J. Ruben Garcia Villalobos

Nuevo Foundation Workshop

Sun follower project

Difficulty: Intermediate - Advanced

Pre-requisites: Arduino Light Game, basic electronics understanding

Contents

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Introduction

A sun follower, or solar tracker, is a device that moves solar panels to follow the sun throughout the day. This helps the panels get more sunlight and produce more energy compared to panels that stay in one place. It's like how a sunflower turns to face the sun!

William Kamkwamba, a young innovator from Malawi, built wind turbines and solar trackers from scrap materials to generate electricity and improve life in his village. Inspired by his story, the Nuevo Foundation designed this workshop to teach students about using programming on renewable energy.

Materials needed

Hardware

4 Light Dependent Resistors (LDR)

4 Resistors 10kΩ

2 Servo Motors 180° (SG90, MG996R, or any 180° servo)

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Arduino Nano Board (or any other Arduino board)

Breadboard and Jumper Wires

Power Supply (will use USB-C in this project, check Voltage requirements)

Base and Frame for Mounting Components (cardboard)

Silicone glue gun

Solar cells (optional)

Software

Arduino IDE

Setting up the PC

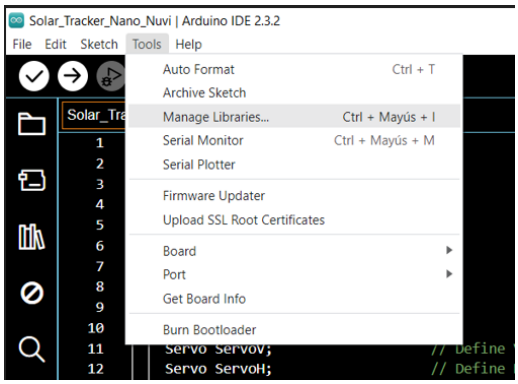
To set up the PC and the Arduino IDE software, please refer to the “Arduino Light Game” workshop and follow the steps to configure the components and board.

In this case, we are going to be using an Arduino Nano (any other Arduino board can be used). Make sure to select the correct board on the Arduino IDE software.

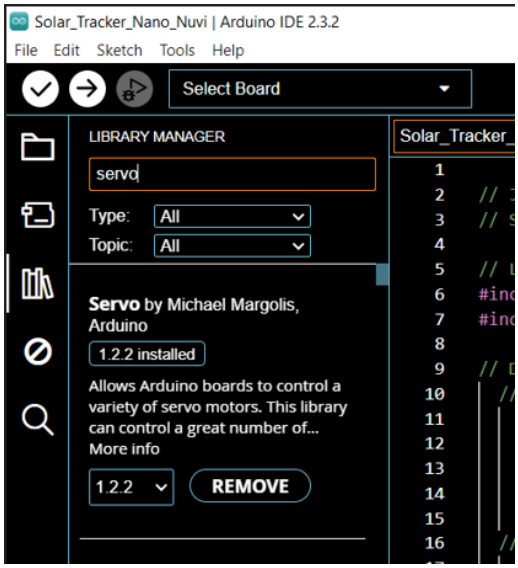
Try setting up something simple like some LED to turn on and off to test the board is configured correctly.

Additionally to setting up the board, we will need to install a library (“Servo”) to be able to move the servo motors following the next steps:

1. Select the Tools menu, and go to Manage Libraries…

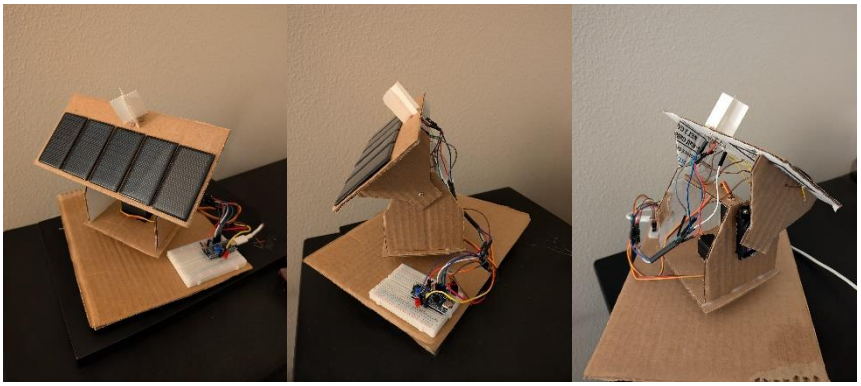


2. Search for the Servo Library, and select the one for Arduino. Make sure to install the latest version.

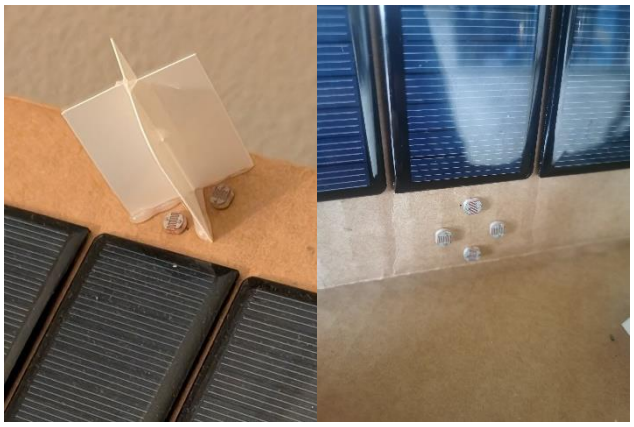


Good job setting everything up, now lets get to the project!

Building the project



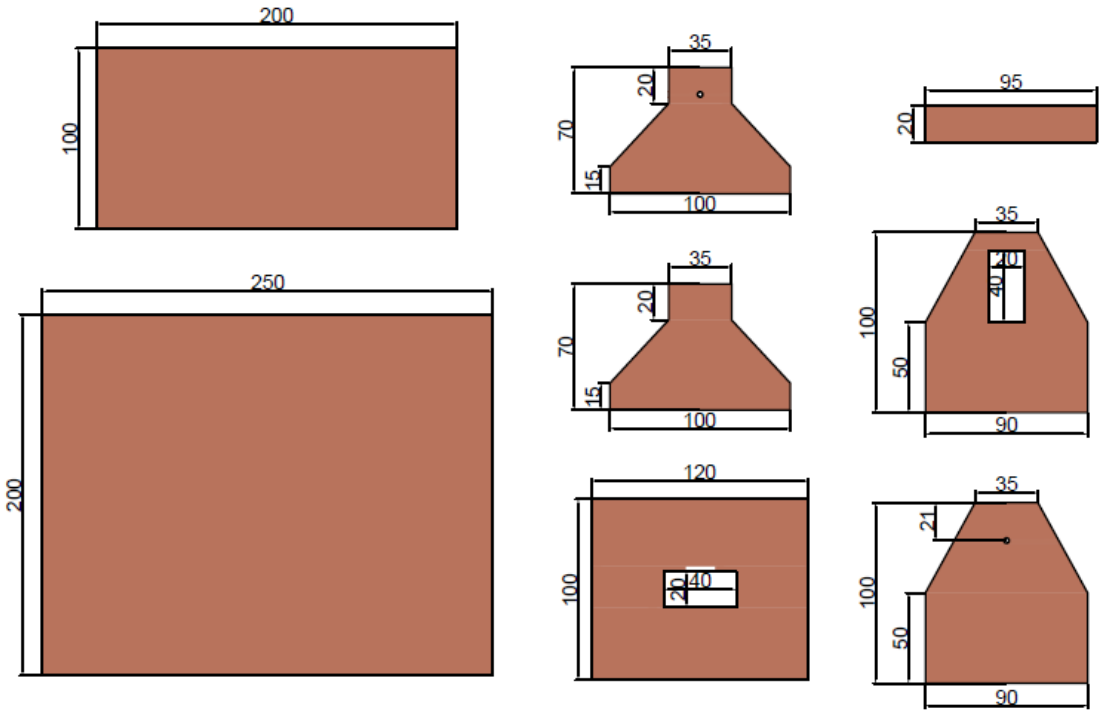
First, we need to understand the basic behavior of our project. We are going to use 4 LDRs positioned in an array to compare the incident light from a source. As we can see in the images, the screen we are using will shade the LDRs depending on its position, changing its resistance. Those changes in resistance will give us the opportunity to program the movement of our servo motors.



Building and assembling the cardboard structure

To mount the hardware, we will need to build a structure that is able to hold the servo motors and at the same time move our LDR array (or the solar panels) to the source of light.

In this project, we used the following cardboard parts to assemble the structure:



We must mention that you can be creative with the design of the structure and that the measurements are made to house 2 MG996R servo motors. You can change the size of the holes made to hold the servos to your requirements.

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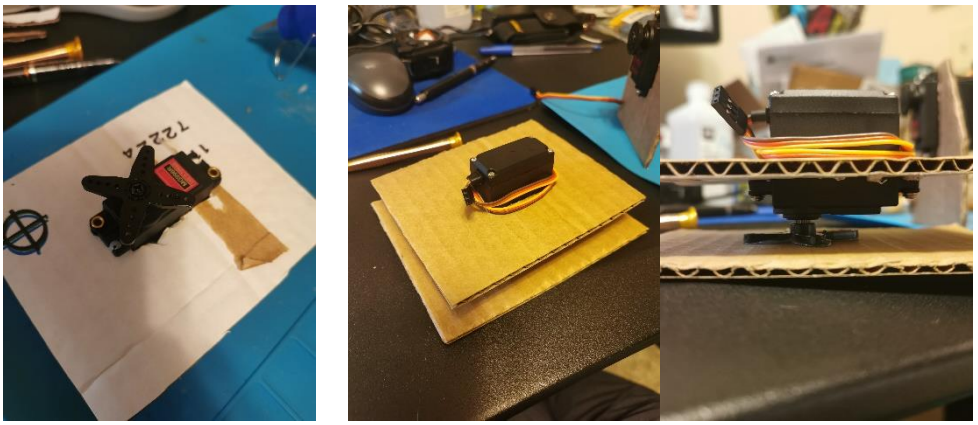
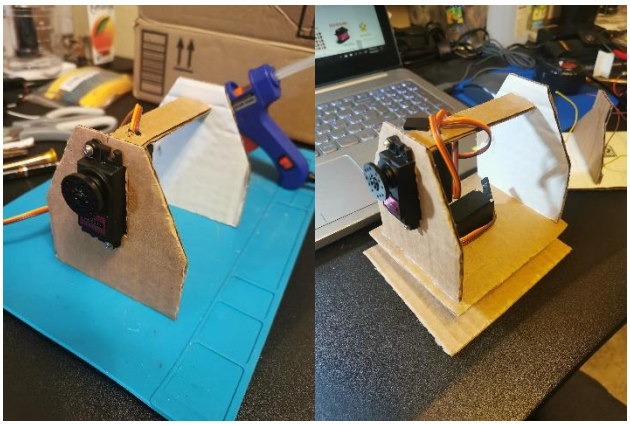
We will start by positioning our first servo motor in the perforated cardboard. We can use the little screws that come with the set or hot glue to hold it in place. Once in place we will add hot glue to the cross like adaptor to hold it to the main base where all the structure will rest.



Next step is to put the other servo motor in the other perforated cardboard, that will serve as our second axis. Once there, we can use some hot glue to stick the long thin cardboard to hold together the two vertical supports of our structure. Once the hot glue dries, we can get it glued over the first cardboard. Almost there!



Last but not least, and a bit tricky to get done as everything else is already assembled, we need to glue our last pieces to the cardboard that will serve as support for the LDR array and the solar panels (optional). I strongly recommend to add the LDRs to the cardboard BEFORE mounting the last parts of cardboard to the main structure, just as in the last couple of images. Preferably use a thin and strong plastic or cardboard to build the screen like LDR divider.

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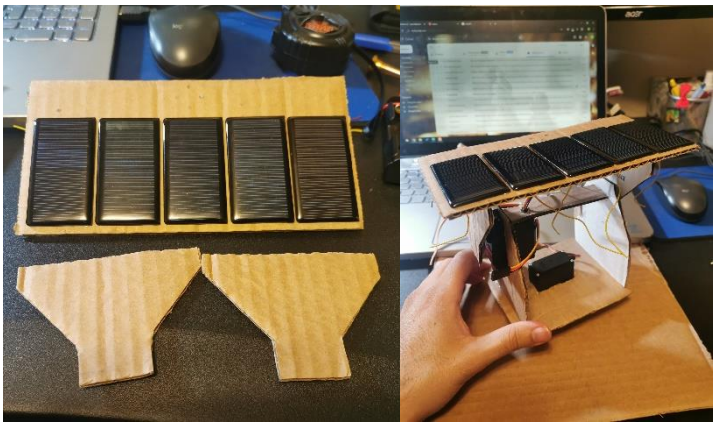
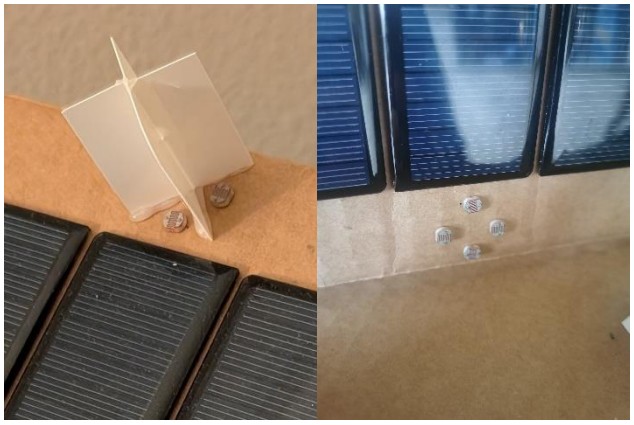




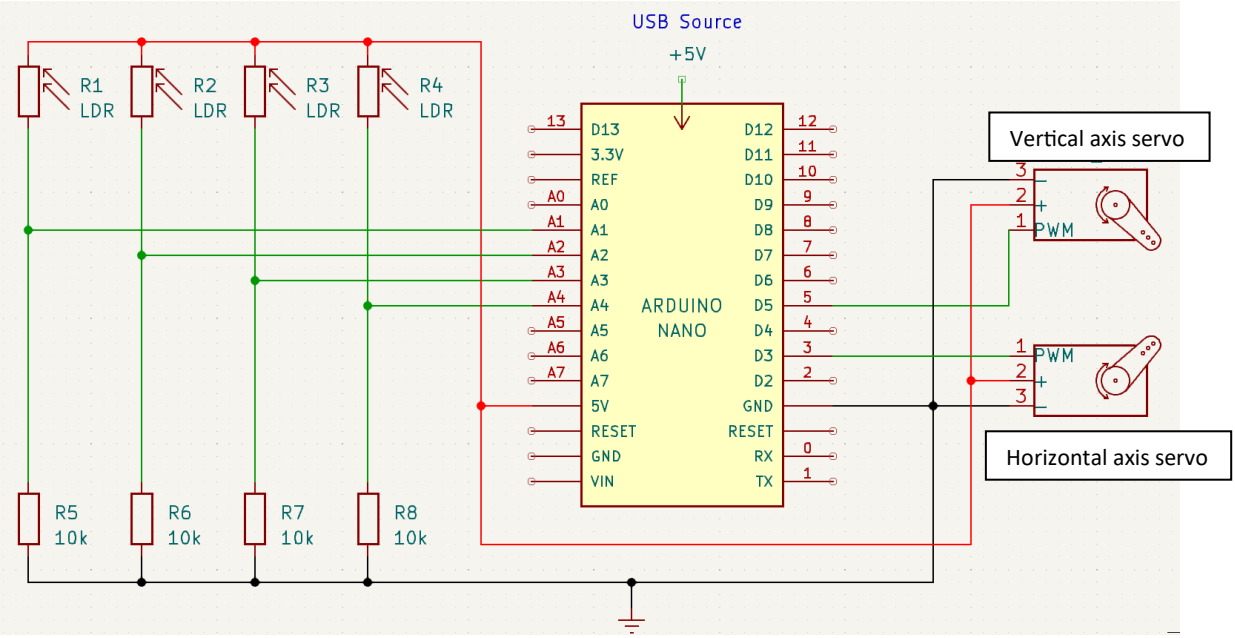
And the structural part is complete! Now we just need to make the respective connections and programming to get the project working!

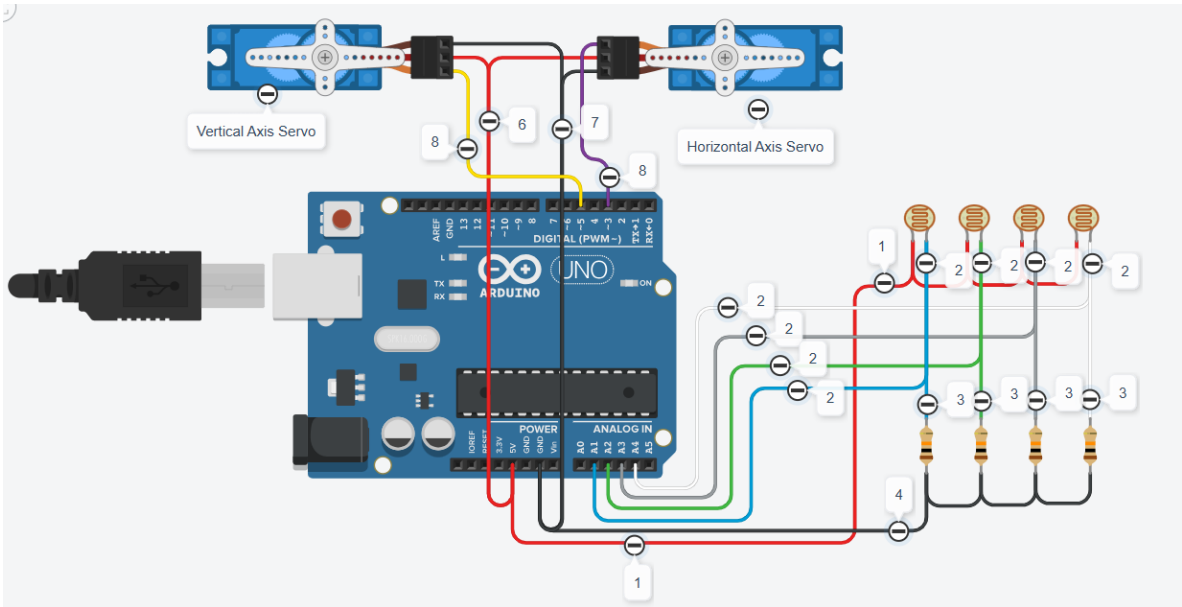
Connecting the project parts

Next we will be doing the appropriate connections between the Arduino board and the other elements.

The following steps will explain how to properly make the connections and later on a section to understand how the project technically works. If most of this doesn´t make sense, just try to connect correctly each of the cables and ports following the next diagram and the instructions.

The second diagram is a more physical diagram which shows the step explaining the specific connection. In this diagram we are using an Arduino Uno to show the flexibility of boards.





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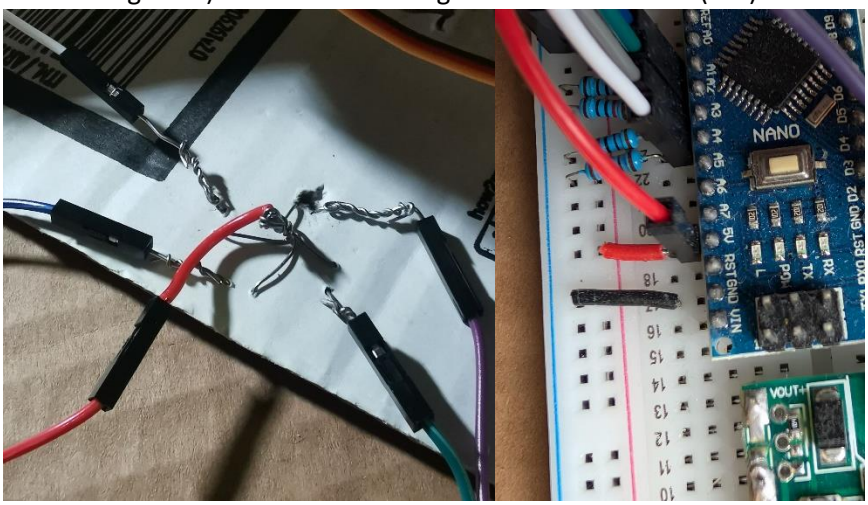
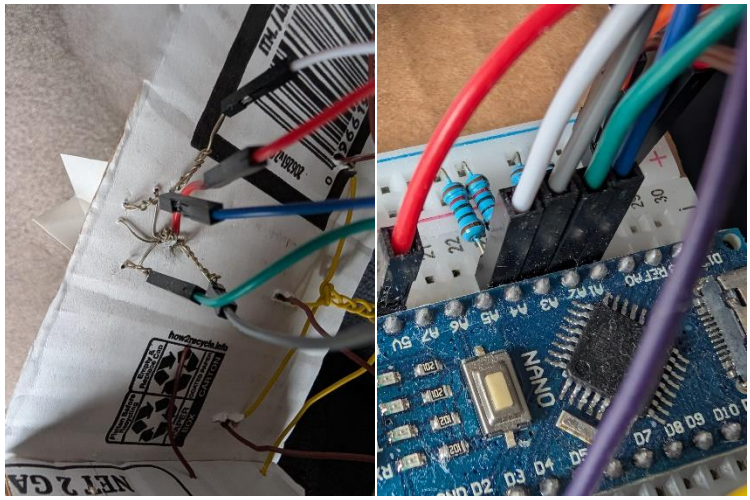
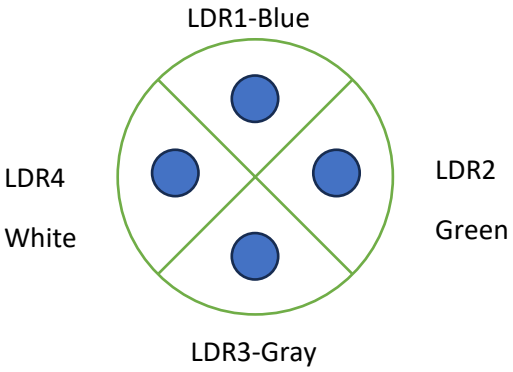
Step by step connections

1. We start by connecting one of the terminals of our LDRs to our source of voltage in the board (5V port). To make things easier, what I did was to connect the terminals between them (wire them together) and then use a single wire to feed them (red).

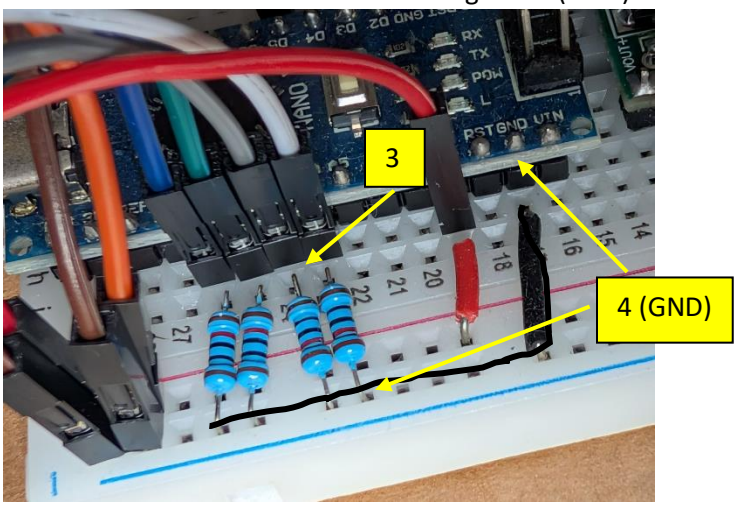


2. We continue by connecting the free LDRs terminals individually to an individual port in the Arduino (A1-A4). Using a different color for each of the LDRs terminals make the connections easier to track! (A1-Blue, A2-Green, A3-Gray, A4-White).

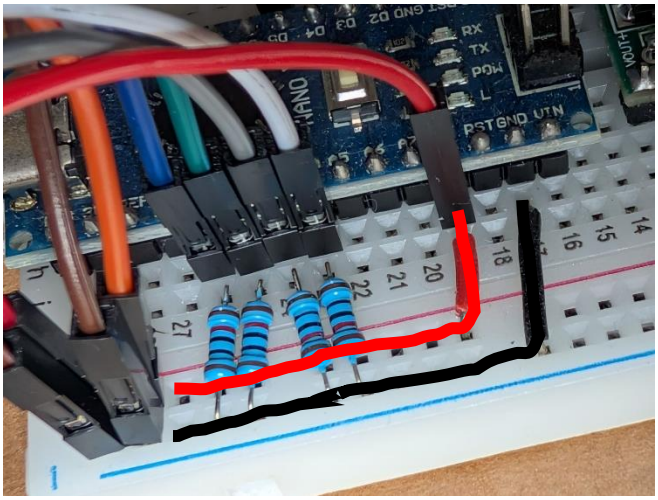


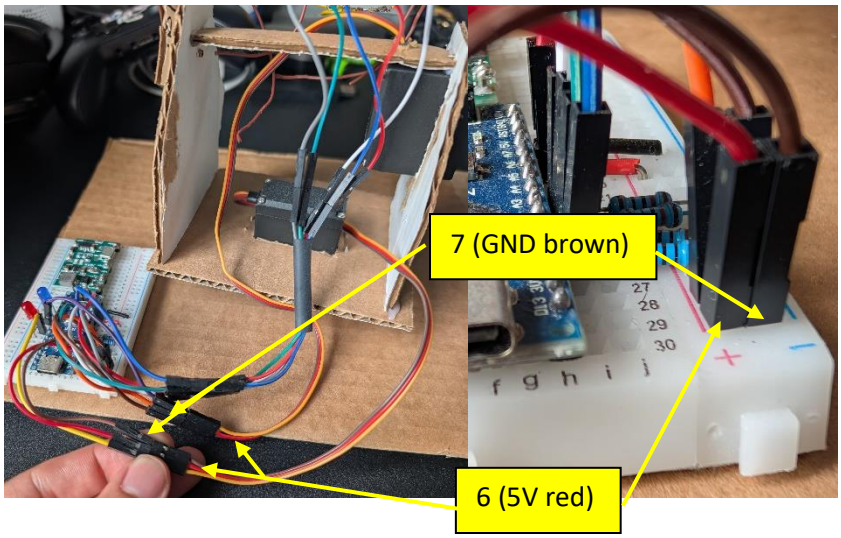


3. We continue by connecting one terminal of our resistors to each of the four LDR-Arduino connections.
4. The other resistor's terminal will connect to the Arduino ground (GND) terminal.

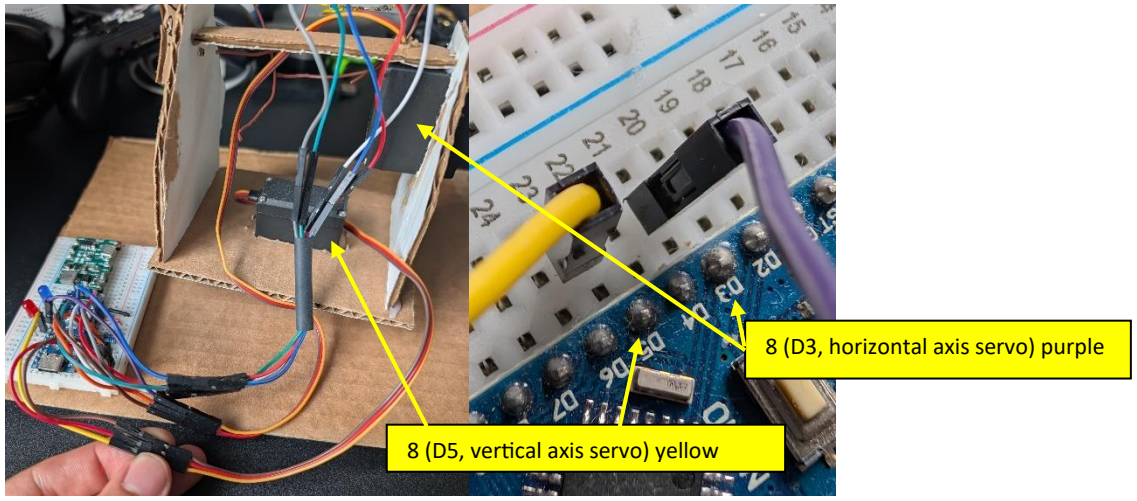


5. Now that our LDRs are properly connected and powered, we proceed to connect our Servo motors.
6. We start by powering our servos, connecting their power terminal (red cable) to our 5V port in the Arduino (picture after 7).
7. Continue by connecting the black (or brown) wires (GND) of the servos to our GND port in the Arduino. In this case I'm using little wires as conductors to be able to feed the 5V and GND respectively through the breadboard.



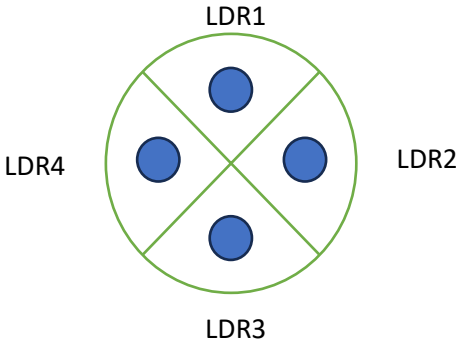


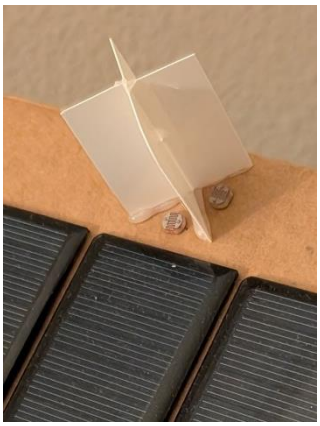
8. Once our servo's power and ground are connected, connect our servo's signal wire (generally yellow or orange) to their digital ports in the Arduino. This will control the movement of the servos.
   The vertical axis servo (the one glued to the base) will be connected to D5 (yellow wire).
   The horizontal axis servo (sitting vertically in the structure) will connect to D3 terminal (purple wire).



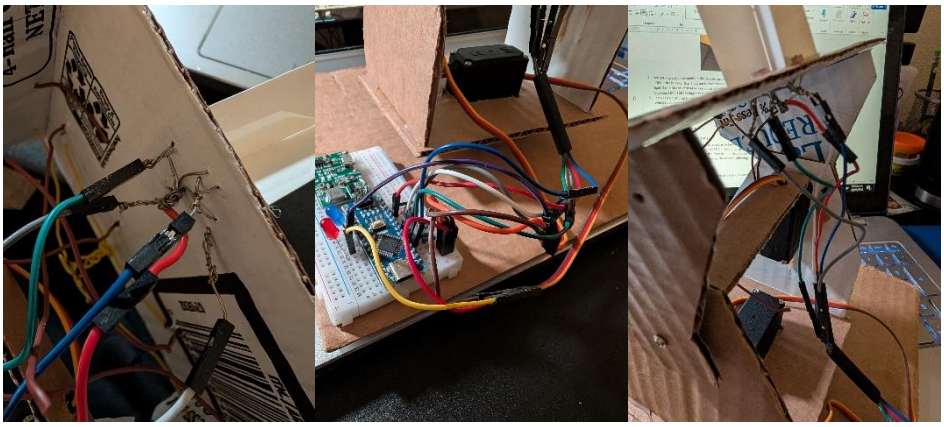
Understanding how the project works

1. First of all we get our controller powered by a source (normally a USB source, aka computer), which then will have the power to energize all the other components.
2. We then proceed to power the LDRs and measure the voltage drop across each LDR and its corresponding 10k resistor. The voltage drop will vary depending on the amount of light each LDR receives, as their resistance changes in response to the incident light.
3. Now we compare the values received on each of the measured inputs (A1-A4), and we can give instructions to the servo motors after comparing these values.





4. We set a specific threshold (in this specific project 100) and when the difference between LDR1-LDR3 is bigger than that, our horizontal axis servo will move, directing our array to the light. Same for the vertical axis servo, which will be instructed to move when the difference between LDR2-LDR4 is bigger than the threshold.
5. It takes a bit of time to get all the connections properly done, just make sure you identify which cable goes where, as it is easy to loose track of each of the connectors.



Programming our Sun Follower

For the final step of our project, we will proceed to program our model. We can proceed to copy and paste the following code and our project will be complete!

```
// J. Ruben Garcia Villalobos
// Solar Tracker Project

// Libraries required
#include <Servo.h>
#include <math.h>

// Define variables and objects
// Servo related variables
Servo ServoH;         // Define Horizontal axis servo (180°)
Servo ServoV;         // Define Vertical axis servo (180°)
int servoAngleH = 0;  // Angle of Horizontal axis Servo
int servoAngleV = 0;  // Angle of Vertical axis Servo

// Declaring LDR related variables
int LDR1 = 0;
int LDR1pin = 1;  // Light Dependent Resistor 1 and Pin
int LDR2 = 0;
int LDR2pin = 2;  // Light Dependent Resistor 2 and Pin
int LDR3 = 0;
int LDR3pin = 3;  // Light Dependent Resistor 3 and Pin
int LDR4 = 0;
int LDR4pin = 4;          // Light Dependent Resistor 4 and Pin
int LDRH = 0;             // LDR 2 & 4 comparative
int LDRV = 0;             // LDR 1 & 3 comparative
int LDR_threshold = 100;  // Value difference when start to move
int Mov_Speed = 1;        // Speed at which the servos move (recommended 1)

void setup() {
  //Define Servo pins
  ServoH.attach(3);  // Digital pin 3 on board
  ServoV.attach(5);  // Digital pin 5 on board

  // Define if pins are Inputs or Outputs
  pinMode(LDR1pin, INPUT);
  pinMode(LDR2pin, INPUT);
  pinMode(LDR3pin, INPUT);
  pinMode(LDR4pin, INPUT);

  pinMode(LED_pin, OUTPUT);
  pinMode(LED_H, OUTPUT);
```

```
  pinMode(LED_V, OUTPUT);

  // Define default Servo's Angles
  servoAngleH = 60;
  servoAngleV = 90;
  ServoH.write(servoAngleH);
  ServoV.write(servoAngleV);
}

void loop() {

  // Read values from LDRs  0-4095
  LDR1 = analogRead(LDR1pin);
  LDR2 = analogRead(LDR2pin);
  LDR3 = analogRead(LDR3pin);
  LDR4 = analogRead(LDR4pin);

  // LDR array comparative to define movement in H horizontal and V vertical
axis
  LDRH = abs(LDR1 - LDR3);
  LDRV = abs(LDR2 - LDR4);

  // Checking if comparatives are bigger than threshold
  if (LDRV > LDR_threshold || LDRH > LDR_threshold) {

    // When one or both of the array comparatives is bigger than the
threshold, start the servos movement
    // The LDR with the biggest difference starts to move first
    if (LDRV > LDRH) {
      if (LDR2 > LDR4 & servoAngleH < 90 & servoAngleV < 180) {
        servoAngleV = servoAngleV + Mov_Speed;
        ServoV.write(servoAngleV);
      }
      if (LDR2 < LDR4 & servoAngleH< 90 & servoAngleV > 0) {
        servoAngleV = servoAngleV - Mov_Speed;
        ServoV.write(servoAngleV);
      }
      // When Horizontal axis angle is more than 90, Vertical axis rotation
is inverted
      if (LDR2 > LDR4 & servoAngleH >= 90 & servoAngleV > 0) {
        servoAngleV = servoAngleV - Mov_Speed;
        ServoV.write(servoAngleV);
      }
      if (LDR2 < LDR4 & servoAngleH >= 90 & servoAngleV < 180) {
        servoAngleV = servoAngleV + Mov_Speed;
```

```
        ServoV.write(servoAngleV);
      }
    }
    if (LDRV < LDRH) {
      if (LDR1 > LDR3 & servoAngleH < 180) {
        servoAngleH = servoAngleH + Mov_Speed;
        ServoH.write(servoAngleH);
      }
      if (LDR1< LDR3 & servoAngleH > 0) {
        servoAngleH = servoAngleH - Mov_Speed;
        ServoH.write(servoAngleH);
      }
    }
  }
  delay(30);
}
```

You did it! You built your own light follower. You can test changing values, speed of movement of the servos or even add some LED lights that activate when each of the servo motors are working. Try to expand and improve the project. There is even several ways to put solar cells connected to a battery and make the follower auto sufficient, the possibilities are endless!

Appendix

Understanding the Components

- **Light Dependent Resistors (LDR)**
    - Component that changes its resistance based on the light intensity it detects. In low light or darkness, the LDR's resistance is high, often in the range of megaohms, which limits the flow of electrical current. As the light intensity increases, the LDR's resistance decreases, allowing more current to pass through.
- **Resistors**
    - Resistors work by limiting the flow of electrical current in a circuit.
- **Servo Motors**
    - Servo motors work by receiving a control signal that determines their position. Inside the motor, a small circuit interprets this signal and adjusts the motor's angle accordingly, usually between 0° and 180°.
- **Arduino Nano**
    - Compact, microcontroller board. It is used for building and programming electronic projects.

- **Breadboard**
    - Reusable platforms for building and testing electronic circuits without soldering. They consist of a grid of interconnected holes where you can insert electronic components and wires.
- **Jumper wires**
    - Short, insulated wires with connectors at each end, used to make temporary electrical connections.
- **Power Supply**
    - Device that provides electrical power to a circuit or electronic device.
- **Solar Cells**
    - Devices that convert sunlight directly into electrical energy.