CS5053NI– Cloud Computing & IoT

Solar Tracking System

Assessment Type

Main Report

Semester

2024 Spring

Group Members

London Met ID	Student Name
23047549	Ayush Bhattarai
23049026	Nigel Awale
23048457	Priya Soni
23047589	Sanniva Shakya

Assignment Due Date: 7th January 2025

Assignment Submission Date: 6th January 2025

Submitted to: Mr. Sugat Man Shakya

Word Count: 3130

I confirm that I understand my coursework needs to be submitted online via Google Classroom under the relevant module page before the deadline in order for my assignment to be accepted and marked. I am fully aware that late submissions will be treated as non-submission and a mark of zero will be awarded.

23047589 Sanniva Shakya L2C2 Team5.docx

Islington College,Nepal

Document Details

Submission ID

trn:oid:::3618:77341970

Submission Date

Jan 6, 2025, 4:05 PM GMT+5:45

Download Date

Jan 6, 2025, 4:26 PM GMT+5:45

File Name

23047589 Sanniva Shakya L2C2 Team5.docx

File Size

27.9 KB

45 Pages

4,385 Words

23,254 Characters

14% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Match Groups

- **58** Not Cited or Quoted 14%
  Matches with neither in-text citation nor quotation marks
- **1** Missing Quotations 0%
  Matches that are still very similar to source material
- **0** Missing Citation 0%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

4%	Internet sources
1%	Publications
13%	Submitted works (Student Papers)

Integrity Flags

0 Integrity Flags for Review

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

Match Groups

- **58** Not Cited or Quoted 14%
  Matches with neither in-text citation nor quotation marks
- **1** Missing Quotations 0%
  Matches that are still very similar to source material
- **0** Missing Citation 0%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

4% Internet sources
1% Publications
13% Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Submitted works	George Bush High School on 2023-09-13	1%
2	Internet	www.ijraset.com	1%
3	Submitted works	University of Technology, Sydney on 2024-11-11	1%
4	Internet	ijsret.com	1%
5	Submitted works	Asia Pacific University College of Technology and Innovation (UCTI) on 2024-12-01	1%
6	Submitted works	University of Glasgow on 2015-04-17	1%
7	Submitted works	University of Sydney on 2024-09-15	0%
8	Submitted works	Asia Pacific University College of Technology and Innovation (UCTI) on 2024-08-15	0%
9	Submitted works	University of Warwick on 2024-12-05	0%
10	Submitted works	Asia Pacific University College of Technology and Innovation (UCTI) on 2023-10-08	0%

ACKNOWLEDGEMENT

On behalf of the members of Team 5, it is our honor to thank all people who helped in preparing this proposal for Internet of Things (IoT) project. First, we would like to extend our sincere and deep sense of gratitude to our Module leader/ Tutor, Sugat Man Shakya for his valuable guidance and recommendation in development of this proposal. The input has been extremely useful in providing guidance on what direction the project should take as we head into the implementation process.

We also wish to express our grateful to Resource department for availing to us the necessary material, equipment and support we needed for our early planning stage of the project. The infrastructure and equipment have made a significant contribution to determining our project's feasibility.

We are delighted to report that the conceived and planned IoT project has taken off well and, for that we are indeed thankful to everyone who assisted us during the initial phase of this venture.

ABSTRACT

Electricity is a necessity across the globe, and solving the problems of power scarcity is crucial; this is more so particularly to Nepal where migrating to renewable sources of power such as solar power will be more beneficial. PV energy systems are most in need of efficient solutions since efficiency of solar panels depends on light irradiance and orientation of the panel with respect to sunlight.

This work is specifically devoted to using Arduino UNO microcontroller for the design and development of solar tracking system for better performance of the solar panel. LDRs are incorporated as sensors to measure the intensity of sunlight and then the Arduino controls a servo motor to tilt the panel to allow maximum sunlight exposure. The sensors are controlled by a 1000-ohm resistor to reduce the input voltage and current, and a solar cell to continue the power supply to the system.

By managing to have the solar panel moving from one orientation to another as it follows the sun, the system increases the efficiency of the solar panel in question. For the existing conditions in Nepal, this solar tracking system is cheap, efficient, and sustainable to ensure the increased usage of solar power to accommodate the current and future energy requirement of this region.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

This academic prototype deals with a Solar Tracking System that can help improve the efficiency of solar energy through an Arduino -based mechanism. The system tilts the solar panel in accordance with the sun, regulating the position towards solar rays for power provision.

The Arduino UNO controls the entire device; it captures sunlight intensity using light dependent resistors and rotates the panel using a servo motor. Additionally, a 1000 ohms’ resistor is used for controlling the voltage and current to make the circuit stable and to run it effectively.

This solar tracking system is ideal for supply of electricity in Nepal as its supply has been a problem at many times. In doing so, it targets static panel problems and provides a real working solution to optimize the generation of reliable energy of the area.

1.1 Current Scenario

Nepal has an estimated solar potential of 40,000 to 50,000 TWh annually, which is 7,000 times the country's current power demand. Despite this immense potential, the solar sector's development remains low, with solar PV generating only 103 GWh of electricity by 2022, accounting for just over 1% of total electricity generation (Koons, 2024).

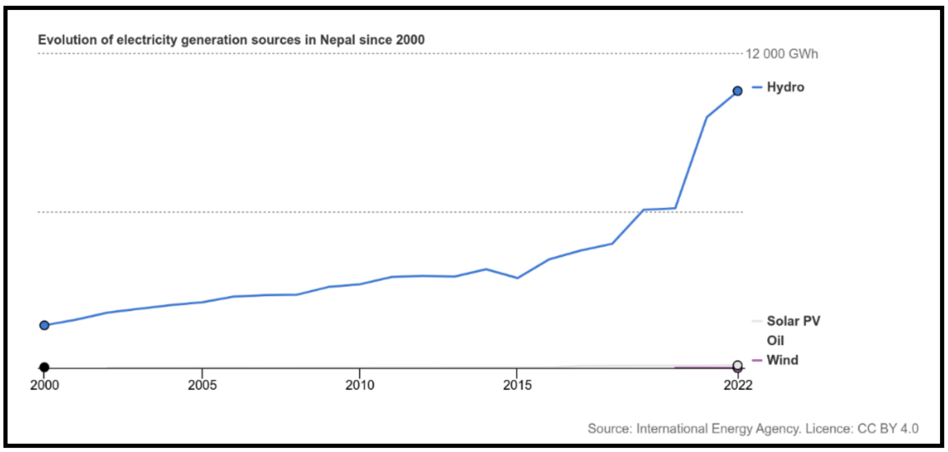

Figure 1: Evolution of electricity generation in Nepal (IEA, n.d.).

Currently, biomass and fossil fuels dominate energy consumption at 66.54% and 27.24%, respectively, contributing to energy inefficiency and high energy poverty. However, the growing presence of solar PV in recent years indicates Nepal's initial steps toward investing in solar energy, highlighting its potential as a vital supplementary renewable energy source (Lohani, 2023).

1.2 Problem Statement

Nonetheless, Nepal continues to experience several challenges that slow the expansion of adequate solar electricity for addressing its increasing power needs. Some of these challenges include; wide power shutdowns, old-aged infrastructure, minimal market access to modern energy products and low conversion ratio of between 30- 40% of the static solar panels.

However, excessive cost, absence of research, inadequate professional human resources, political barriers, legal, and logistical problems such as land acquisition and inadequate incentives delay buildup of mega solar projects. These pose a challenge to solar energy as to whether the benefits can be able to offer sustainable solution to the energy problems of Nepal.

Read more

1.3 Solar Tracking System as a solution

The utilization of the solar tracking system using Arduino enables the following solutions to many constraints facing the solar energy sector in Nepal, particularly in the rural areas. Installation of solar panels with fixed positions is ineffective because they cannot move to chase the sun around the sky.

All these will enhance the producing power under off grid solar home systems which are applied in most of the developing nations especially in the countryside; therefore, enhancing availability of power to the consumers. Investing in this system promotes renewable energy integration in Nepal while reducing pollution.

Read more

1.4 Aim

The aim of this project is to develop an inexpensive but effective Solar Tracking System powered by an Arduino microcontroller. The system will improve efficiency of photovoltaic (PV) solar panels by way of orienting photovoltaic (PV) solar panels in response to the position of the sun at a given time or day to ensure that the panels evenly capture sunlight thereby improving efficiency of conversion of the solar energy to electricity.

1.5 Objectives

- **Develop an Automated Solar Tracking System**: Design a feature that will allow the positioning of the solar panel to change as the day progresses so that the solar panel is always pointing toward the sun.
- **Enhance Solar Energy Efficiency**: Generate at least 20% more energy than fixed solar panel systems.
- **Promote Renewable Energy**: Promote its use by demonstrating with examples the effectiveness of the tracking system.
- **Provide a Cost-Effective and Sustainable Solution**: Create a simple, low-cost tracking technology that will enhance utilization of solar energy resource in off-grid areas by increasing reliability and efficiency of the solar system.
- **Increase the Reliability of Solar Power Systems**: Solve the issues experienced with stationary solar panels and ensure they always generate power to enhance reliability and functionality as needed in developing the world, including Nepal.

2 BACKGROUND

2.1 System Overview

A single axis tracking system enables sun imbalance altering the position of solar panels in only one direction, usually the North South direction as the sun rises from the East and sets in the West during the day.

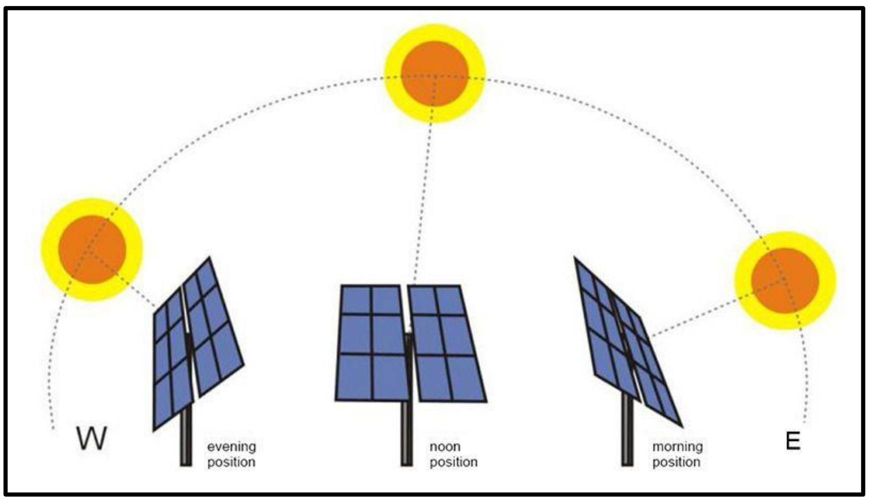

Figure 2:Visual Representation of the Working of a Solar Tracking System

The main objective of the system is to keep the solar panel facing the sun to maximize on shade and sunlight. In so doing, it enhances efficiency of energy capture which enhances energy yield by 25-30% compared to Fixed Angle systems (Solar Square, 2022).

The system operates on the basic principle that Light Dependent Resistors (LDRs) are employed to measure the intensity of sunlight. Using information from sensors mounted on the solar panel, a servo motor posits and corrects the angle of the solar panel to the right position throughout the day and as a result the efficiency of the solar panel is enhanced, and the performance of the entire solar system is increased.

2.2 Design Diagram

2.2.1 Block diagram

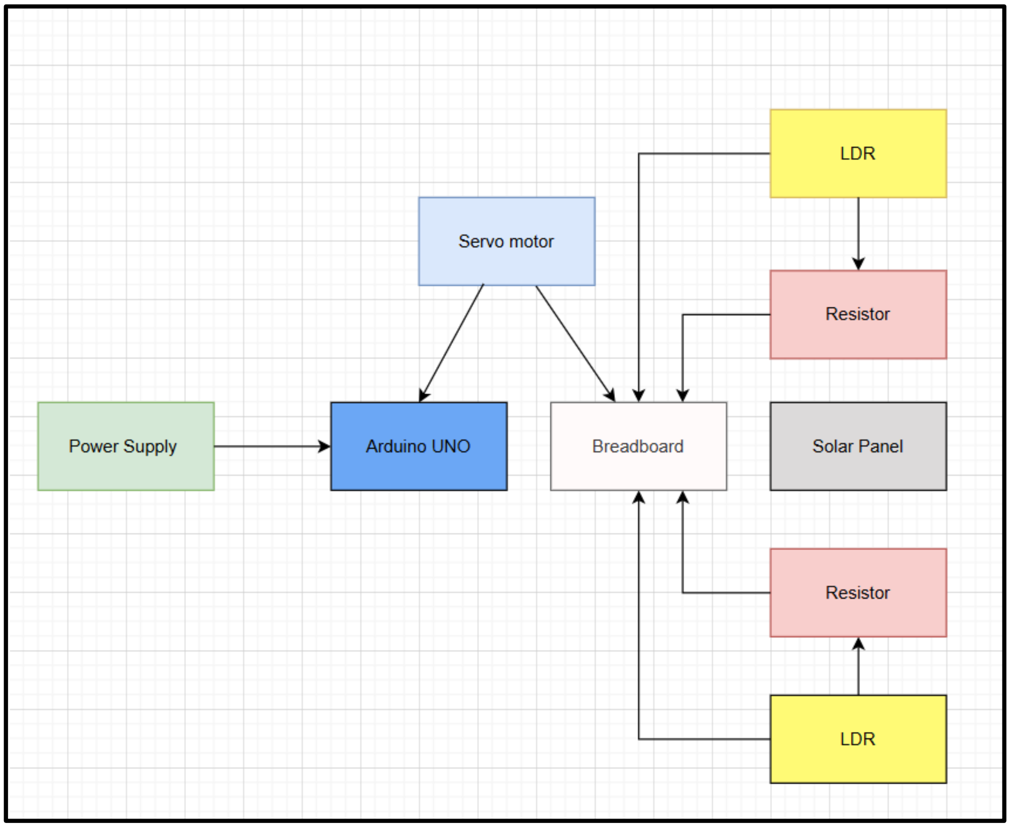

Figure 3:Block diagram of the Solar Tracking System

The block diagram shows a solar tracking system built with an Arduino UNO. The system is powered by a power supply, which powers the Arduino and connected devices. LDRs detect light intensity and send data to the Arduino, which controls a servo motor to position the solar panel for optimal sunlight exposure. A breadboard holds the circuit components, with resistors used to adjust the LDR signals, enhancing solar energy absorption by tracking the sun's movement throughout the day.

2.2.2 System Architecture

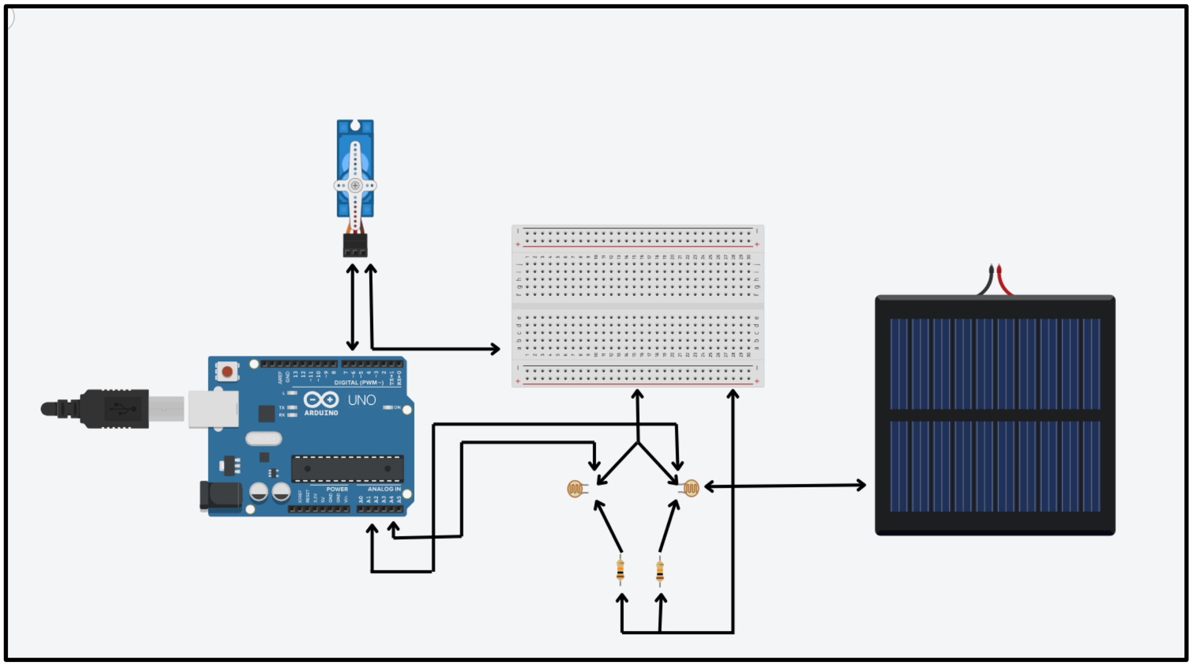

Figure 4:System Architecture for Solar Tracking System

2.2.3 Flowchart

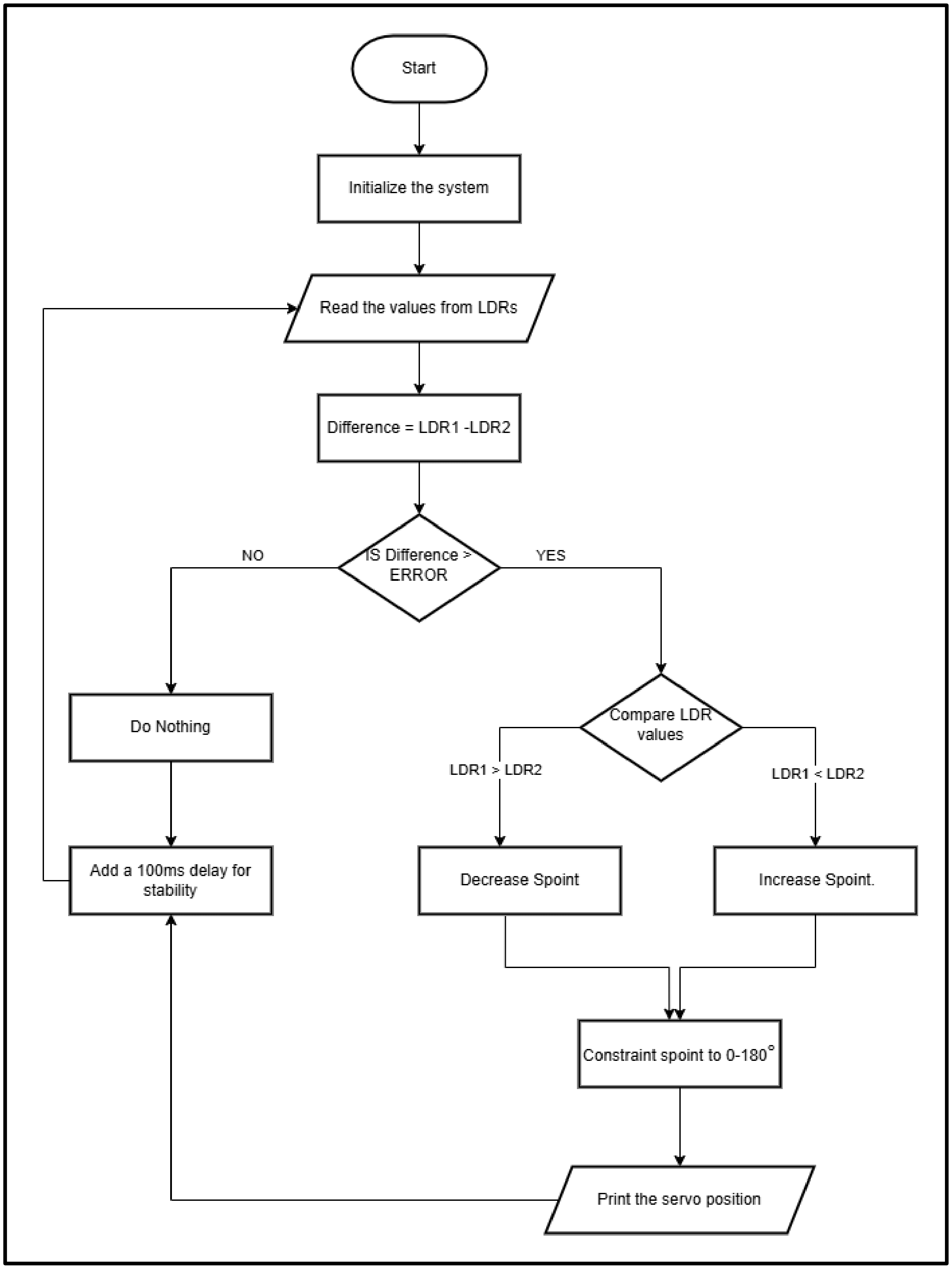

Figure 5: Flowchart for the Solar Tracking System

2.2.4 Circuit Diagram

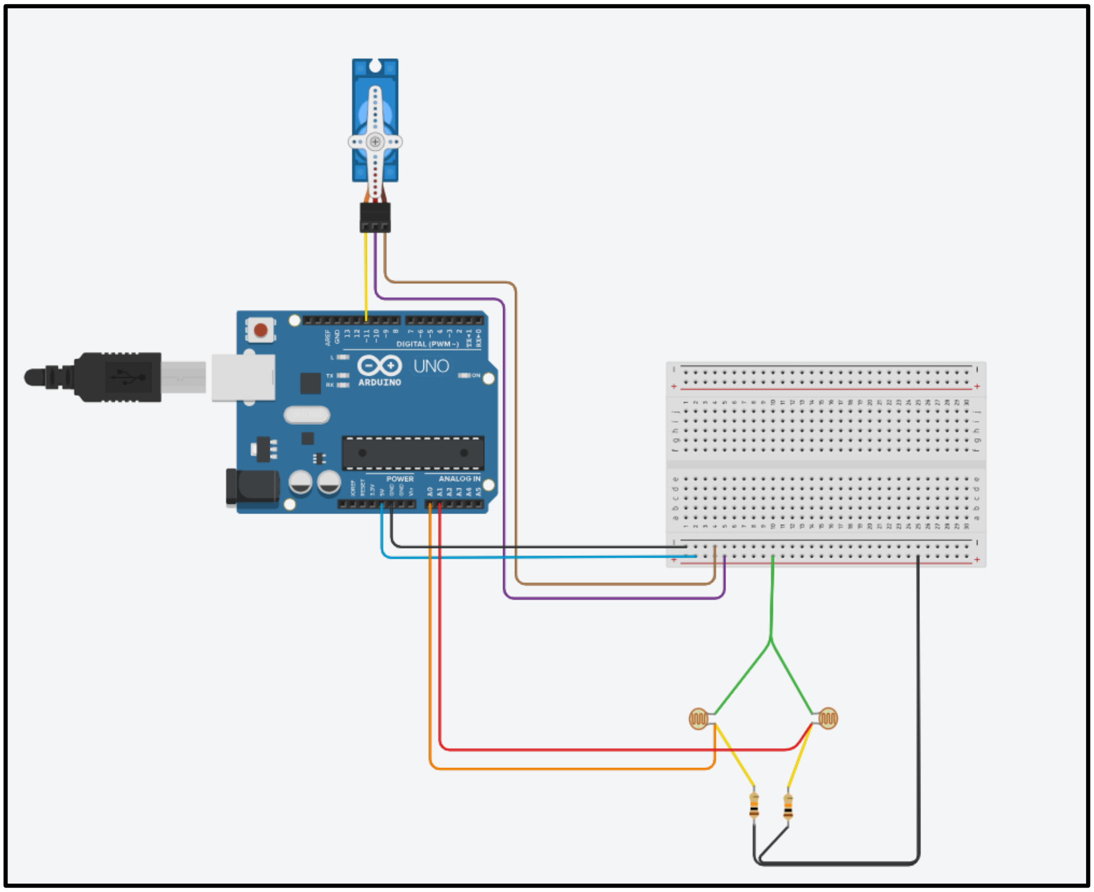

Figure 6:Circuit diagram for Solar Tracking System

2.2.5 Schematic Diagram

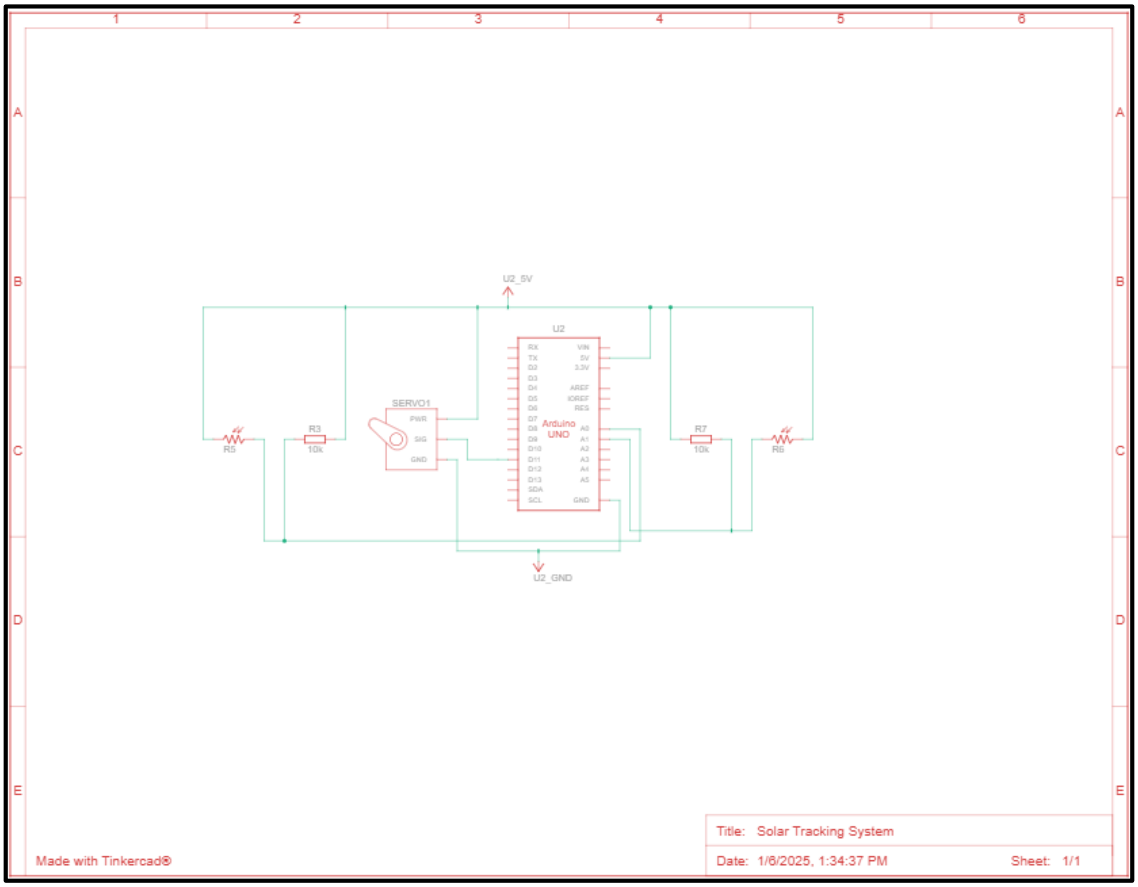

Figure 7:Schematic diagram for Solar Tracking System

2.3 Hardware and Software Requirements

2.3.1 Hardware Components

a. Arduino UNO board

Arduino worked as the master control mechanism receiving data from LDR regarding intensity of sunlight and manipulating motor for positioning the solar panel in the most efficient way. It gave the opportunity to track the light in real time, control the motion effectively and provided easy solution expandable for the future changes.

Read more

Figure 8:Arduino used for controlling the solar tracking system (JavaTpoint, 2024)

b. Solar Panel

This project consists of a single solar panel and its main goal is to explain the idea of solar tracking under condition of making the solar panel receive sunlight as much as possible without considering power. The panel is not connected to a battery or load to highlight the tracking system's purpose and exclude energy storage and consumption.

Read more

Figure 9:Solar panel demonstrating sunlight capture in the tracking system.

c. Servo motor

With a rotary design, the servo motor is most suitable for operations that require the shaft to turn to exact angles. Based on the source of energy, the servo motor is known to be an electrical actuator that works using electrical power and is regulated using electronic signals known as Pulse with Modulation (PWS) signals. This makes it possible to provide precise and rapid motion for the tasks that call for a controlled turning movement.

[Read more]

Figure 10:Servo motor adjusting the solar panel.

d. LDR Sensor x 2

Based on energy conversion, the Light Dependent Resistor (LDR) is a Passive Sensor which does not produce electrical signals on its own. Instead, it delivers change of resistance, which electronic quantity, passive in its nature, responds to the intensity of light. This change cannot be measured by internal circuit; it needs an external circuit.

Based on the output signal, the LDR is defined as an Analog Sensor as it delivered varying resistance values that are proportional to different intensities of light. This analog output is converted into voltage signal and from this voltage signal Arduino board calculates the direction having maximum sunlight.

Read more

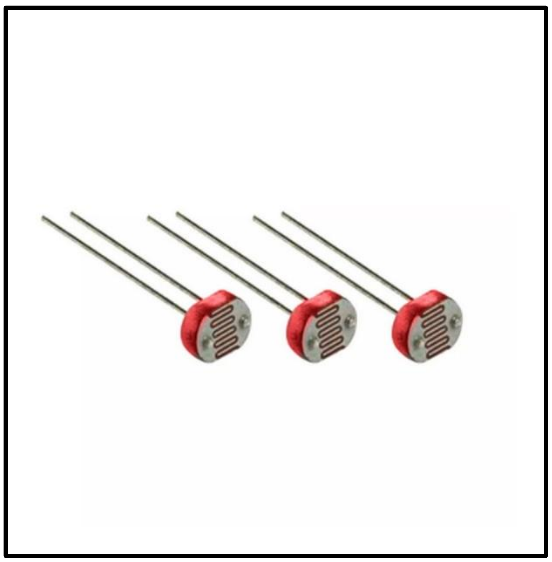

Figure 11:LDR sensor detecting light intensity.

e. Jumper wires

There were electrical connections made using jumper wires in the solar tracking system to facilitate signal and power connections. They mounted the analog input pins of the Arduino board with the LDR sensors, PWM output pins for the servo motor, and fixed up the rest of the power and ground circuits. Their ease of use and reusability made them essential for building and testing the system.

Read more

Figure 12:Jumper wires connecting components.

f. 10kΩ resistor x 2

The variable resistor 10kΩ was connected in parallel with the LDRs in a voltage divider circuit which measures voltages changes on the LDRs. This value ensured a normal response to typical lighting condition by regulating the change in output voltage to fall within the Arduino's 0-5V range while allowing fluctuations to reflect changes in light intensity.

[Read more](#)

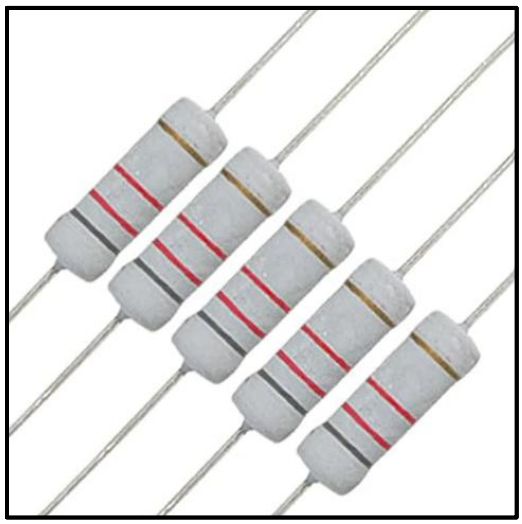

Figure 13:10kΩ resistor

g. Breadboard

The breadboard made prototyping of the solar tracking system easier in the sense that one could easily connect and disconnect wires and components such as the Arduino, LDRs, resistor and servo motor. They were further used to separate the 5V power supply to the LDRs and the servo motor – it came in handy while creating voltage divider circuits for use by the LDRs and in relaying control signals to the servo motor. This allowed for fast and easy debugging and design changes but kept it neat and allowed for easy testing of the connections.

Read more

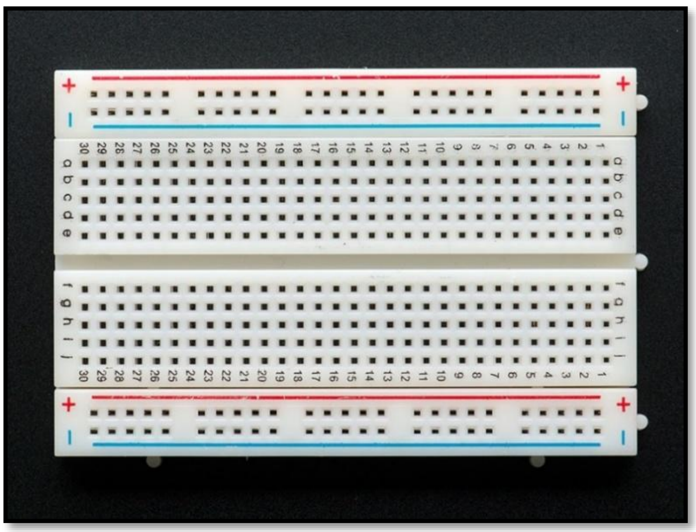

Figure 14:Breadboard for circuit assembly.

2.3.2 Software components

a. Arduino IDE 2.3.4

The functionality of the solar tracking system was programmed in the Arduino Integrated Development Environment IDE, and it was used for coding and uploading.

[Read more]

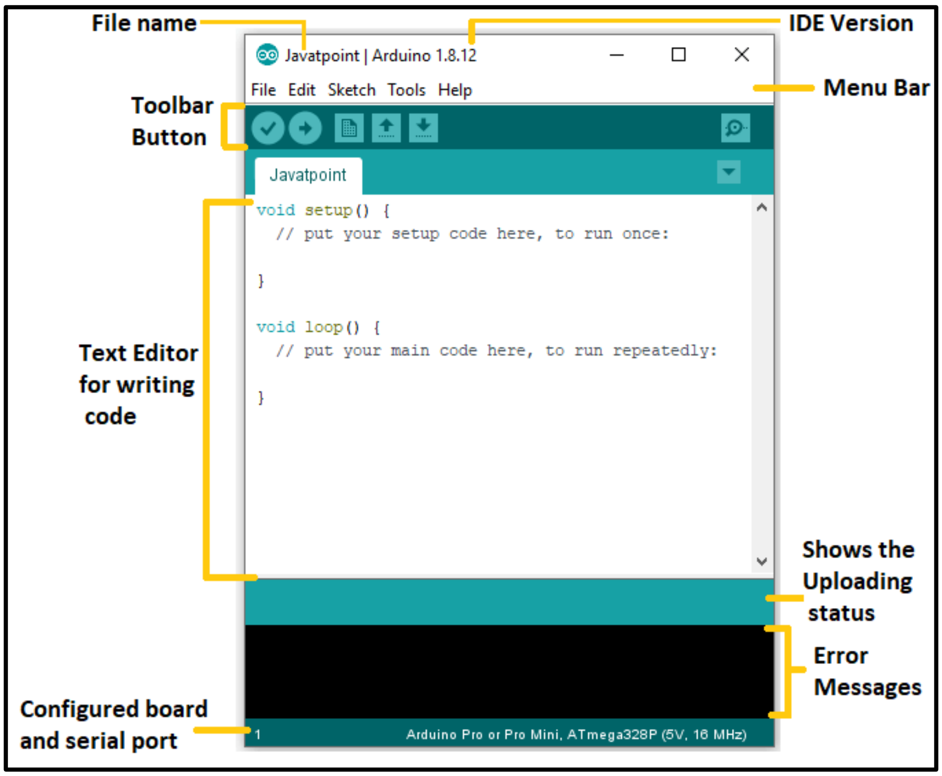

Figure 15:Using Arduino IDE for coding and uploading (Javatpoint, 2024).

b. Tinkercad

Tinkercad was used to simulate the circuit before physical assembly, allowed us to virtually assemble the components like Arduino, LDRs, servo motor, and resistors, and test their connections. It provided an opportunity to check how the system works, and whether the design of the model was correct.

[Read more](#)

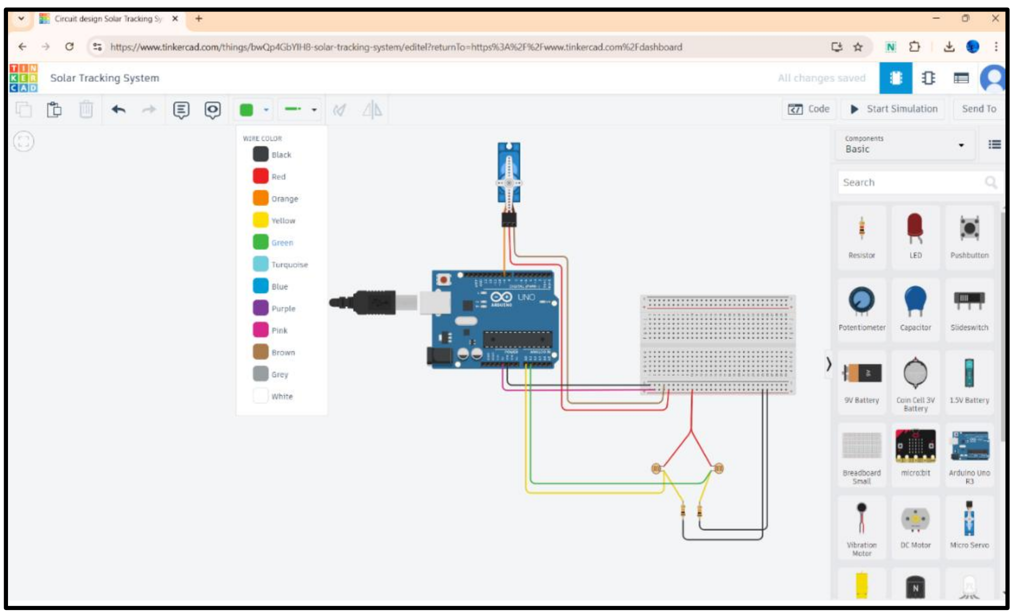

Figure 16:Using tinkercad to make the circuit diagram

c. Draw.io

According to this project, we utilized 'Draw.io' for drawing a block diagram to signify the elements of the system as well as their connectivity. This diagram helped to explain the structure of the system and included in the development, debugging and documentation of the Arduino, LDRs, Servo motor and power supply.

d. Microsoft Word

For documentation purposes in Microsoft Word, we described the components, circuit diagram and working of the project briefly. To support these arguments, we integrated the entire Arduino code and the explanation of the code, pictures of the connections, and diagrams. An obvious advantage of the report was the clear focus on its results, conclusion, and potential improvements, all of which were systematized in this section.

Read more

3 DEVELOPMENT

3.1 Planning and Design

We kicked off the project with a brainstorming session to define goals and finalize the idea of creating a Solar Tracking System that adjusts the solar panel's position throughout the day for optimal energy harvesting.

To ensure the idea was feasible, we began assembling the core hardware components, including the Arduino, servo motor, and Light Dependent Resistors (LDRs). The design process involved sketching the system’s architecture and developing an algorithm to control the servo motor based on the light intensity and drawing a circuit diagram to verify wiring and voltage levels. Proper simulations completed using Tinkercad confirmed theories and provided insight into the development of the system.

3.2 Resource Collection

During the Resource Collection phase, we gathered the necessary components for the solar tracking system, including the Arduino board, LDRs, servo motor, resistors, jumper wires, breadboard, and solar panel. We also ensured we had the Arduino IDE for coding and Tinkercad for circuit simulation. Additional tools like a soldering iron were collected for potential use during final integration. Once all components were gathered, we conducted tests to confirm their stability before integration. This phase was crucial for ensuring readiness to move on to the development phase.

3.3 System development

<u>Phase 1</u>: Preparing the Sensor Circuit

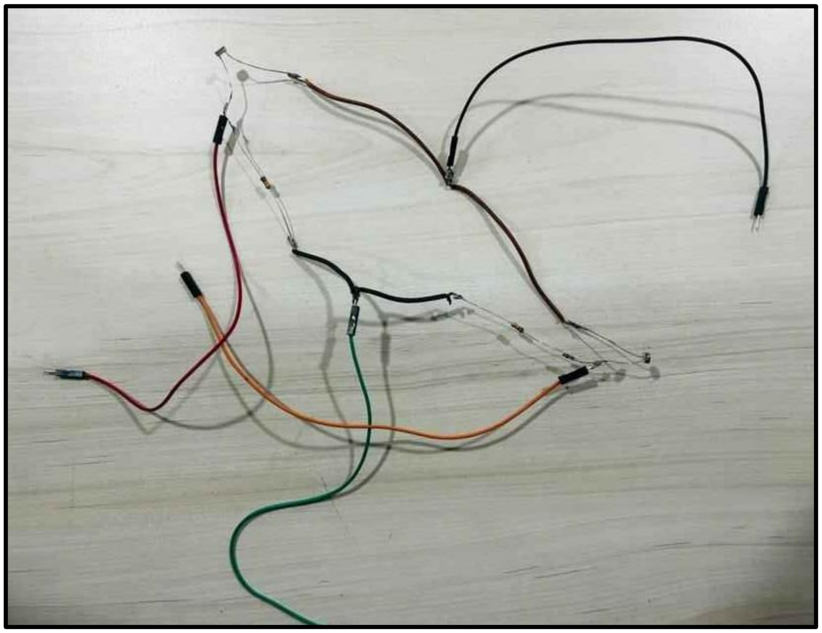

Figure 17:Preparing the Sensor Circuit

- **LDR and Resistor Connections**:
  - For each LDR sensor, one terminal was connected to a resistor, making the configuration of a voltage divider.
  - The connection between the LDR and the resistor was signal output, that provided variable voltage based on light intensity.

- **Adding Jumper Wires:**
  - For connection to Arduino analog pins soldering was done at the junction of the LDRs and resistors by inserting a jumper wire.
  - Additional jumper wires were connected to provide power (5V) and ground (GND).

<u>Phase 2</u>: Connecting the Circuit to the Arduino

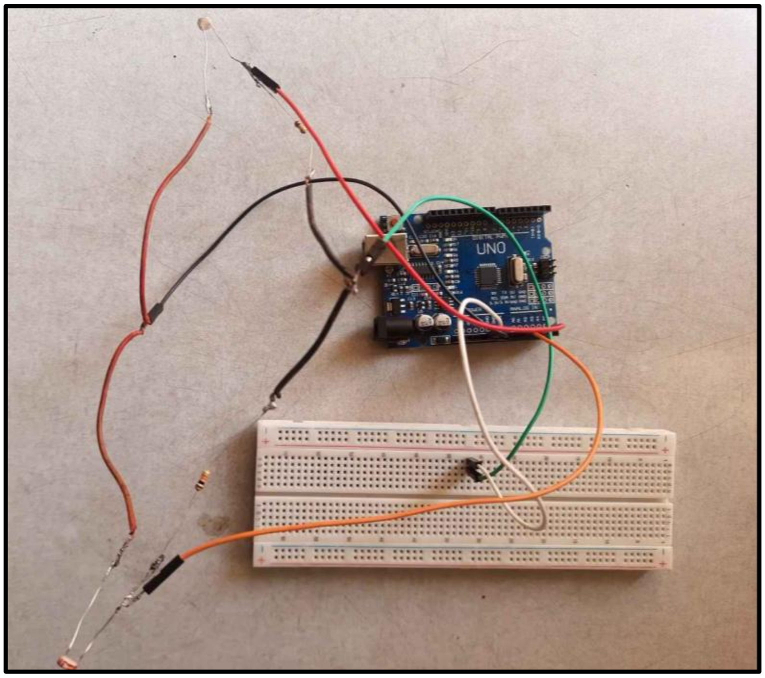

Figure 18:Connecting the Circuit to the Arduino

- **Power Supply:** Arduino was supplied either through the USB port.
- **LDR Circuits:**

  VCC (5V):

  - A purple jumper wire was connected from the Arduino's 5V pin to the breadboard's power rail, allowing the breadboard to distribute 5V.
  - A green jumper wire was connected from the breadboard's power rail to the LDR sensors and the servo motor, ensuring both received 5V.

GND:

- The black jumper wire was taken to connect the ground of the Arduino with one end of each of the fixed resistors on the breadboard.

- **Analog Pins:**

    - **A0:** The orange jumper wire was connecting from the join of LDR1 together with its resistor to port A0 at Arduino.
    - **A1**: The red jumper wire was used to connect the joint of LDR2, and their associated resistor reads on A1 terminal on the Arduino.

This deployment made it possible for the Arduino to have a chance to read Analog voltage of the LDRs with capability of light intensity measurement.

<u>Phase 3</u>: Servo Motor Connection:

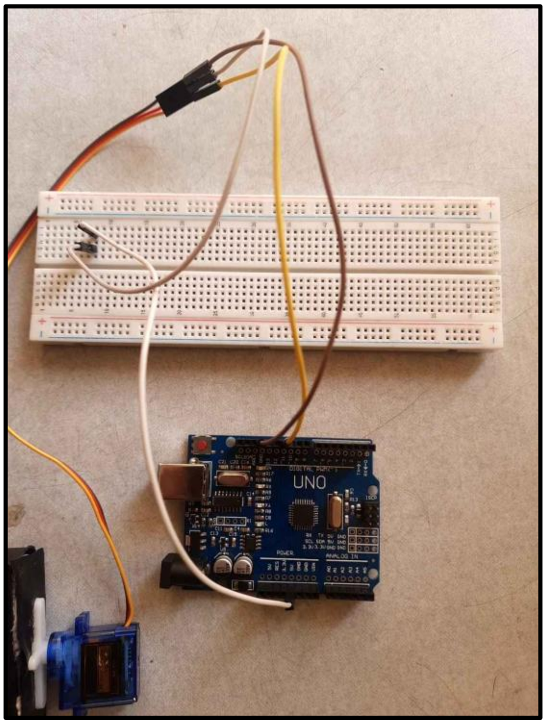

Figure 19:Servo Motor Connection

- **Jumper Wires to Servo Motor:**

    - Three jumper wires were connected to the servo motor:
        - **Signal Pin**: A jumper wire was used to join the signal pin to the servo motor to digital pin 11 on the Arduino. This configuration allowed Arduino to control servo motor through the PWM with the aid of digital pin 11 according to the data received from LDR sensors.

    - **VCC (5V)**:
        - A jumper wire connected the servo motor's power pin to the **breadboard's 5V rail**.

- **GND**:
  - Another wire inserted the ground pin of servo motor through a GND pin on the Arduino board.

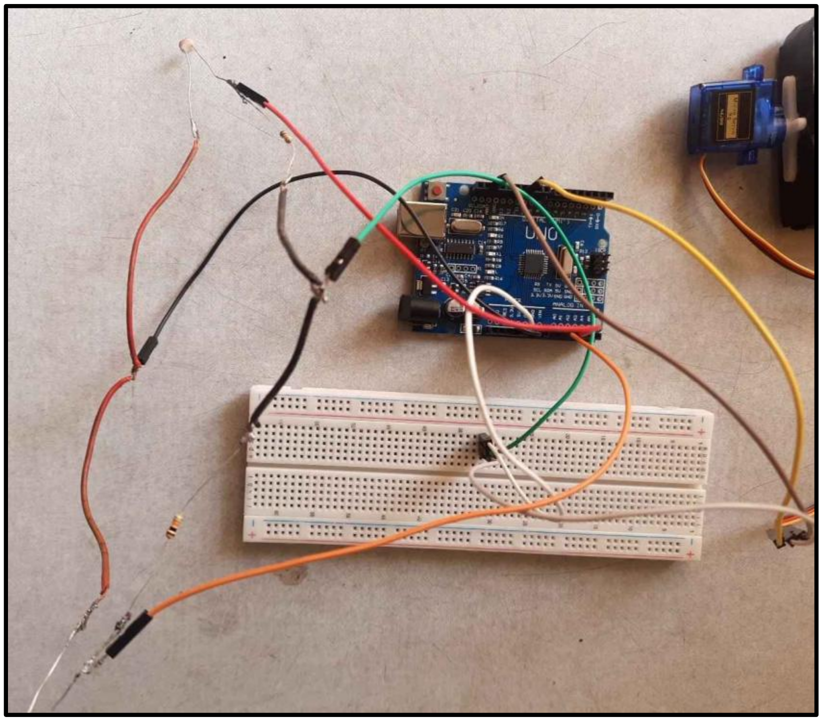

Figure 20:Final Circuit Connection

<u>Phase 4:</u> Coding the Arduino

Figure 21:Coding the Arduino

The Arduino was programmed to directly control the rotation of the servo motor via the LDR sensor which measures the level of light in the atmosphere.

- **Uploading the Code:**
    - Writing of the code was done using the Arduino IDE and then uploaded to the Arduino board via USB cable.
    - The serial monitor was used to verify the readings and debug the system during testing.

4 RESULT AND FINDINGS

An academic version of the Solar Tracking System proved feasible in orientating the solar panel's position whenever the light's intensity fluctuates. By utilizing LDRs, the system was able to sense light changes while an Arduino controlled servo motor turned the panel in a position that allows for the best light harvesting.

It was sampled under artificial test conditions using a torchlight to set the panel against the brightest artificial light source to gain movement of the sun. The tests showed how it is possible to use sensors, a servo motor and Arduino in IoT applications for renewable energy. Real time light tracking was proved, and the prototype gave ideas on the improvement of such a system specifically for use in renewable energy technologies.

Testing:

4.1 Test 1: To compile the code and upload it.

Test	**1**
Objective	To upload and compile the code on Arduino Uno microcontroller.
Activity	• Compiled the code using the Arduino IDE. • Attempted to upload the compiled code to the Arduino Uno.
Expected Result	This code should compile and upload to the Arduino Uno without error which will allow the solar tracking system.
Actual Result	The upload process failed with the following error: • avrdude: ser_open(): can't set com-state for "\\.\COM5" • Error message: Failed uploading: uploading error: exit status 1.
Conclusion	The test was unsuccessful due to an issue with the serial port connection. Potential causes include: • COM port chosen in Arduino IDE not corresponding to the port of the Arduino board. • Another program using the same COM port, therefore the problem arises from a conflict.

Table 1:Test to compile and upload the code

<u>Output:</u>

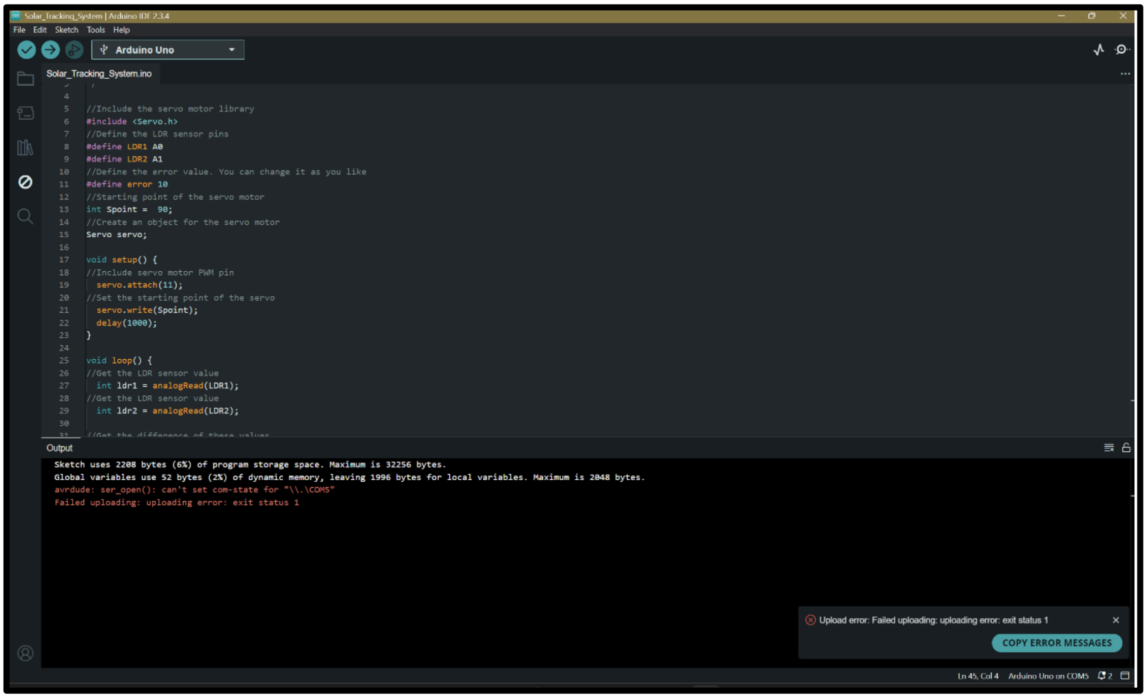

Figure 23: Arduino IDE showing upload error

4.2 Test 2: Execution of the code

Test	**2**
Objective	To upload and execute the Solar Tracking System code on an Arduino Uno microcontroller.
Activity	• Compiled the Solar Tracking System code using the Arduino IDE. • Uploaded the compiled code to the Arduino Uno. • Observed the servo motor and LDR sensor functionality.
Expected Result	The code uploads and the servo motor operates depending on LDR sensor input in order to follow the light.
Actual Result	The code uploaded successfully, and the servo motor adjusted its position according to the LDR sensor readings as expected.
Conclusion	The test was successful. The Solar Tracking System code worked as intended.

Table 2: Code Functionality test

Output:

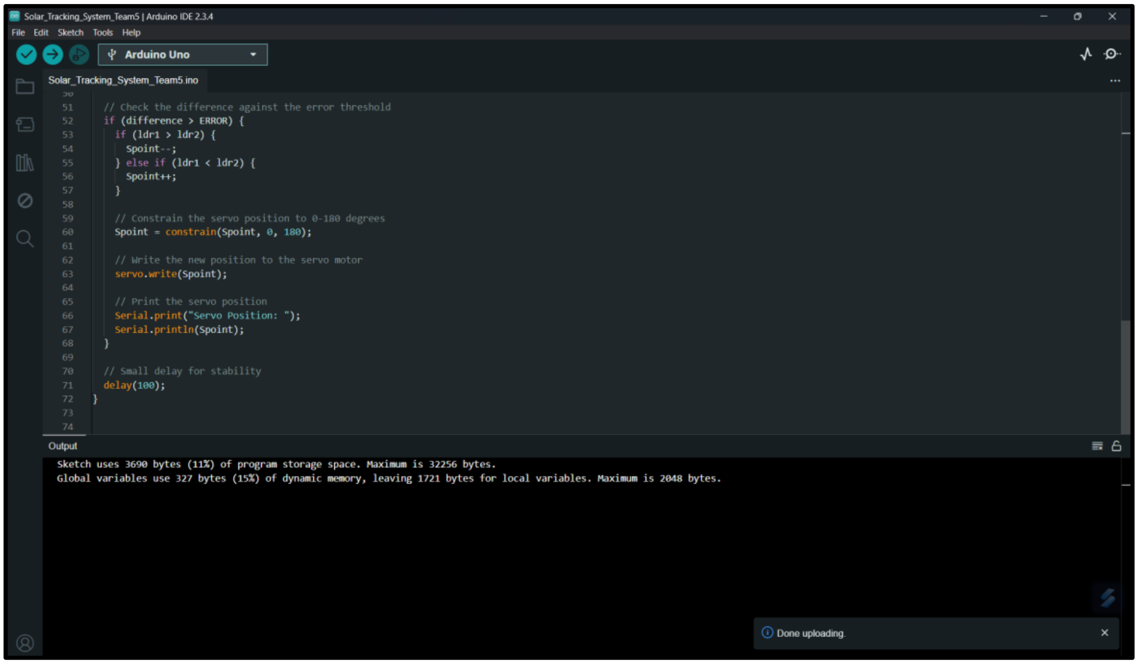

Figure 24:Successfully uploaded the code

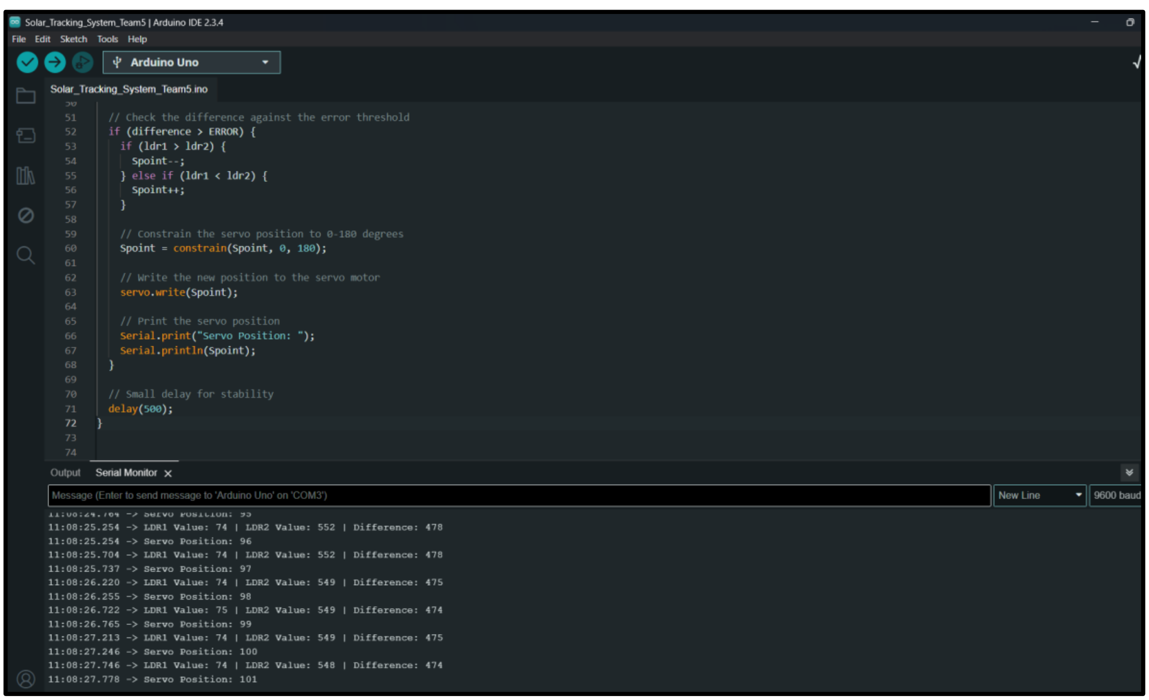

Figure 25:Successful execution of the code

4.3 Test 3: Sensor Calibration (LDRs)

Test	3
Objective	To calibrate the LDR sensors for optimal light detection in the Solar Tracking System.
Activity	• Uploaded the Solar Tracking System code to the Arduino Uno. • Monitored sensor readings for different light intensities. • Adjusted the threshold values in the code to ensure accurate tracking.
Expected Result	The LDR sensors should succeed in identifying and measuring the changes in the intensity of light and the servo motor should act accordingly.
Actual Result	The sensors were calibrated successfully, with consistent and accurate readings across different light intensities. The servo motor adjusted its position accordingly.
Conclusion	The test was successful. Sensor calibration ensured precise light detection and motor control.

Table 3: Sensor Calibration test

Output:

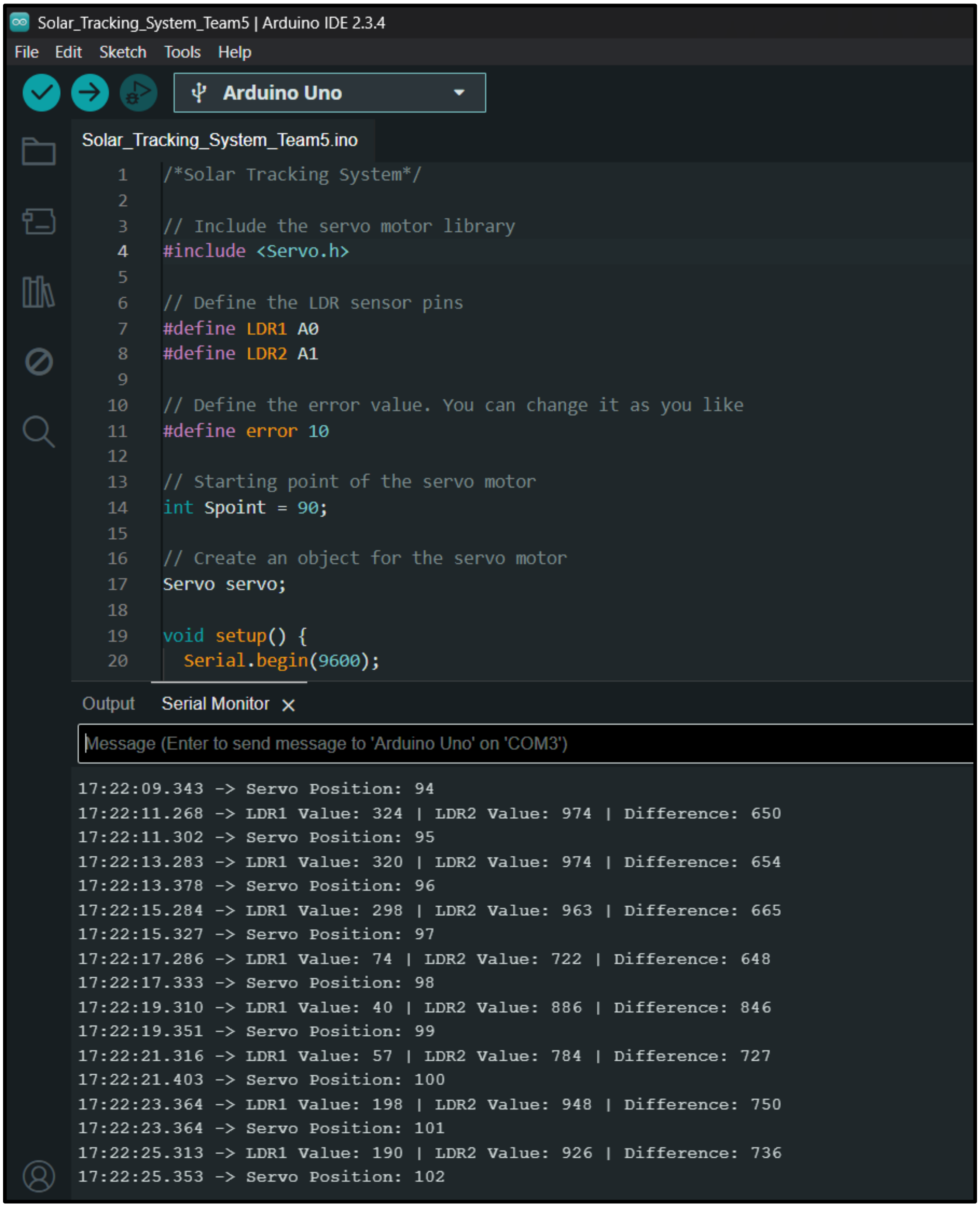

Figure 26:Output of the Light Dependent Resistor displayed on the Serial Monitor

4.4 Test 4: Servo Motor Movement

Test	**4**
Objective	To verify the movement of the servo motor based on LDR sensor inputs.
Activity	• Uploaded the Solar Tracking System code to the Arduino Uno. • Observed the servo motor's movement in response to light intensity changes detected by the LDR sensors.
Expected Result	The servo motor should rotate smoothly to align with the direction of maximum light intensity.
Actual Result	The servo motor moved accurately and smoothly to track the light source based on LDR sensor readings.
Conclusion	The test was successful. The servo motor responded correctly to sensor inputs, ensuring accurate light tracking.

Table 4: Servo Motor movement test

Output:

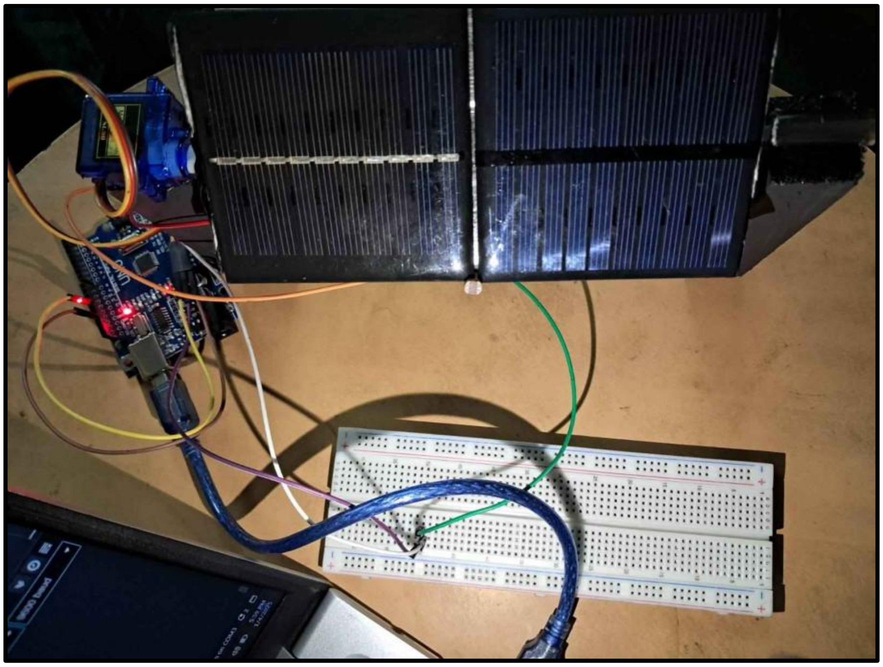

Figure 27:Servo motor test, turning the solar panel to the left

Figure 28:Servo motor test, turning the solar panel to the right

5 FUTURE WORKS

As for future research, the Solar Tracking System is to be developed in its efficiency, effect on the environment, and energy demand. Some changes include incorporating the system with a Smart Grid through direct information sharing with a central energy command system. This would mean that any additional energy could be either stored or put back into the power system.

A transition from Arduino to Raspberry Pi is recommended for dealing with higher-frequency connections, massive quantities of sensor data, and composite tracking algorithms. Another upgrade is the dual-axis tracking, which adds extra motors and sensors to raise the output by 25- 35%.

A mobile application and web option enables monitoring and controlling the generation of energy, position of the panels, and other maintenance-related tasks. AI could work to improve performance by using past data to predict the weather and then readjust the positioning of panels.

These advanced improvements of the system are expected to enrich the capabilities of the systems, its reliability and modularity, especially in off-grid areas, such as Nepal, increasing the usage of solar energy and access to electricity.

6 CONCLUSION

The purpose of this coursework is to design and evaluate a Single Axis Solar tracking system to improve the efficiency of solar energy systems. While working on this project, we were able to understand IoT systems and their applications in daily life as well as their possible connections for solving daily problems.

Evaluating the Single Axis Solar Tracking System in combination with Arduino technology provides the right approach to increase the efficiency of solar energy in Nepal. It turns the solar panel to face the sun all through the day and therefore it gathers a lot of sunlight and therefore produces more power than those other panels mounted in a single post.

This project mainly focuses on Nepal, which heavily relies on inefficient and polluting energy sources such as biomass and fossil energy. Due to differential tracking performance, the solar tracking minimizes energy wastage as well as the emission of green gases and aims at enhancing rural electricity supply. Addressing these minor difficulties and subsequent refining of the system makes it a potential standard solution for solar energy systems around the globe.

Accordingly, this coursework showed the feasibility of having a Single Axis Solar tracking system which could completely transform the use of solar energy in Nepal. The Solar tracking system not only improves the efficiency of the solar power, but it also successfully starts transforming Nepal for the use of more environmentally friendly energy and commendable energy for the future use.

7 References

Apoorve, 2015. *What is a Servo Motor? - Understanding the basics of Servo Motor Working.* [Online] Available at: https://circuitdigest.com/article/servo-motor-working-and-basics [Accessed 28 November 2024].

Arduino Docs, 2024. *Arduino Docs.* [Online] Available at: https://docs.arduino.cc/ [Accessed 28 November 2024].

Aryal, P., 2024. *Neglected solar energy in Nepal: Capitalizing on the nation's sunlit potential,* s.l.: Setopati.

Hakan Alici, B. E. O., 2021. In: *Design, Analysis, and Applications of Renewable Energy Systems.* s.l.:Academic Press, pp. 165-184.

Hemmings, M., 2018. *What is a Jumper Wire?.* [Online] Available at: https://blog.sparkfuneducation.com/what-is-jumper-wire [Accessed 28 November 2024].

IEA, n.d. *Sources of electricity generation.* [Online] Available at: https://www.iea.org/countries/nepal/electricity [Accessed 29 November 2024].

Javatpoint, 2024. *Arduino IDE.* [Online] Available at: https://www.javatpoint.com/arduino-ide [Accessed 28 November 2024].

JavaTpoint, 2024. *Arduino LDR.* [Online] Available at: https://www.javatpoint.com/arduino-ldr#:~:text=It%20is%20defined%20as%20a,as%20intensity%20of%20light%20increases.
[Accessed 28 November 2024].

JavaTpoint, 2024. *Arduino UNO.* [Online] Available at: https://www.javatpoint.com/arduino-uno [Accessed 29 November 2024].

Karki, S. K., 2021. International Journal of Scientific and Research Publications. *Solar Energy Potential in Nepal: A Meta-Analytic Review* , 11(5), p. 416.

Koons, E., 2024. *Renewable Energy in Nepal: Building A Sustainable Future.* [Online] Available at: https://www.climateimpactstracker.com/renewable-energy-in-nepal-building-a-sustainable-future/
[Accessed 20 December 2024].

Koons, E., 2024. *Solar Energy in Nepal: Why It's Important?.* [Online] Available at: https://www.climateimpactstracker.com/solar-energy-in-nepal/#:~:text=The%20Current%20Solar%20Energy%20Landscape,of%20solar%20energy%20is%20captured.
[Accessed 24 November 2024].

Kuchta, D. D. M., 2021. *Solar Trackers Explained: How It Works, Pros and Cons.* [Online]
Available at: https://www.treehugger.com/solar-trackers-explained-5189463
[Accessed 5 January 2025].

Lohani, S. P., 2023. Sustainable Development. *Current status, prospects, and implications of renewable energy for achieving sustainable development goals in Nepal,* 31(1).

Mr.Solar, 2024. *What Is A Solar Panel?.* [Online] Available at: https://www.mrsolar.com/what-is-a-solar-panel/ [Accessed 28 November 2024].

Mybotic, 2024. *Resistor 0.5 Watt 10k ohm.* [Online] Available at: https://mybotic.mta6.sitegiant.me/resistor-0-5-watt-10k-ohm [Accessed 28 November 2024].

Pokhrel, A., 2024. *Challenge in Land Aquisition and Mangagement for Solar Energy in Nepal.* [Online]
Available at: https://urjakhabar.com/en/news/1710546329
[Accessed 20 December 2024].

Sadek, R. A., 2018. An Agile Internet of Things based Software Defined Network Architecture. *Egyptian Computer Science Journal,* Volume 42.

Science Direct, 2024. *Embedded control fundamentals.* [Online]
Available at:
https://www.sciencedirect.com/topics/engineering/breadboard#:~:text=A%20breadboard%20is%20a%20board,conduct%20various%20experiments%20and%20projects.
[Accessed 28 November 2024].

Solar Square, 2022. *Solar Tracking System: Its Working, Types, Pros, and Cons.* [Online]
Available at: https://www.solarsquare.in/blog/solar-tracker/
[Accessed 5 January 2025].

Uptodown, 2024. *Tinkercad.* [Online]
Available at: https://tinkercad.en.uptodown.com/android
[Accessed 28 November 2024].

Wainer, J., 2024. *Download Microsoft Word for Windows: The iconic word processor is ready for action.* [Online]
Available at: https://microsoft-word.en.softonic.com/
[Accessed 28 November 2024].

8 APPENDIX

8.1 Problem Statement (Continued…)

Although advanced solar cells and solar photovoltaic systems can provide high conversion efficiency and generate electricity at high voltage, they remain expensive because of a lack of research, weak workforce, and inadequate money to purchase the necessary materials and avert mishaps of solar technologies. Apart from political constraints, legal and logistical challenges deter the formation of large-scale solar projects because of land acquisition (Pokhrel, 2024). It noted that lack of policy harmonization, excessive procedural formalities, and absence of fiscal incentives restrict investments in solar power projects (Aryal, 2024).

These constraints reduce the utilization of solar energy in Nepal to a significant extent and hinder its potential to make a convenient and sustainable solution to the energy demand in the country. Mitigating such setbacks is crucial in enhancing energy efficiency, lessening dependency on imported electricity, and complementing the country’s shift to a more sustainable energy regime.

8.2 Solar Tracking System as a solution (Continued…)

As a result of its being cheap and flexibility, the solar tracking system offers a viable means of increasing the scale of solar power utilization in Nepal. This project leads to the growth of green renewable energy sources and an effective power generation in the power-starved country.

In addition, it helps to eliminate the problem of energy poverty and enhance the quality of education and health, for example, in the rural area.

8.3 Hardware Components

8.3.1 Arduino UNO Board (Continued…)

Arduino UNO is a microcontroller board and is based on ATmega328P microcontroller. It has 14 digital I/O pins, 6 of the pins can be configured to act as PWM output pins, 6 analog pins, integrated 16 MHz ceramic resonator, USB connection, a power jack, ICSP header and a reset button. This circuit comprises of all components required for the microcontroller to operate as required. (Arduino Docs, 2024) .

8.3.2 Solar Panel (Continued…)

A solar panel or PV panel generates electricity from sunlight through photons. This electricity can then be used to power different essential devices. Solar power is cost friendly and is highly efficient in providing power for various uses (Mr.Solar, 2024).

8.3.3 Servo motor (Continued…)

A servo motor is a high accurate motor that has been designed to turn to given positions or degrees. It incorporates a control circuit that supplies feedback information relative to the position of the motor shaft thus allowing for accurate motion. The accuracy makes servo motors suitable for rotating objects to certain degree or position. In particular, it is just a common motor with an attached servo motor (Apoorve, 2015).

8.3.4 LDR Sensor x 2 (Continued…)

The Sensor X2 includes an improved photonic detection system and an aluminum body suitable for frequent trips. It also has provision for manual measurement and simple installation if used with an automated system. This guarantees it meets international standards due to its small aperture angle. Lastly, an extra utility is that there is an acquisition key on the sensor and in the user interface in the base unit (JavaTpoint, 2024).

8.3.5 Jumper wires (Continued…)

Jumper wires are regular wire with male pins at two ends, commonly used to make connections without having to solder. They are normally connected with breadboard and other tools for prototyping circuits which are easily modifiable (Hemmings, 2018).

8.3.6 10k resistor x 2 (Continued…)

A resistor is an electrical device that uses resistance as a circuit element and is always a two-terminal device. Carbon film resistors are used in a particular resistor form type that is also known as axial lead resistors. They are made of a ceramic carrier coated with a layer of pure carbon and serve as restive material. Resistors serve to limit the amount of current passing through circuits, and at the same time help to limit high voltages (Mybotic, 2024).

8.3.7 Breadboard (Continued…)

A breadboard is a kind of board on which wires, resistors, capacitors, coils, and other electronic items can be joined to solve different problems and create circuits (Science Direct, 2024).

8.4 Software Components

8.4.1 Arduino IDE 2.3.4 (Continued…)

It helped us to learn how to send LDR values to the Arduino card, to analyze sunlight data received by the LDR, and how to control the position of the servo motor. It also used the serial monitor for debugging and verifying the system, making the IDE essential for development and testing.

Most components supported by the open-source Arduino Software (IDE) are also relatively easy to program and upload onto the board. It can be operated with any kind of Arduino board. Ongoing development of the Arduino software is done through the online service called GitHub (Javatpoint, 2024).

8.4.2 Microsoft Word (Continued…)

Microsoft Word is an efficient word-processing tool well known to be from Microsoft. It is a part of Microsoft office application series and provides the basic tools and options to write, edit, format, and print as well as distribute documents, offering a range of features and tools to create, edit, format and share (Wainer, 2024).

8.4.3 Tinkercad (Continued…)

We could upload and run the Arduino code within the simulation to observe how the system would behave. This allowed us to troubleshoot and make circuit adjustments and code adjustments in a risk-free environment, ensuring the design worked as intended before assembling the actual hardware.

Tinker cad provides a good ground of those people who are ready to begin a journey through the world of 3D designers, electronics, and coding, offering users the opportunity to unleash their creativity with the help of the program (Uptodown, 2024).

8.5 Source Code

```
/* Solar Tracking System */

// Include the servo motor library
#include <Servo.h>

// Define the LDR sensor pins
#define LDR1 A0
#define LDR2 A1

// Define the error value. You can change it as you like
#define ERROR 10

// Starting point of the servo motor
int Spoint = 90;

// Create an object for the servo motor
Servo servo;

void setup() {
```

```
  Serial.begin(9600);

  // Attach servo motor PWM pin
  servo.attach(11);

  // Set the starting point of the servo
  servo.write(Spoint);
  delay(2000);

  // Initial message
  Serial.println("Solar Tracking System Initialized");
}

void loop() {
  // Get the LDR sensor values
  int ldr1 = analogRead(LDR1);
  int ldr2 = analogRead(LDR2);

  // Print LDR values to the Serial Monitor
  Serial.print("LDR1 Value: ");
  Serial.print(ldr1);
  Serial.print(" | LDR2 Value: ");
```

```
Serial.print(ldr2);

// Calculate the absolute difference between the LDR values
int difference = abs(ldr1 - ldr2);

// Print the difference value
Serial.print(" | Difference: ");
Serial.println(difference);

// Check the difference against the error threshold
if (difference > ERROR) {
  if (ldr1 > ldr2) {
    Spoint--;
  } else if (ldr1 < ldr2) {
    Spoint++;
  }

  // Constrain the servo position to 0-180 degrees
  Spoint = constrain(Spoint, 0, 180);

  // Write the new position to the servo motor
  servo.write(Spoint);
```

```
    // Print the servo position
    Serial.print("Servo Position: ");
    Serial.println(Spoint);
  }

  // Small delay for stability
  delay(100);
}
```

8.6 Extra Design diagrams

Team Members	Core Responsibilities	Contribution
Sanniva Shakya	**Proposal:** Introduction and Individual contribution plan and Abstract. **Application Implementation:** Firmware setup to connect between the components. **System Development Report:** System Overview and Design Diagrams. **Presentation:** Working mechanism of the code.	25%
Nigel Awale	**Proposal:** Aims/Objectives and Conclusion of the proposal. **Application Implementation:** Setting up hardware components and making connection between them. **System Development Report:** Development of the system. **Presentation:** Purpose and objectives of the project.	25%
Ayush Bhattarai	**Proposal:** Expected Outcomes and deliverables of the proposal. **Application Implementation:** Connecting the Arduino between different components. **System Development Report:** Extra design diagrams Results and Findings. **Presentation:** Working mechanism of the project.	25%
Priya Soni	**Proposal:** Requirement Analysis of the proposal and Appendix. **Application Implementation:** System testing results and debugging. **System Development Report:** Future Works and Conclusion. **Presentation:** Exception of the project.	25%

Figure 29:Individual Contribution Plan

8.7 Visual Representation of Our Prototype

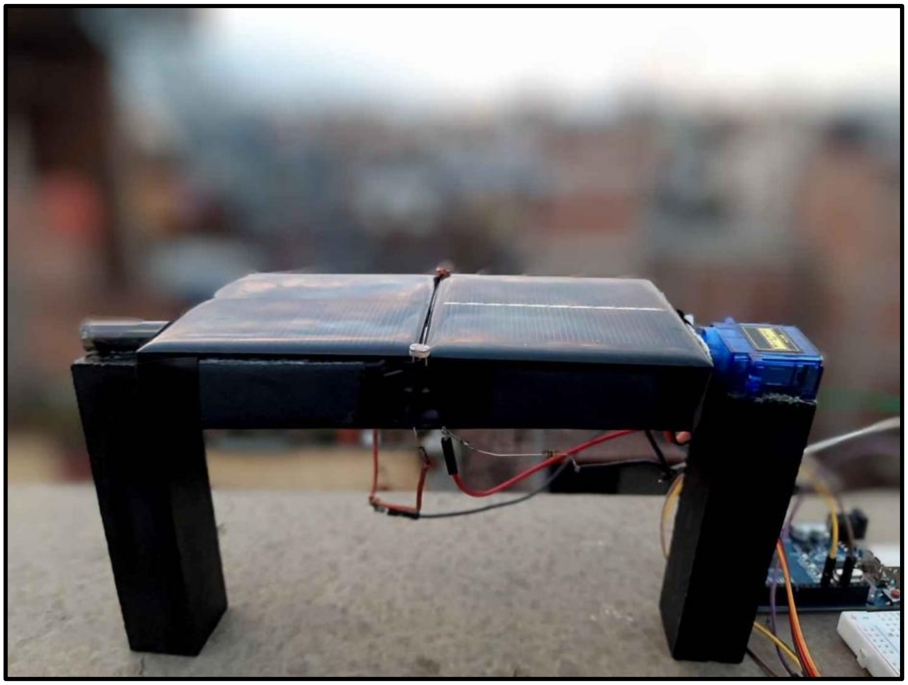

Figure 30:Solar Tracking System Prototype

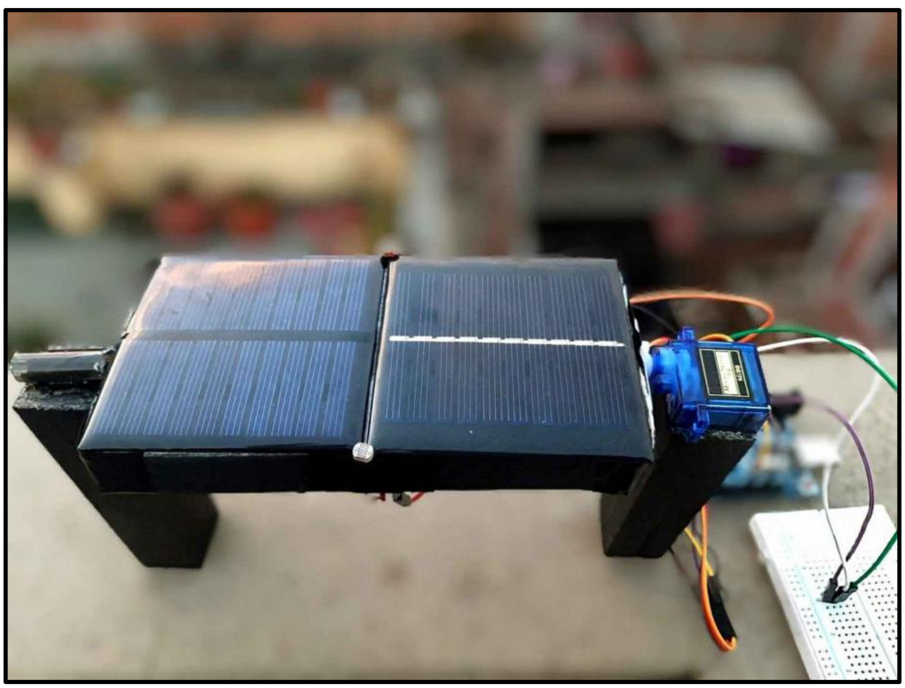

Figure 31:Solar Tracking System Prototype II