDE.
- Compile and upload the code.

7. Results

The system was tested under various lighting conditions. The solar panel consistently aligned itself with the brightest light source. Videos and images showcasing the working prototype are provided in the Media section.

8. Challenges Faced

- ❿ Servo motor jitter due to abrupt light changes.
- ❿ Stabilizing the panel during strong winds.
- ❿ Fine-tuning the light difference threshold for precise tracking.

9. Future Enhancements

- ❿ Integrate solar panel efficiency monitoring.
- ❿ Add a real-time display for tracking performance.
- ❿ Implement data logging for solar efficiency comparison.
- ❿ Upgrade the system to be weather-resistant.

10. Conclusion

Project Sunflower successfully demonstrates a low-cost, efficient solar tracking system. By using 3D-printed parts and commonly available electronic components, it offers a practical solution for enhancing solar panel efficiency in small-scale setups.