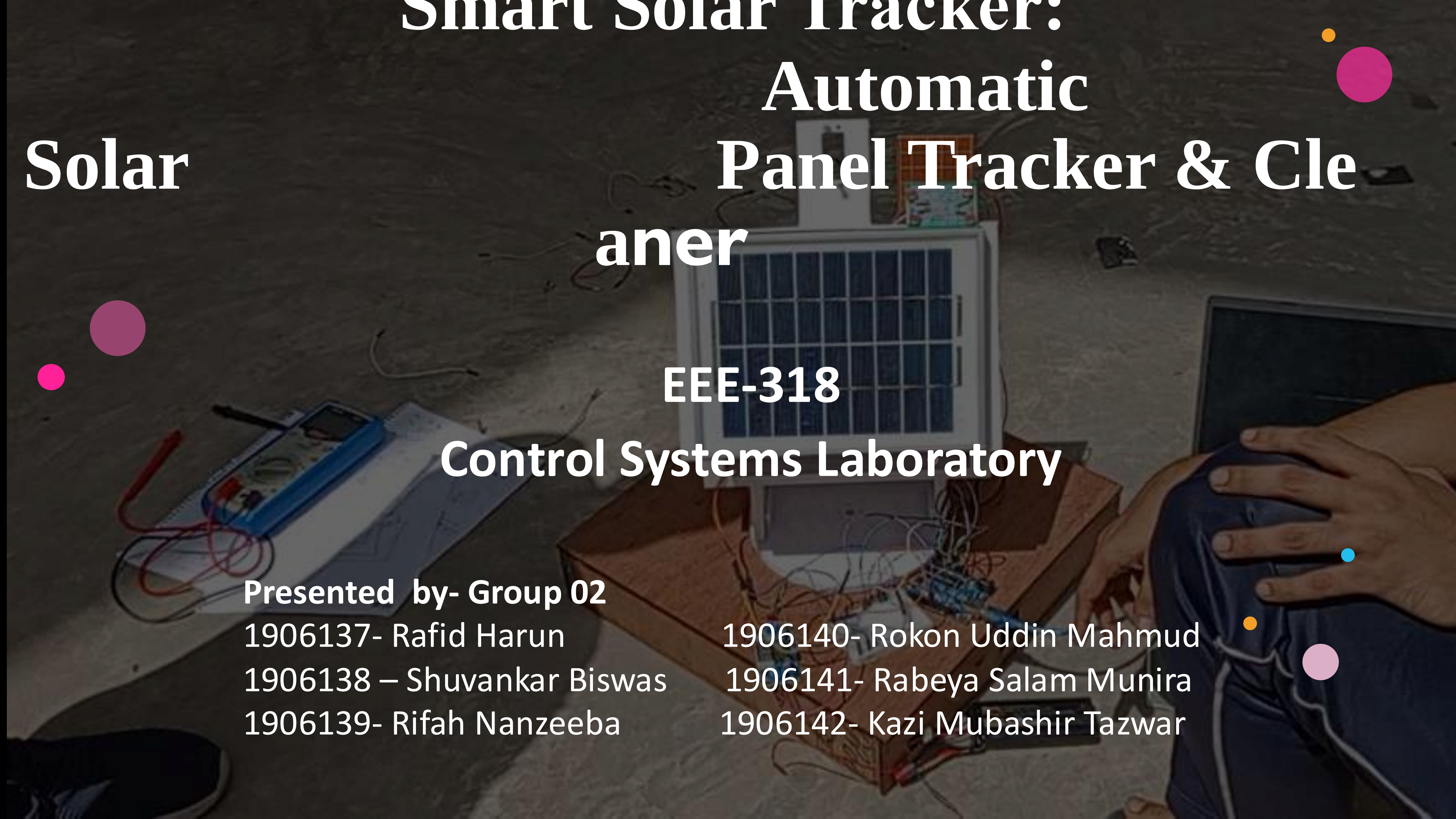

Smart Solar Tracker: Automatic Solar Panel Tracker & Cleaner

EEE-318

Control Systems Laboratory

Presented by- Group 02

1906137- Rafid Harun
1906138 – Shuvankar Biswas
1906139- Rifah Nanzeeba
1906140- Rokon Uddin Mahmud
1906141- Rabeya Salam Munira
1906142- Kazi Mubashir Tazwar

Smart Solar Tracker:
Automatic Solar Panel Cleaner & Tracker

EEE-318

Control Systems Laboratory 1

Presented by-

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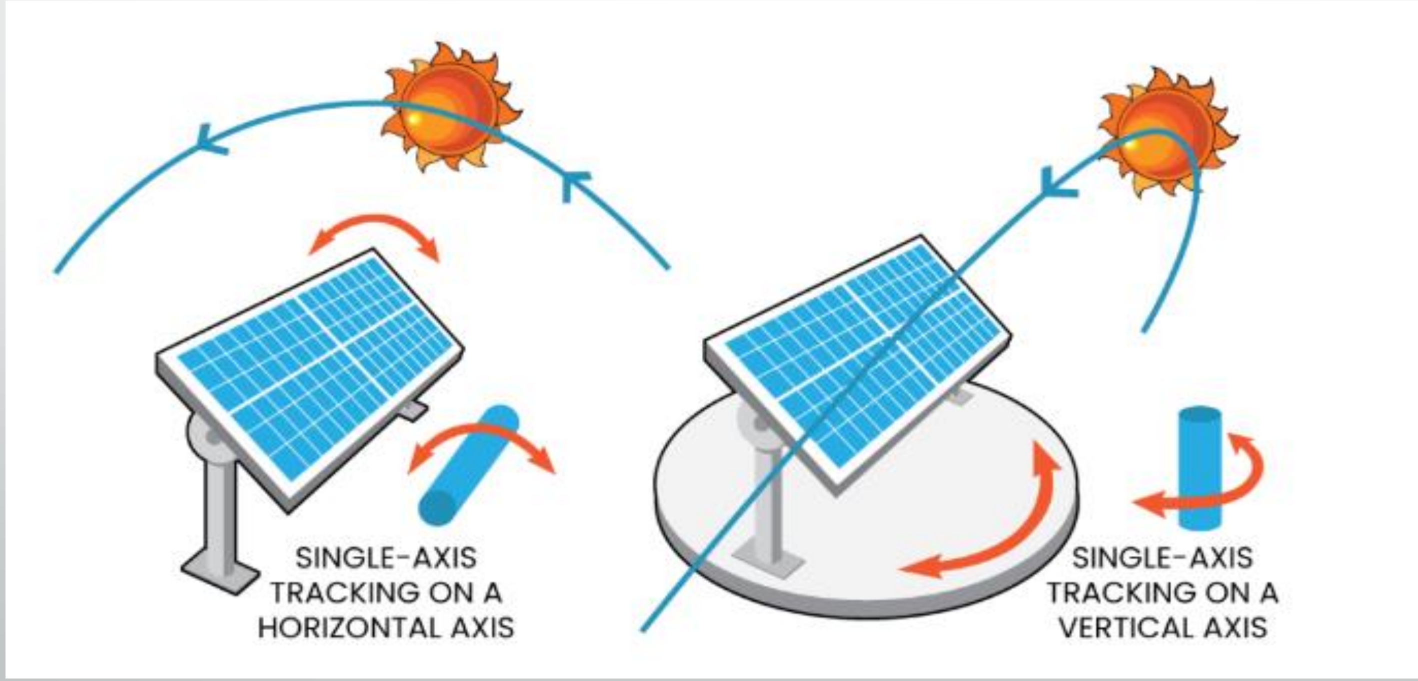
Introduction:

Smart solar tracking is basically a device that contains a controlled motor so that the payload is directed toward the sun to generate maximum solar power. The sunlight intensity is detected by a light dependent resistor (LDR). An automated wiper is connected to keep the panel clean so that it can absorb maximum sun rays. Mainly 3 control systems are present in the device- Horizontal Axis Controller, Vertical Axis Controller and Cleaner Controller.



Comparison :

1.Usually the dual axis solar tracker system does not have the wiper control. But we will have the wiper control system attached with the solar panel.

2.Our solar panel will be of moderate size which can be easily installed in every building with maximum efficiency.

3.Self-maintenance such as auto cleaner.

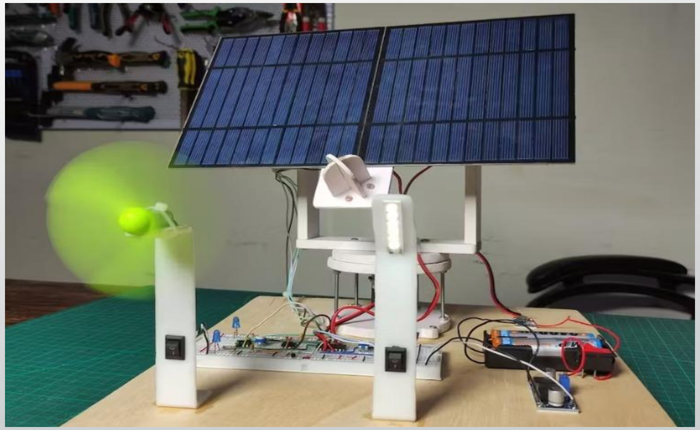
4. A single-axis solar tracking system has a high initial cost of installation whereas dual axis system are effective commercially.

Comparison

Single axis commercial solar tracker

Dual axis commercial solar tracker

Single axis prototype solar tracker



Dual axis prototype solar tracker

Features of our product:

1.Dual axis solar tracker system i.e. horizontal movement and vertical movement.

2. Hourly wiper control system.

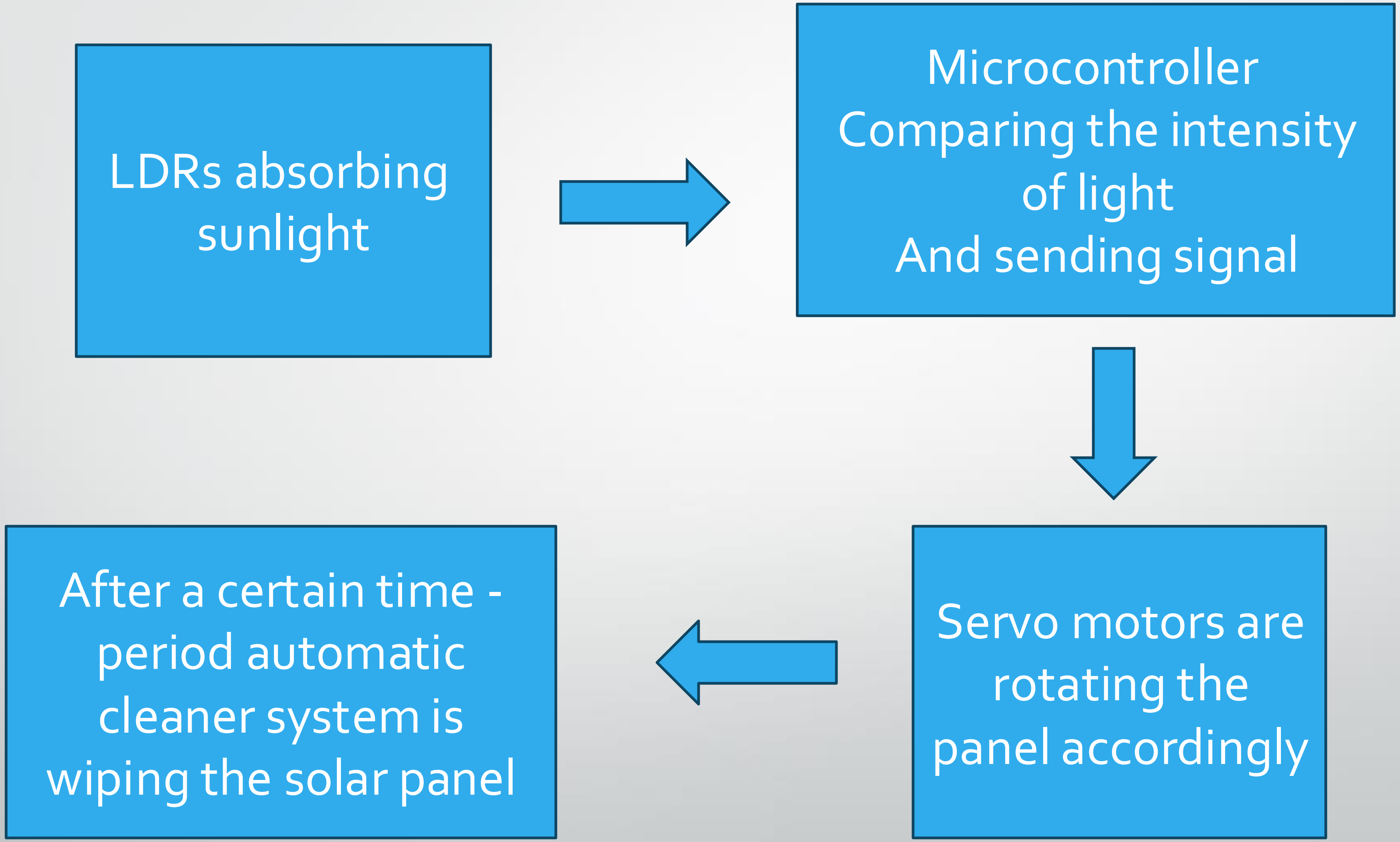
3. It determines the intensity of the sunlight by utilizing light sensors and its system evaluates where the solar modules should be oriented.

4. A dual-axis solar tracking system is designed to maximize solar energy generation across the year.

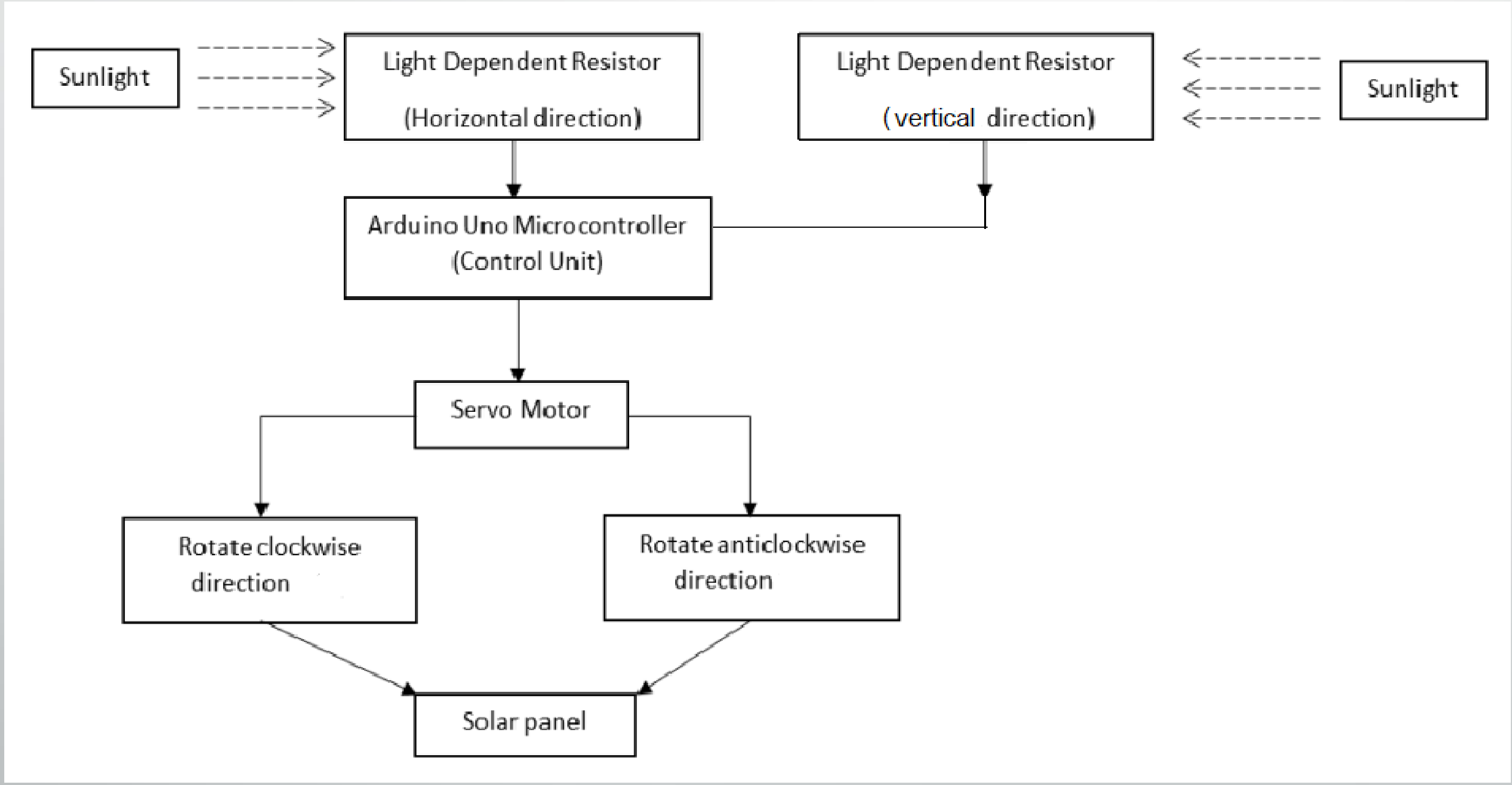
List of papers:

- https://cdn.fbsbx.com/v/t59.2708-21/357353689_129304220195406_7010156000050454839_n.pdf/ComputedAidedDesignandSimulationofaDualAxisSunTrackingSolarPanelTransmission.pdf?_nc_cat=106&ccb=1-7&_nc_sid=0cab14&_nc_eui2=AeFb9Vi1wXmtw7M9aojcOA4ss0CVbrNCL_CzQJVus0Iv8Cx6JvhPmQRaryfNic93ScHZ_v7Y4_dmPd6ppqJAx0Qo&_nc_ohc=Kc_BddNhP0cAX8wh8OB&_nc_ht=cdn.fbsbx.com&oh=03_AdT65bgrxYvoBu2BlF1oHROWENxp7gV4DNXAEln9zKLgzQ&oe=64A616BF&dl=1
- https://cdn.fbsbx.com/v/t59.2708-21/358143548_261503939832151_7761629014929506391_n.pdf/Fixed_versus_sun_tracking_solar_panels_an_economic.pdf?_nc_cat=104&ccb=1-7&_nc_sid=0cab14&_nc_eui2=AeFQH9KQRKtQuoGiGiI7uh3kwqcuqTe9w3zCpy6pN73DfLtl9I0rvz6D_8jEWes-nDF9dSP85zRZ4W7wkZaeCJLt&_nc_ohc=SgeO3gzy1-cAX8RA791&_nc_ht=cdn.fbsbx.com&oh=03_AdQOED0zF65eVFS9Si3Ce6OQH5YFAE0I8HLTAUh1DTE2KA&oe=64A58033&dl=1
- https://cdn.fbsbx.com/v/t59.2708-21/358242800_114636708349633_3298748523757203010_n.pdf/Maximizing_Output_Power_of_a_Solar_Panel_via_Combi.pdf?_nc_cat=101&ccb=1-7&_nc_sid=0cab14&_nc_eui2=AeFL7FFzuhVlzMami-NBfDia2ga9gzUS8OzaBr2DNRLw7ESFFTUsEPK6YitN6y6IFzXhenu2tIMWil78pxzHX5V6&_nc_ohc=OUVW6YDzX7oAX9fRE0A&_nc_ht=cdn.fbsbx.com&oh=03_AdRtgcJBorzZpxp3Uzi7CKSfs2dSioNvw5NSaf9fgaK2HQ&oe=64A5AB94&dl=1
- https://cdn.fbsbx.com/v/t59.2708-21/356783817_1328425331408636_4586513518674629290_n.pdf/Techno-economic_analysis_of_fixed_versus_sun-track.pdf?_nc_cat=110&ccb=1-7&_nc_sid=0cab14&_nc_eui2=AeESMxmkL3HGQakfkmfjejAv74_rVRnkYJLvj-tVGeRgkluCgeOSbHUCvC1_vBTZk2IoarVRN6AlnjVp1EKejiwY&_nc_ohc=LlE1d-kodzgAX-MIfeH&_nc_ht=cdn.fbsbx.com&oh=03_AdQNubbgik1kLtycVewxHtVPhD4SFJLbNx8nTcwPD_EwMw&oe=64A57AF3&dl=1
- https://cdn.fbsbx.com/v/t59.2708-21/358232046_655857912725623_1630111432007495198_n.pdf/SunTrackingSolarPanelWithAutoDustCleaningSystem.pdf?_nc_cat=110&ccb=1-7&_nc_sid=0cab14&_nc_eui2=AeGbib_FYhQdWT0u_tIl-TLv2mrrIvJhRgTaausi8mFGBA4NkNlcIkVNNpPwYsSreAnGiHpdcORE-YxbBOSboXKD&_nc_ohc=MPF791fo48gAX-kVjvv&_nc_ht=cdn.fbsbx.com&oh=03_AdTTRTvxcPRib9wk3QJBNwD83fCdZQLf0IbY9x0RdeioLA&oe=64A59A4E&dl=1
- Solar Tracking and Cleaning System – IJERT
- https://cdn.fbsbx.com/v/t59.2708-21/357837329_823853802475780_635805017978391118_n.pdf/1606213973798_152.pdf?_nc_cat=108&ccb=1-7&_nc_sid=0cab14&_nc_eui2=AeFFUD4j96KysocauBvq40c8K8H5nLoe7SIrwfmcuh7tIlprDI0BPA01cNc6plwdk6QdA5geUDLvOVsw5KsAsJCN&_nc_ohc=Y4maP4t_m6wAX8ZcF2t&_nc_ht=cdn.fbsbx.com&oh=03_AdQJp302NRPGDZtgLP97e9JsDn6ssOFNBFJF47T3Sm53-w&oe=64A5B335&dl=1

Work-flow:


LDRs absorbing sunlight
Microcontroller Comparing the intensity of light And sending signal
Servo motors are rotating the panel accordingly
After a certain time - period automatic cleaner system is wiping the solar panel

Block Diagram:



Components and Cost:

Components	Quantity	Price (BDT)
Solar panel(9cm*9cm)	1	800
Arduino Uno	2	2000
LDR Sensors, Dust sensor Humidity sensor	10,1,1	2500
Servo motors	5	2000
Rechargeable battery, holder And charger		1000
Breadboard, jumpers		400
Structure Material		6000

Different Segments of the Project:

This project can be broadly divided into two main segments.

1. Hardware segment
2. Software segment

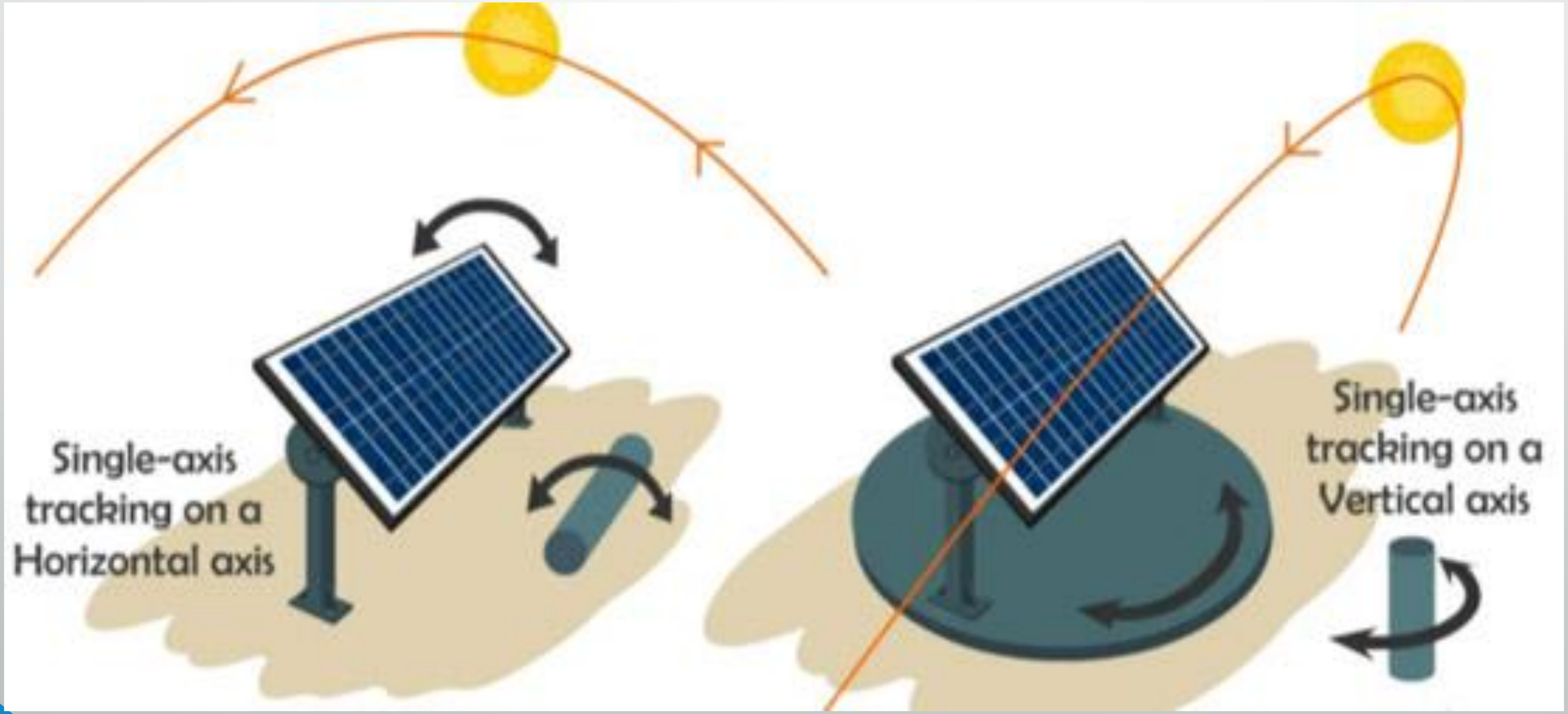
Hardware segment:

This section can be further divided into some parts, they are

1. Horizontal and vertical axis control
2. Wiper control
3. The overall assembly of the hardware segments

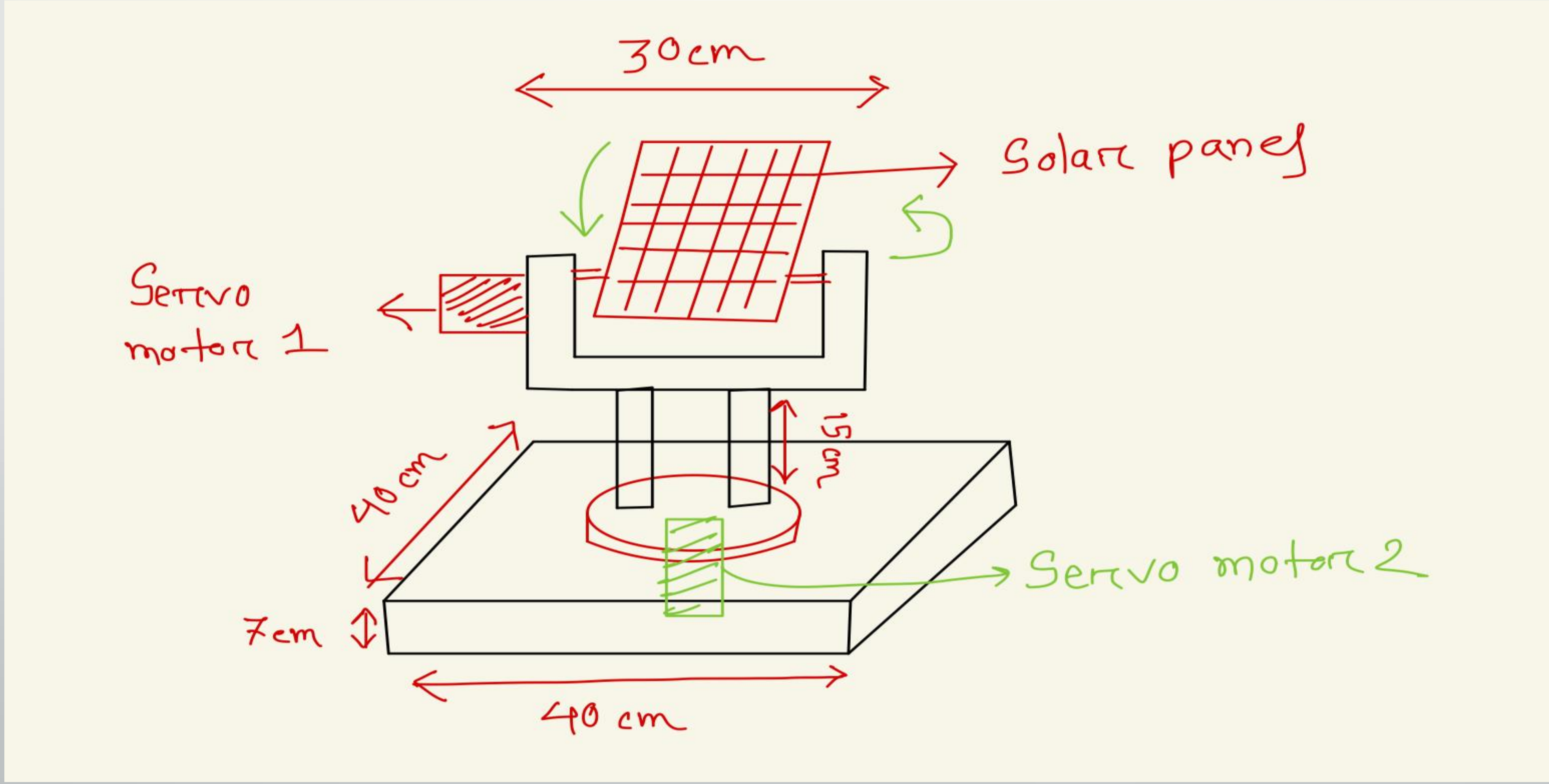
Horizontal and vertical axis control

1906140 and 1906142 will work on this hardware segment design and implementation

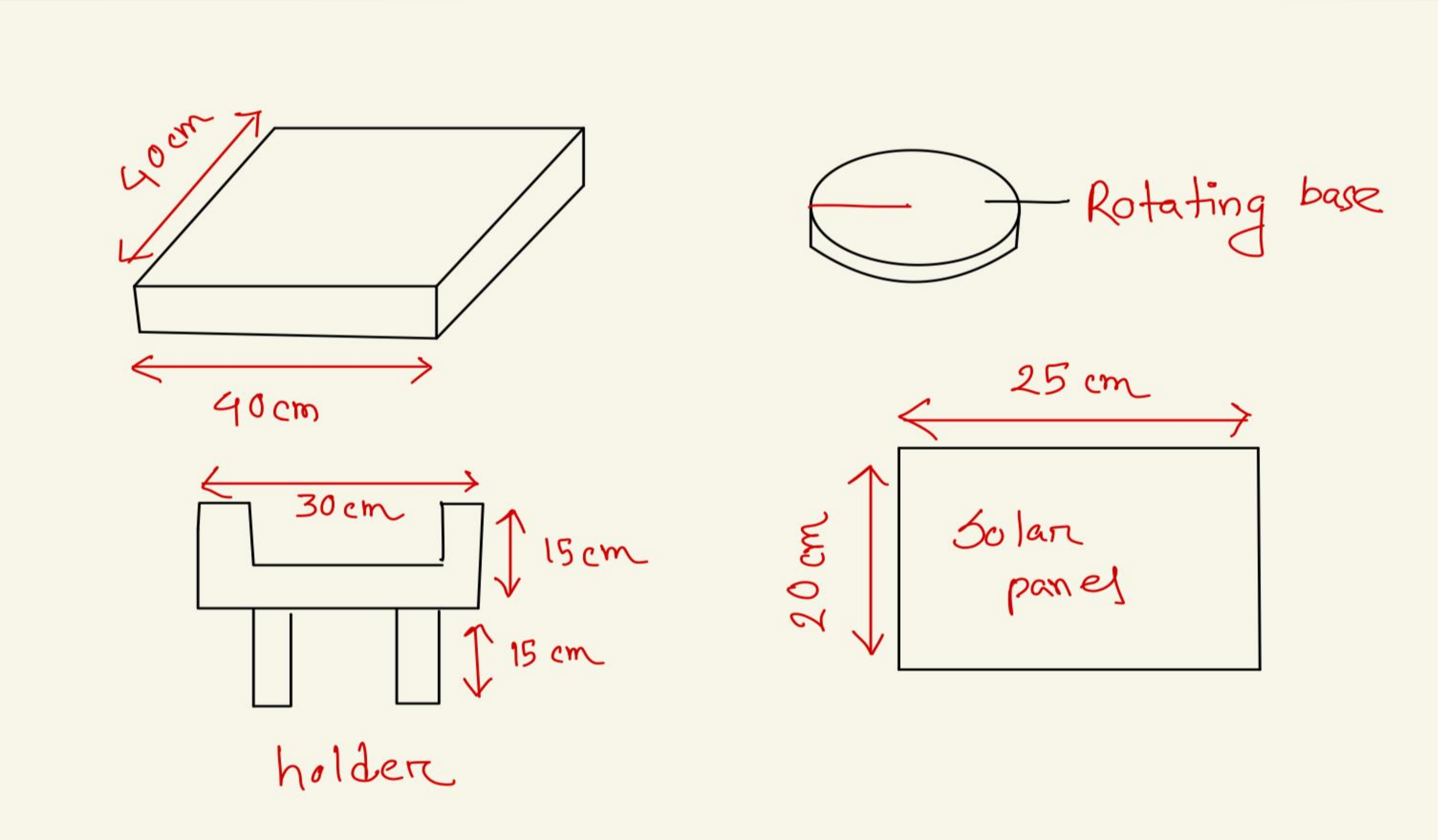


Design of the hardware:

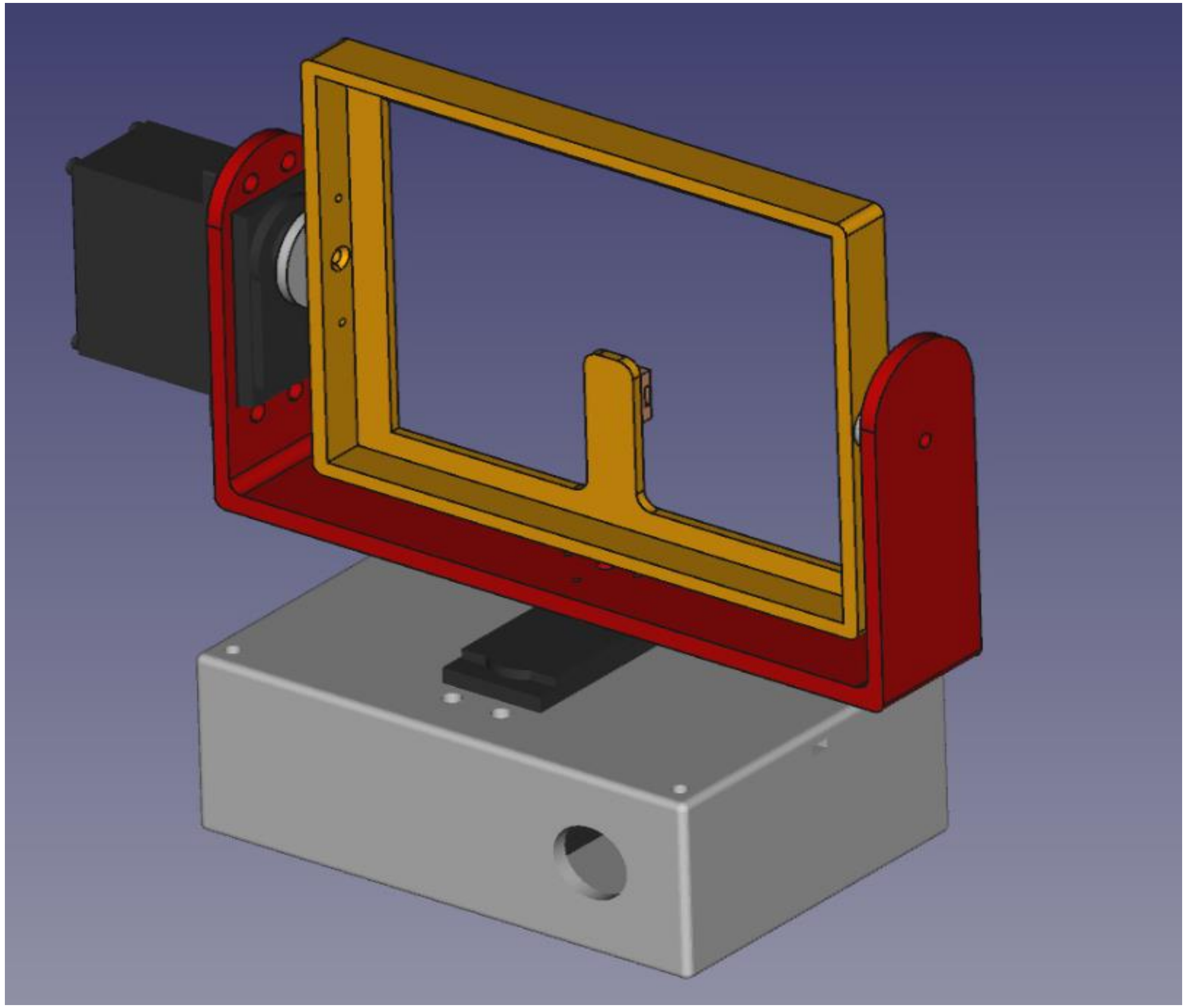
Overall structure with approximated dimension



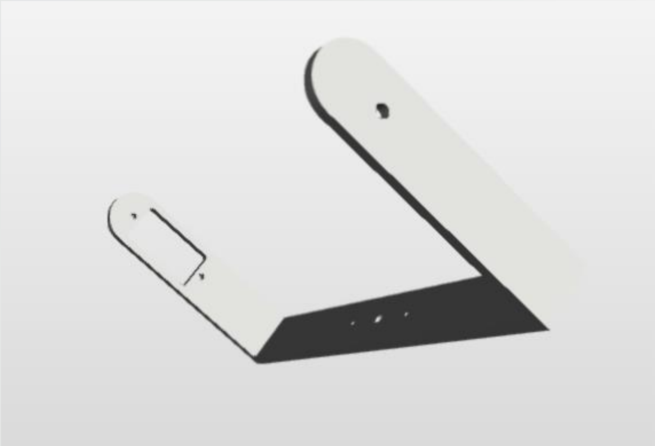
Different parts of the structure with approximate dimensions



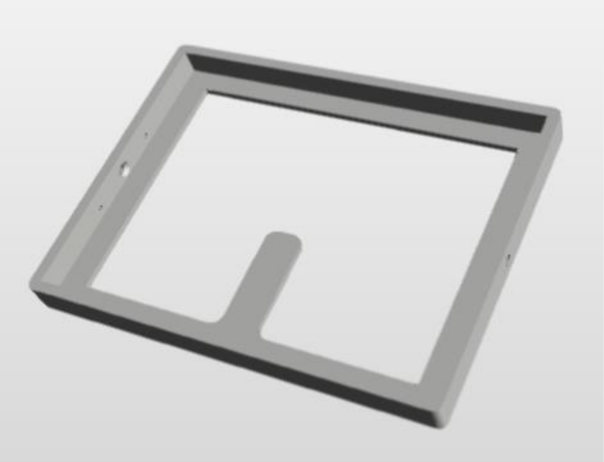
Design of the hardware(3D model):



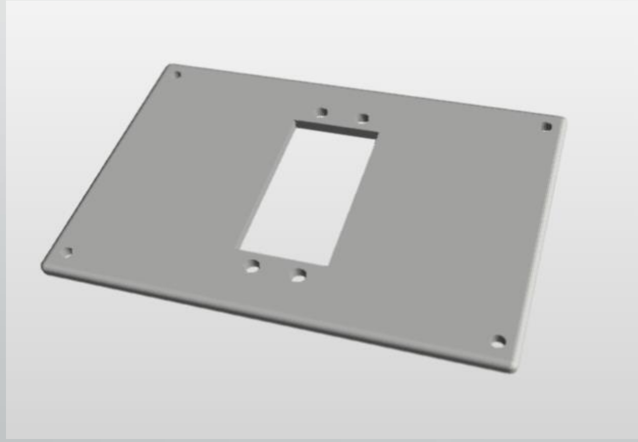
Different parts of the structure with 3D visualization:



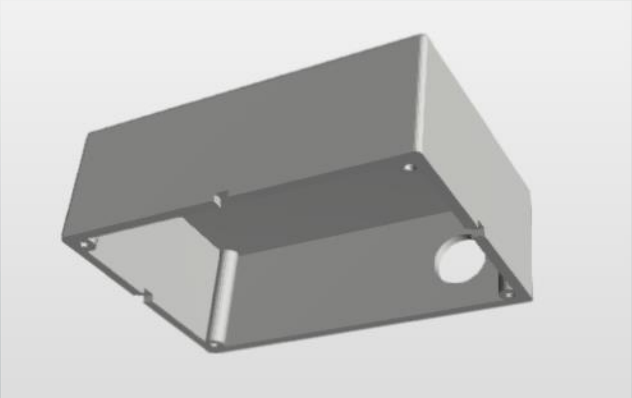
Solar panel Holder



Solar panel Holder



Top view of the base



Base

Components on this part:

Light Dependent resistors:

Specifications:

- LDR 20 mm Light Depending Resistor
- Low-cost sensor device
- Wide spectral response
- Use in fire alarms, smoke alarms, control street-light
- Low cost.
- Ambient Temperature Range.
- Wide spectral response.

No of units needed = 4
Cost per unit = 78 BDT

Arduino Uno:

No of units needed= 1
Cost per unit = 1000 BDT

Hardware update:

Procured Components:

Solar panel:

The dimension of our solar panel is 25cm X 19cm.

Components on this part:

MG996R Servo motor:

Specifications:

- Weight: 55g
- Dimension: 40.7×19.7×42.9mm
- Stall torque: 9.4kg/cm (4.8v); 11kg/cm (6.0v)
- Operating speed: 0.19sec/60degree (4.8v); 0.15sec/60degree (6.0v)
- Operating voltage: 4.8 ~ 6.6V
- Gear Type: Metal gear

Cost per unit= 445 BDT
Number of units needed: 2

Servo rating: 10 kg-1 cm torque / (MG995R / MG996R)

Solar panel weight (1200g approx.)

tracker frame " → 300g "

as the tracker is connected approximately 1.5 cm from the shaft, torque = 6.67 kg (approx)

So, 10kg-1cm servo are suitable. as SG90 small servo's has (1.3 - 1.5 kg-cm torque rating which is small).

Hardware update:

Different parts of hardware structure:

Base(40cm X 40cmX 7cm):

Fig : Base

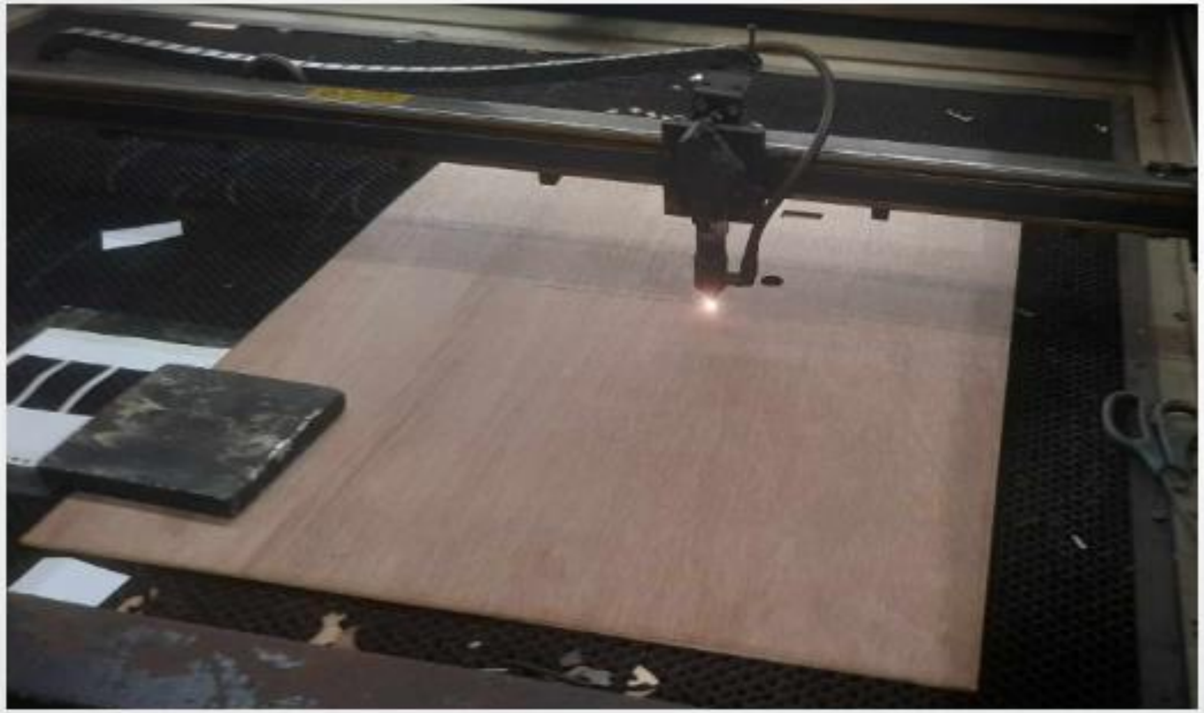


Fig: Laser printing of base structure

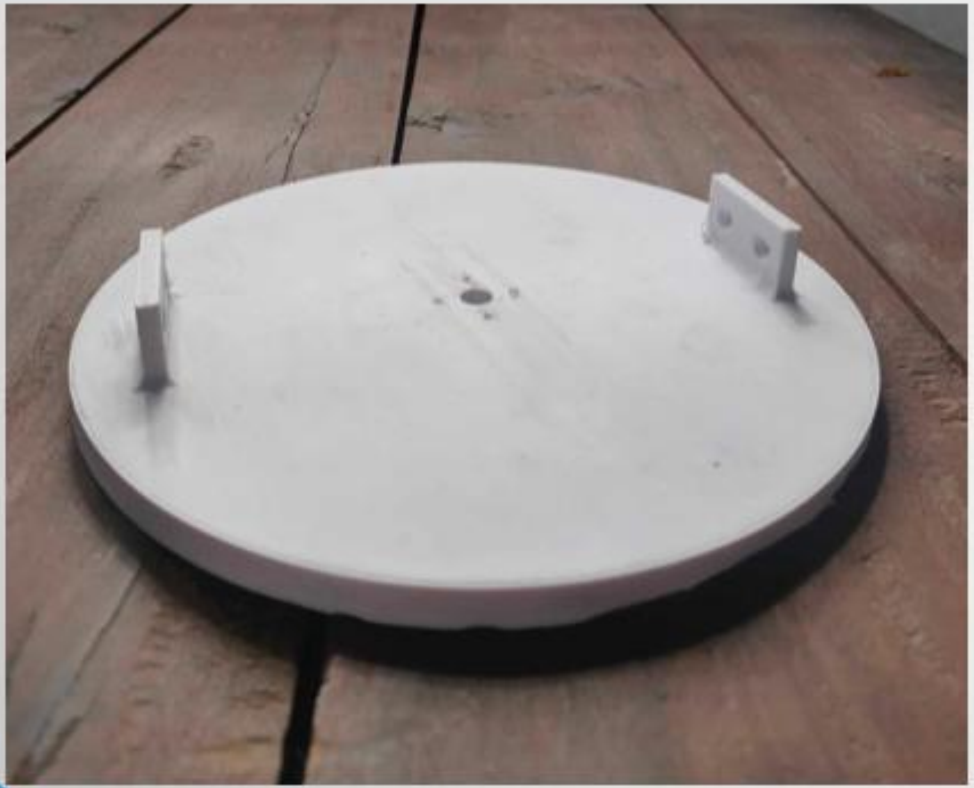
Hardware update:

3D Printerd parts of Upper body :

Solar panel holder:

Hardware update:

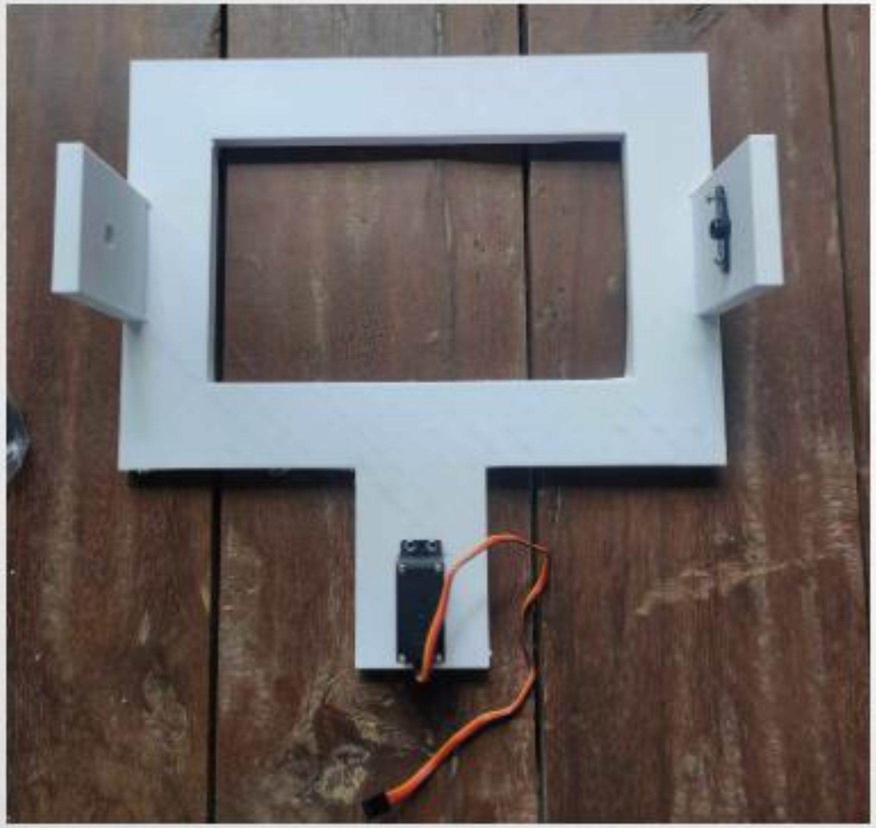
3D Printerd part of base :



Hardware update:

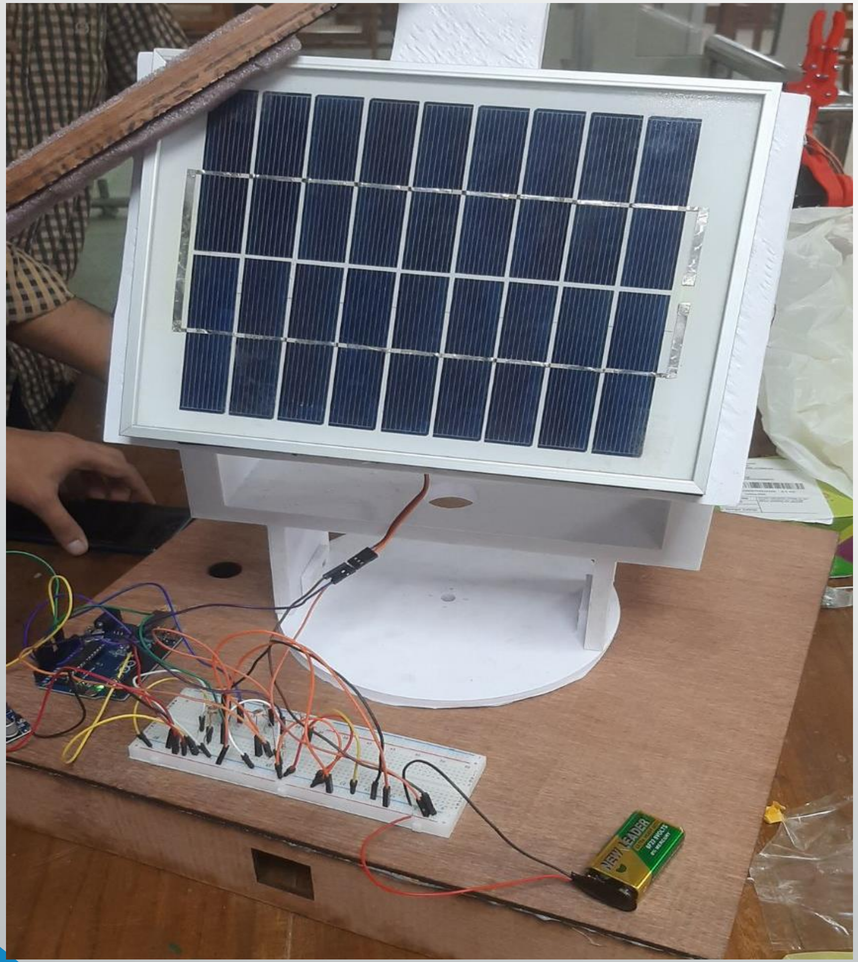
3D Printerd parts of Upper body :

Wiper holder:



Hardware update:

Assembled structure:



Calculations related to light source for final demonstration:

Light source:

Sunlight:

Blue sky → 20000 LUX → 200 Cd

Cloudy → 1000 LUX → 10 Cd

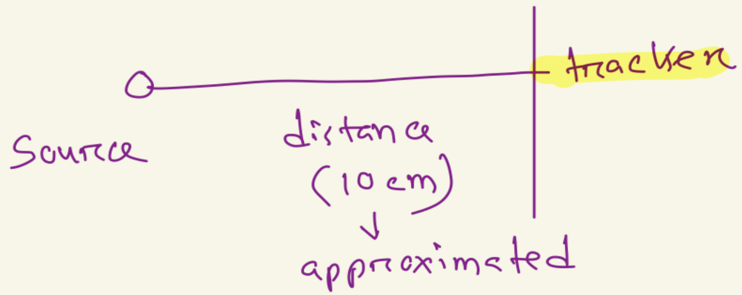
(for 10 cm distance of source from the tracker)

Calculation Explanation:

[1 lux = 1 Cd. sr/m^2]

for 20000 Lux, 0.1 m

= 200 cd



Options:

i) Warm white LED → 20000 mcd

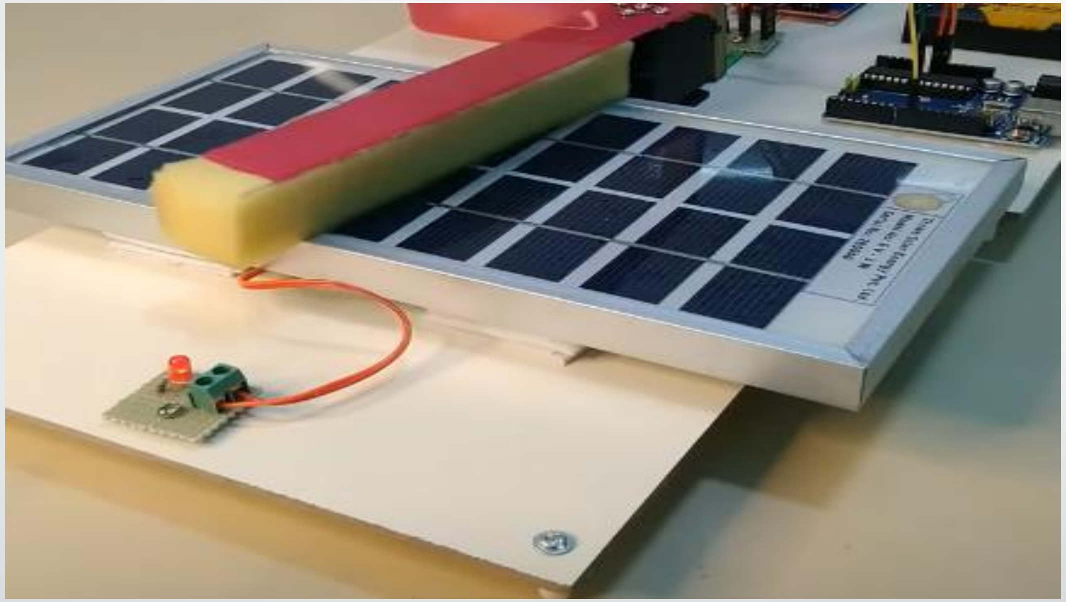
= 0.2 cd

ii) 5 mm yellow round LED = 150 – 200 mcd

(too small)

Wiper Control and hardware assembly

1906137 & 1906139 will work on this part of the project.



The wiper control system seeks to maintain optimal power generation efficiency by keepin g the panel surfaces clean so that they may receive maximum sunlight. The wiper will be controlled on the basis of the time(which can be programmed beforehand). For example- 6 hourly cleaning or 8 hourly cleaning.

Components on this part:

MG995 Fully Metal Servo Motor

Specifications

Weigh

t: 55 gm

Operating voltage: 4.8V~ 7.2V

Servo Plug: JR

Stall torque @4.8V : 10 kg-cm

Stall torque @6.6V : 12 kg-cm

no of unit –1

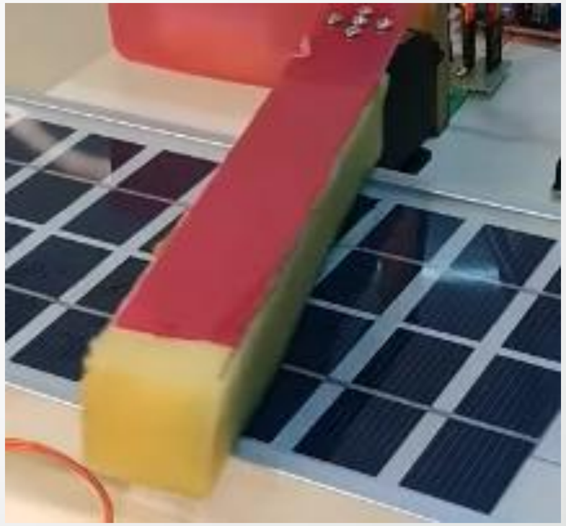
Cost per unit- 445 tk

Components on this part:

Arduino UNO

No of unit – 1

Cost per unit –700



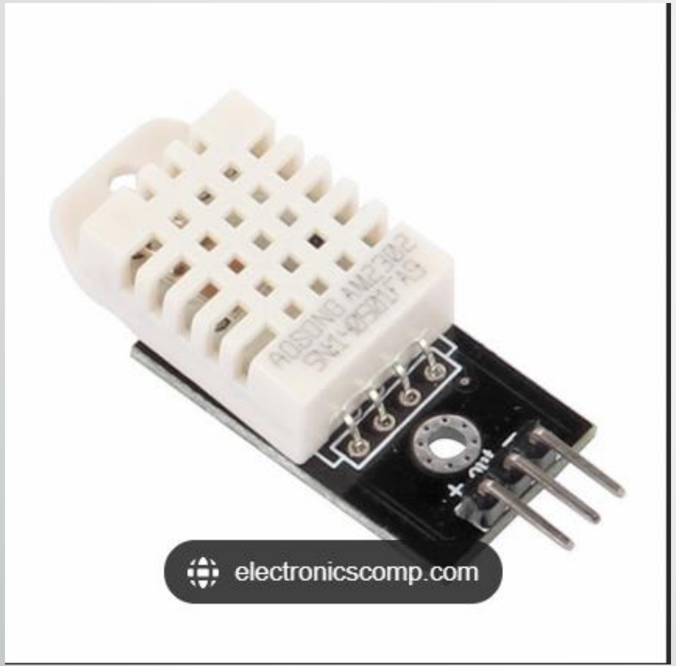
Wiper Using Sponge

no of unit -1

cost – to be determined upon size of the panel

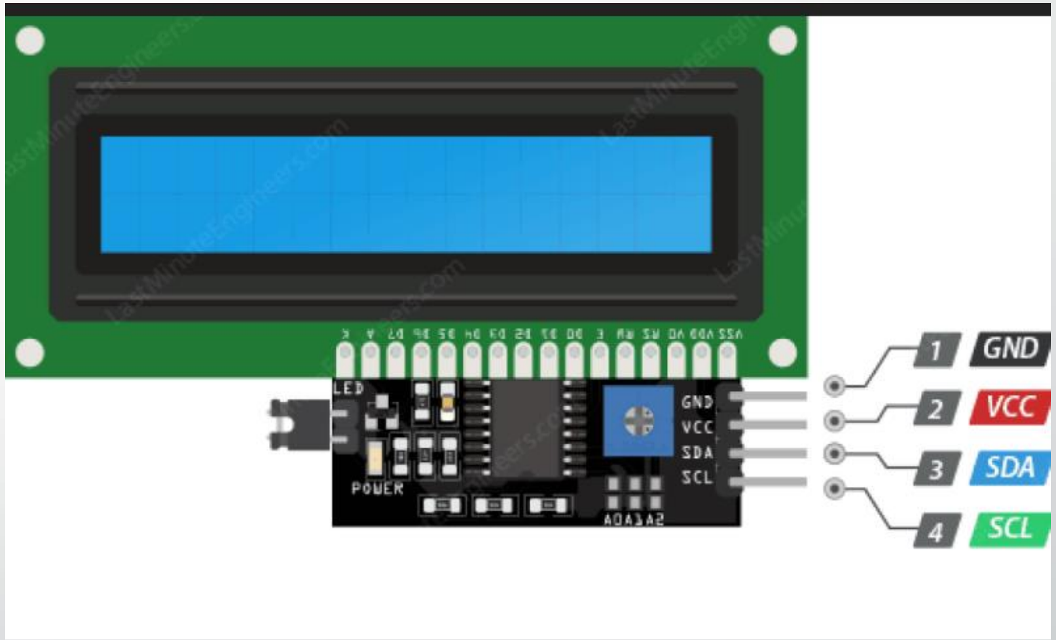
Components on this part:

DHT22 sensor



Unit –1
Price-

LCD Display with I2C Driver



Wiping Mechanism

EVERY 30 MIN TEMPERATURE AND HUMIDITY CHECK

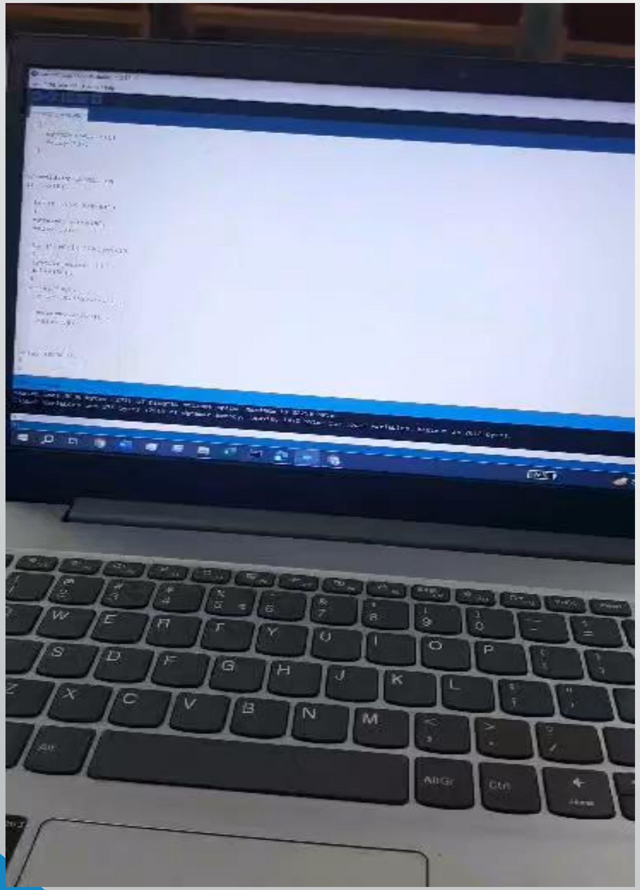
ANALYZING HUMIDITY &TEMPERATURE LIMIT

IF HUMIDITY CROSSES THE LIMIT, THE WIPER MOVES 3 TIMES

REST FOR ANOTHER 30 MINUTES

Hardware Segment:(Wiper)

Video Demonstration of Wiping



Code:(Wiper)

```
//humidity condition
if (h>60)
{
  for(k=1;k<=5;k=k+1)
  {
  myservo.write(90);
  delay(50);

  for(j=90;j<=180;j=j+10)
  {
  myservo.write(j);
  delay(50);
  }
  delay(600);
  for(i=180;i>90;i=i-10)
  {
    myservo.write(i);
    delay(50);
  }
}

delay(180000);
```

```
//temperature condition
if (t>30)
{
  myservo.write(90);
  delay(50);

  for(j=90;j<=180;j=j+10)
  {
  myservo.write(j);
  delay(50);
  }
  delay(600);
  for(i=180;i>90;i=i-10)
  {
    myservo.write(i);
    delay(50);
  }
}
```

Software segment:

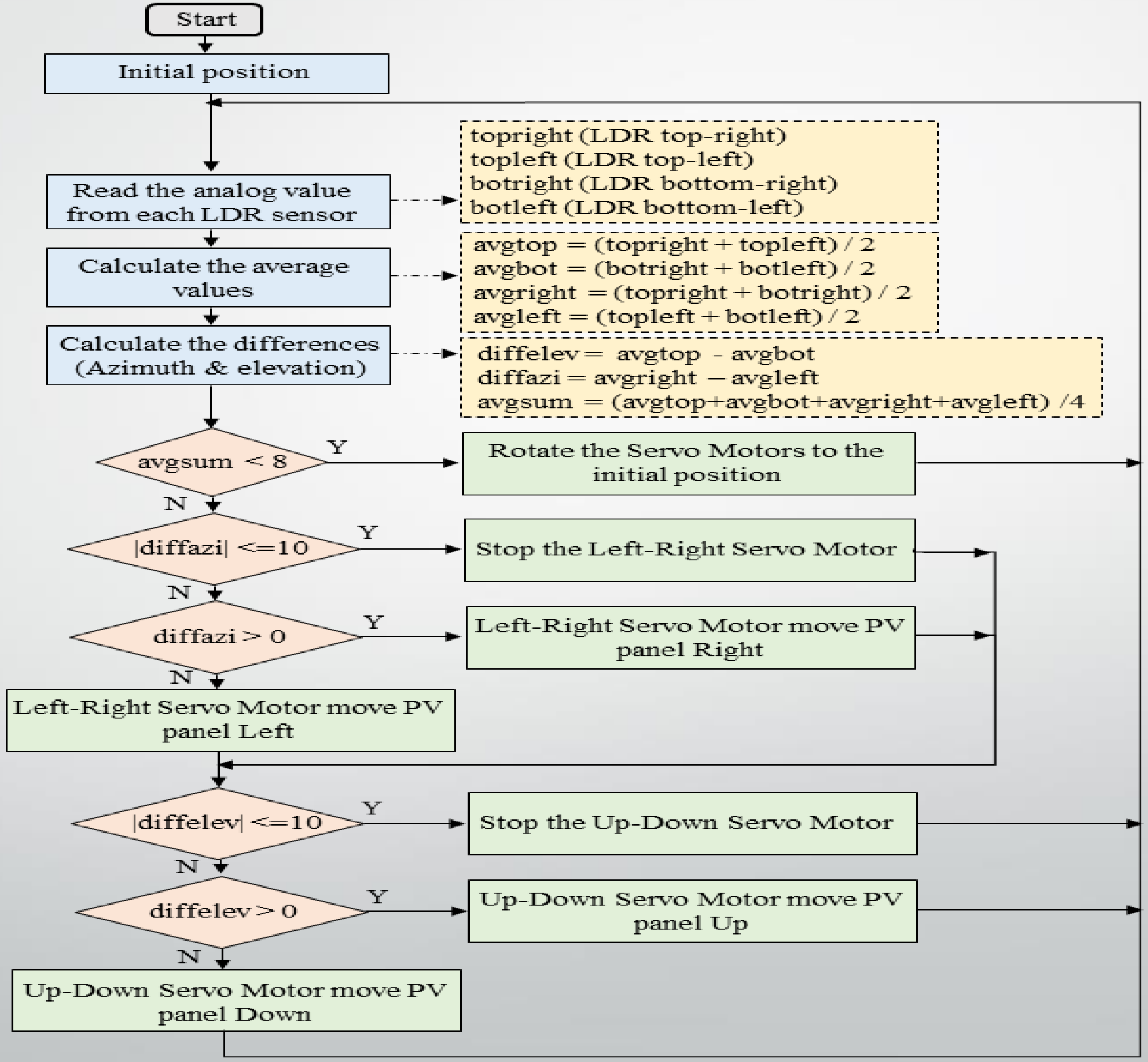
1906138 and 1906141 will work on this part of the project.

The software section is designed using

1. Arduino IDE (for writing the program for the controller)

2. Proteus (for Design and simulation)

Flowchart


Start
Initial position
Read the analog value from each LDR sensor
topright (LDR top-right)
topleft (LDR top-left)
botright (LDR bottom-right)
botleft (LDR bottom-left)
Calculate the average values
avgtop = (topright + topleft) / 2
avgbot = (botright + botleft) / 2
avgright = (topright + botright) / 2
avgleft = (topleft + botleft) / 2
Calculate the differences (Azimuth & elevation)
diffelev = avgtop - avgbot
diffazi = avgright – avgleft
avgsum = (avgtop+avgbot+avgright+avgleft) /4
avgsum < 8
Y
N
Rotate the Servo Motors to the initial position
|diffazi| <=10
Y
N
Stop the Left-Right Servo Motor
diffazi > 0
Y
N
Left-Right Servo Motor move PV panel Right
Left-Right Servo Motor move PV panel Left
|diffelev| <=10
Y
N
Stop the Up-Down Servo Motor
diffelev > 0
Y
N
Up-Down Servo Motor move PV panel Up
Up-Down Servo Motor move PV panel Down

Algorithm for tracking MPPT:

Incremental Conductance (InConc)

- **Initialize:**
    - Set up the pins for voltage and current sensors, as well as for the azimuth and elevation motor controls.
- **Read sensor values:**
    - Continuously read the voltage and current values from the solar panel to calculate its power (P = V * I).
- Find the maximum power point (MPP) using Incremental Conductance (IC) method:
    - Calculate the incremental conductance (dP/dV) using the current and voltage values.
    - Adjust the azimuth and elevation angles based on the sign and magnitude of the incremental conductance:
        - If dP/dV > 0 and dP/dI > 0, the system is near the MPP. Keep the current azimuth and elevation angles.
        - If dP/dV < 0 and dP/dI < 0, the system is far from the MPP. Change both azimuth and elevation angles in the opposite direction.
        - If dP/dV > 0 and dP/dI < 0, the system is to the left of the MPP. Change only the elevation angle in the opposite direction.
        - If dP/dV < 0 and dP/dI > 0, the system is to the right of the MPP. Change only the elevation angle in the same direction.
- **Control the motors**:
    - Convert the azimuth and elevation angles into motor control signals and move the solar panel accordingly.
- **Loop and Repeat:**
    - Continuously run the MPPT algorithm in a loop to keep tracking the sun.

Algorithm for tracking MPPT:

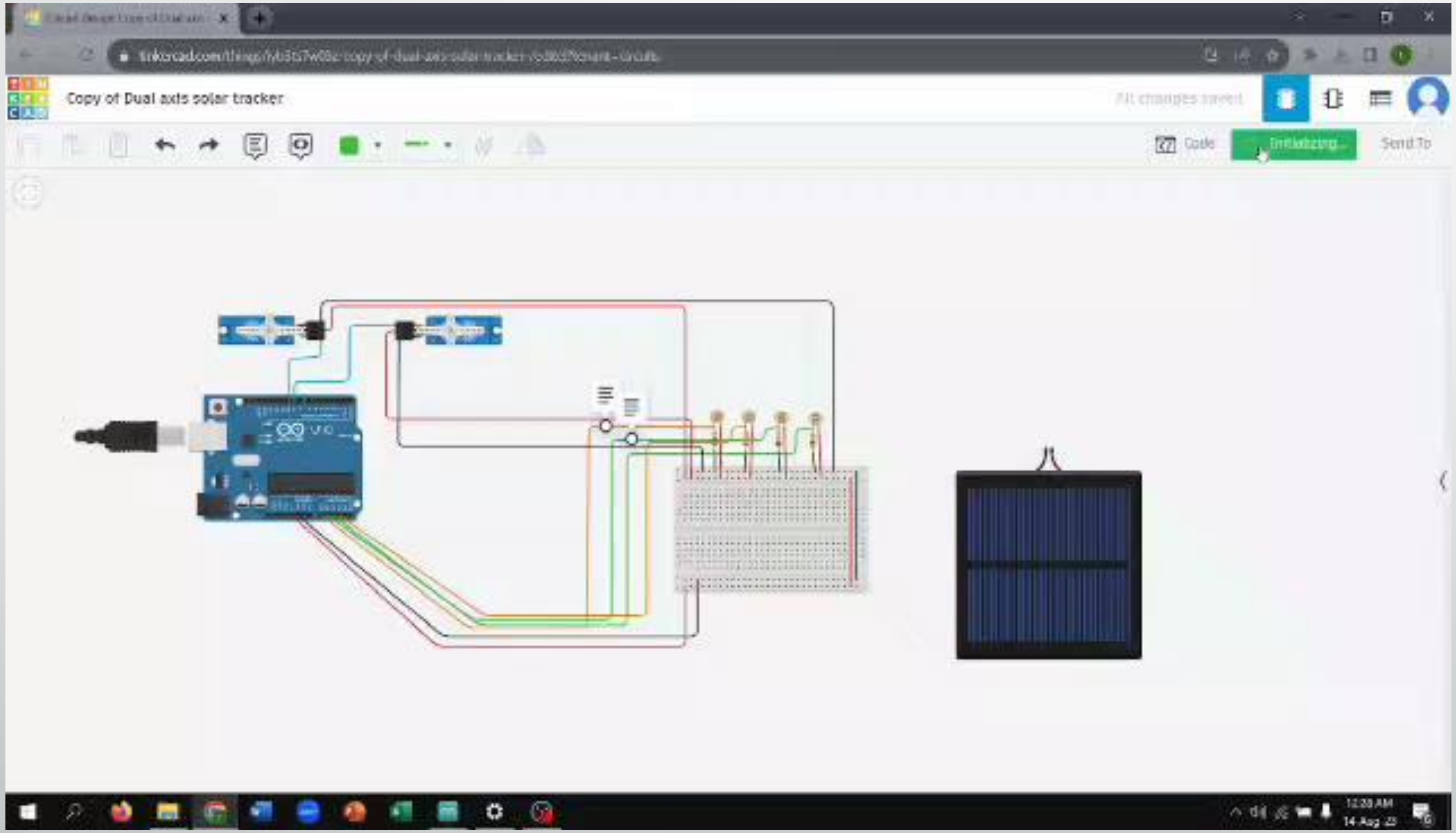
Perturb and Observe(P&O)

initialize:

- Set up the necessary pins for voltage and current sensors, as well as any motor controls or actuators for adjusting the solar panel position.

- **Define variables:**
  - Declare variables to store the previous voltage (V_prev), previous power (P_prev), and the perturbation step size (step_size).
- **Read sensor values:**
  - Continuously read the voltage (V) and current (I) values from the solar panel.
- **Calculate power (P):**
  - Calculate the power generated by the solar panel using the equation $P = V * I$.
- **Perform P&O MPPT algorithm:**
  - Compare the current power (P) with the previous power (P_prev):
    - If P > P_prev:
      - Increase the perturbation in the same direction as before by adding the step_size to the current voltage (V).
    - Else:
      - Change the direction of the perturbation by subtracting twice the step_size from the current voltage (V).
      - Reduce the step_size to half its previous value to perform fine-tuning near the maximum power point.
- **Update variables:**
  - Update the previous voltage (V_prev) and previous power (P_prev) variables with the current values.
- **Control the motors:**
  - Convert the voltage (V) or other relevant parameters into motor control signals to adjust the solar panel position.
- **Loop and Repeat:**
  - Continuously run the MPPT algorithm in a loop to track the maximum power point as solar conditions change.

Simulation video



Conclusion:

Task distribution table:

Part of this project	Assigned People
Horizontal and Vertical Axis Control and It's hardware implementation	1906140, 1906142
Automatic cleaner hardware implementation	1906137, 1906139
Software part	1906138, 1906141

Environmental Effect:

As our project is solely dependent on sunlight, rainy weather has a great impact on generating power. The variation in temperature and humidity will also affect the result of our project.
The season will also play a vital role in power generation as the distance between the sun and earth changes which will vary the flux of the sunbeam.

Weekly plan:

Week no	Progress
Upto 11th week	We designed the whole structure, made modifications and then assembled the whole structure after 3D print and laser cutting.Our wiper is also assembled.Then uploaded our code and trying to make the tracking more perfect.
5th-6th week	We aim to achieve perfect tracking of the light source and also to implement the dust and temperature sensor in our wiper structure appropriately, though we have tested the sensors individually.

Environmental Impacts:

1. Dependence on Non-renewable Energy Reduced : Dual-axis solar trackers increase solar panel efficiency by orienting them to receive the most sunlight possible throughout the day. More renewable energy production reduces the need for fossil fuels, lowering greenhouse gas emissions and halting climate change.

2. Land Use Maximization: Dual-axis solar trackers maximize land utilization by utilizing smaller areas while producing the same amount of electricity. The overall environmental impact of solar power plants can be reduced by increasing energy production per unit of land.

3. Less Fossil Fuel Based Power Required: Dual-axis solar trackers have the potential to reduce the need for emergency power sources such as fossil-fuel-powered generators due to their comparatively higher energy output.

Economic Impacts:

1. Maximizing Energy Production: Energy production increases because it receives more sunlight than a fixed tilt system. Revenue increases significantly with the ability to sell more electrical energy to the grid or use it for self-consumption due to increased production.

2. Energy Efficiency: A dual-axis solar tracker can follow the sun's path, increasing the energy generated by the system. Higher economic returns can be expected as more energy is produced per system capacity due to better energy efficiency.

3. Land Maximization: Dual-axis solar trackers instead of fixed-tilt systems, can maximize land utilization by producing more energy per unit of land. Land optimization is particularly useful in areas where land is expensive or scarce.

4. Economic Expansion and Employment Opportunities: Engineers, project managers, and technicians will have greater chances as this system requires a skilled workforce. It can also boost local GDP by attracting investors, creating job opportunities, and assisting other industries.

Conclusion:

1.The invention of solar tracking system helps us to improve performance of PV solar system.

2.Establishes a model of automatic tracking system to keep vertical and horizontal contact between solar panels and sunlight.

3.Improves the utilization of rate of solar energy and efficiency of photovoltaic power generation system.

THANK YOU