3D Rotatable SOLAR TRACKER

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Introduction

Solar energy is a renewable and clean source of power, but its efficiency largely depends on the positioning of the solar panels relative to the sun. A fixed panel setup limits the amount of energy harnessed, as the sun's position changes throughout the day and seasons. This project presents a **3D Rotatable Solar Tracker** that uses **Arduino**, **servo motors**, and **LDRs** (Light Dependent Resistors) to dynamically align a solar panel with the sun's position in both horizontal and vertical axes. The aim is to maximize the amount of sunlight the panel receives, thereby increasing power output efficiently using a cost-effective and DIY-friendly approach.

Components Used

S.No	Component	Quantity	Description
1	Arduino Uno	1	Microcontroller board for controlling system logic
2	SG90 Servo Motors	2	Used to rotate the solar panel in 2 axes (horizontal and vertical)
3	LDR (Light Dependent Resistor)	4	Detects light intensity to determine the sun's position
4	10k Ohm Resistors	4	Used with LDRs to form voltage dividers
5	Mini Solar Panel	1	Converts sunlight into electrical energy
6	Cardboard Wheel/Base	1	Structural support for mounting the solar panel and motors
7	Connecting Wires	As required	For electrical connections between components
8	Breadboard/PCB	1	For assembling the circuit (optional)

Methodology

The solar tracker operates based on the principle of comparing light intensities from different directions using LDRs. Here's how the system works:

1. **Sensor Arrangement**: Four LDRs are placed in a cross pattern on the solar panel. Each LDR faces a slightly different direction (North, South, East, West).
2. **Voltage Divider Circuit**: Each LDR is paired with a 10k ohm resistor to create a voltage divider. The voltage values are read by the analog pins of the Arduino.
3. **Arduino Processing**: The Arduino collects the analog input from each LDR and calculates the intensity of light from each direction.
4. **Servo Control**: Based on the comparison:

- If more light is detected from the East than the West, the horizontal servo moves the panel eastward.
- Similarly, vertical movement is adjusted depending on the light detected from the North and South-facing LDRs.
- This enables two-axis (3D) movement to track the sun's position accurately throughout the day.

5. **Mechanical Support**: A cardboard wheel or structure is used to mount the motors and panel securely, allowing smooth rotation.

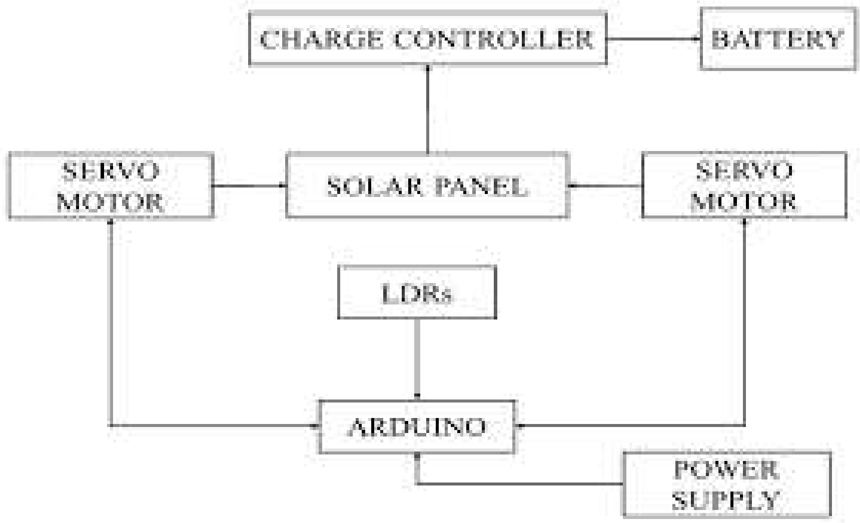
Arduino Code:

```
final code :#include <Servo.h>

Servo horizontal; // Horizontal Servo Motor
int servohori = 90;
int servohoriLimitHigh = 175;
int servohoriLimitLow = 5;

Servo vertical; // Vertical Servo Motor
int servovert = 45;
int servovertLimitHigh = 100;
int servovertLimitLow = 1;

// LDR pin connections
int ldrlt = A0; // Top Left LDR
int ldrrt = A3; // Top Right LDR
int ldrld = A1; // Bottom Left LDR
int ldrrd = A2; // Bottom Right LDR

void setup() {
  horizontal.attach(2);
  vertical.attach(13);
  horizontal.write(servohori);
  vertical.write(servovert);
  delay(2500);
}

void loop() {
  int lt = analogRead(ldrlt); // Top left
  int rt = analogRead(ldrrt); // Top right
  int ld = analogRead(ldrld); // Bottom left
  int rd = analogRead(ldrrd); // Bottom right

  int dtime = 10;
```

```
  int tol = 50; // Reduced tolerance for finer movement

  int avt = (lt + rt) / 2; // Average value of top sensors
  int avd = (ld + rd) / 2; // Average value of bottom sensors
  int avl = (lt + ld) / 2; // Average value of left sensors
  int avr = (rt + rd) / 2; // Average value of right sensors

  int dvert = avt - avd; // Difference between top and bottom
  int dhoriz = avl - avr; // Difference between left and right

  if (abs(dvert) > tol) {
    if (avt < avd) { // Move towards more light
      servovert = ++servovert;
      if (servovert > servovertLimitHigh) servovert = servovertLimitHigh;
    } else {
      servovert = --servovert;
      if (servovert < servovertLimitLow) servovert = servovertLimitLow;
    }
    vertical.write(servovert);
  }

  if (abs(dhoriz) > tol) {
    if (avl < avr) { // Move towards more light
      servohori = ++servohori;
      if (servohori > servohoriLimitHigh) servohori = servohoriLimitHigh;
    } else {
      servohori = --servohori;
      if (servohori < servohoriLimitLow) servohori = servohoriLimitLow;
    }
    horizontal.write(servohori);
  }

  delay(dtime);
}
```

Block Diagram

The following diagram illustrates the workflow of the system, from data acquisition to real-time visualization and analysis:



Conclusion & Results

The implementation of a 3D rotatable solar tracker significantly improves the efficiency of solar energy capture. During testing, it was observed that the panel remained aligned with the brightest source of light, simulating the sun's position accurately. Compared to a fixed panel, this setup demonstrated higher exposure to light throughout the day, indicating potential for improved power generation. The system is cost-effective, simple, and ideal for educational or small-scale applications.

Future Work

- **Use of Stepper Motors**: For more precise movement and positioning of the panel.
- **Integration with Battery Charging Circuit**: To store energy collected for later use.
- **Weatherproof Design**: Building a more durable and weather-resistant tracker for outdoor use.
- **Real-time Data Monitoring**: Adding sensors and IoT modules to log light intensity and panel position.
- **Machine Learning Optimization**: Implementing algorithms to predict sun position and optimize tracking based on historical data.