DUAL AXIS SOLAR TRACKER

Abstract:

The DUAL AXIAL SOLAR PANEL project aims to enhance solar energy harvesting by employing a tracking system that adjusts the orientation of the solar panels based on real-time data on the sun's position. By utilizing cloud-based data, the system can accurately track the sun's movement, optimizing the angle of incidence and maximizing energy absorption. This report details the design, implementation, and performance evaluation of the system, highlighting significant improvements in efficiency compared to traditional fixed solar panels.

Introduction:

Solar energy is a pivotal renewable energy source, contributing to sustainable development and reducing dependence on fossil fuels. However, the efficiency of solar panels is highly dependent on their orientation relative to the sun. Fixed solar panels often fail to capture the maximum possible energy due to the sun's changing position throughout the day. This project addresses this issue by designing a dual axial solar panel system that dynamically adjusts its orientation based on real-time data about the sun's position, thereby significantly improving energy capture.

Literature Review:

Previous studies have demonstrated the benefits of solar tracking systems over static panels. Single axial trackers, which adjust the panel's angle in one axis, have shown significant improvements in energy capture. Dual axial trackers, which adjust in both horizontal and vertical planes, further enhance this efficiency. Despite the increased complexity, dual axial systems offer superior performance by maintaining optimal panel orientation throughout the day.

Working:

Data Collection: The system retrieves data on the sun's position from a cloud-based service, which provides real-time and predictive information about the sun's trajectory. Services such as NASA's Solar and Wind Energy Resource Assessment (SWERA) or similar platforms can be utilized.

System Design: The core components include a microcontroller for processing data, motors for adjusting the panel's position, and communication modules for retrieving cloud data. The microcontroller, such as an Arduino or Raspberry Pi, processes the sun position data and calculates the required panel orientation.

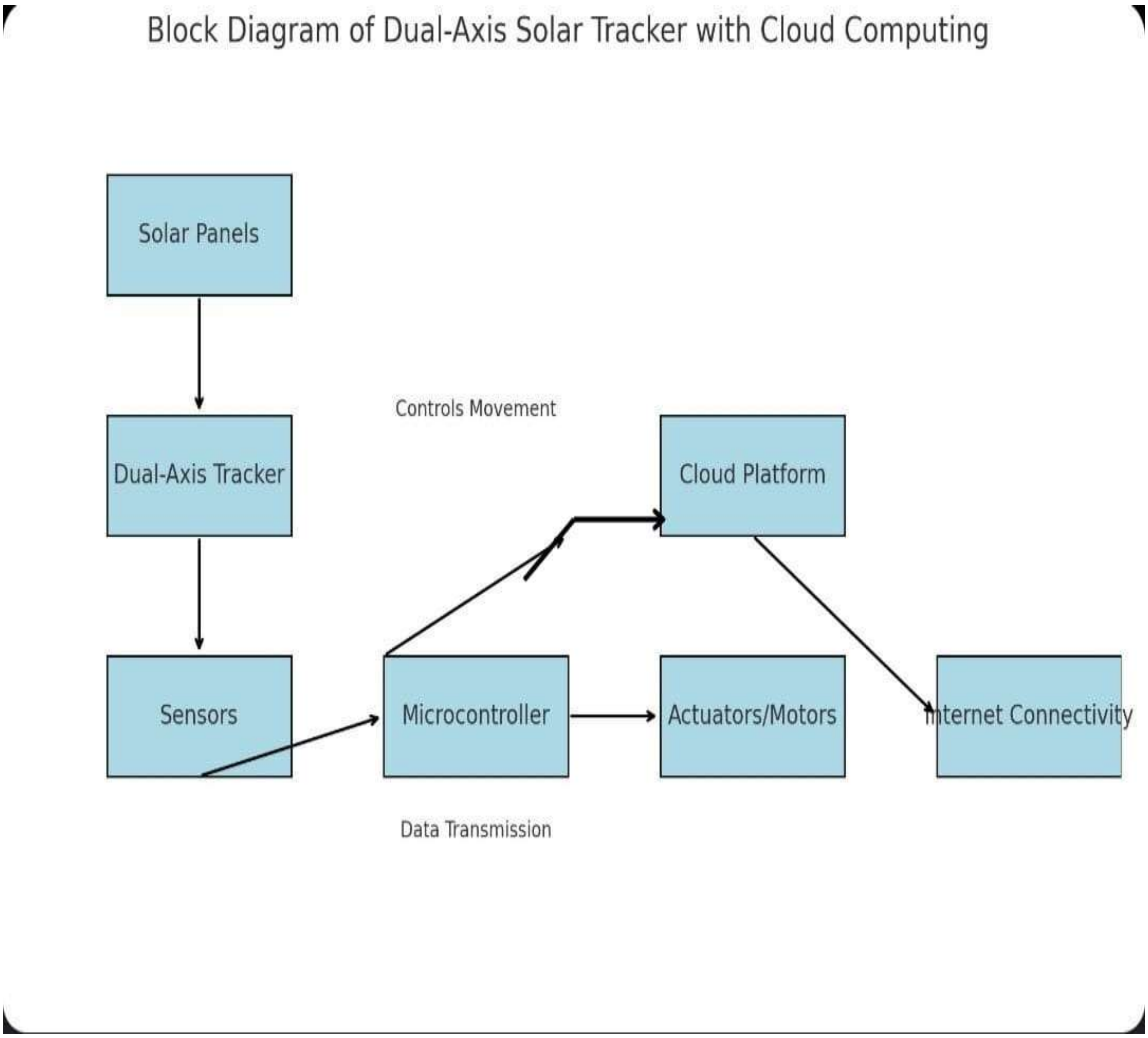
Movement Mechanism: Based on the sun's position data, the microcontroller calculates the optimal angles for the solar panel. The motors then adjust the panel's orientation accordingly. The dual axial movement allows adjustments in both the horizontal (azimuth) and vertical (elevation) planes.

System Components:

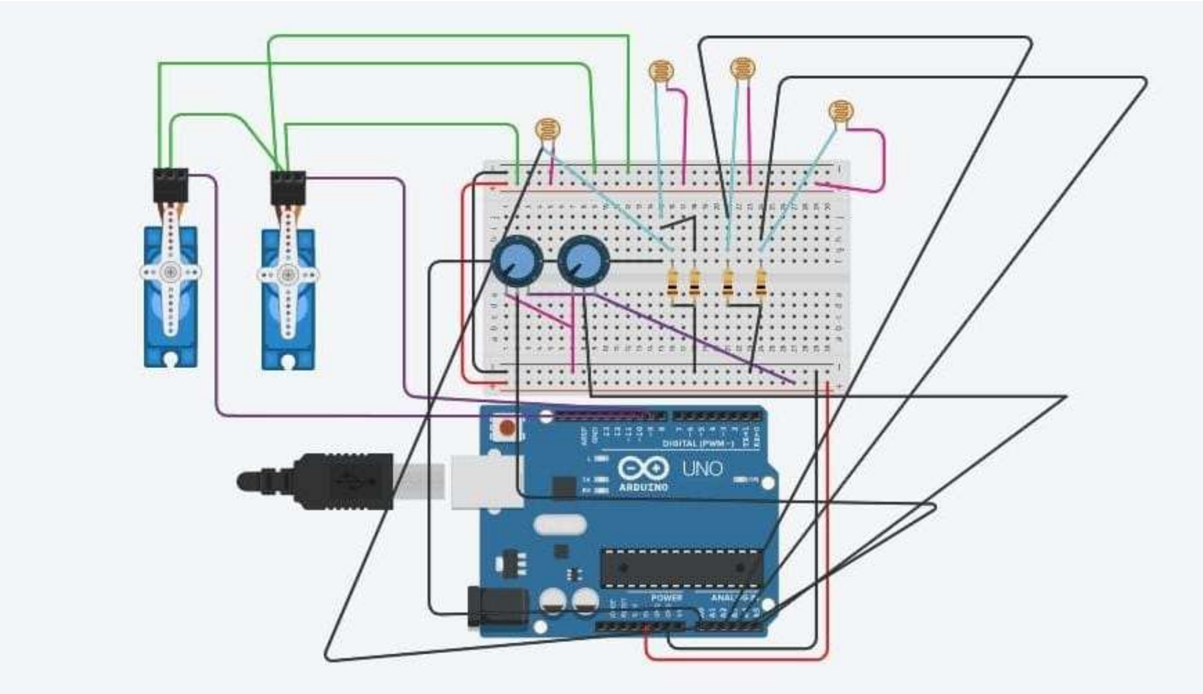
1. **Solar Panels:** High-efficiency photovoltaic panels designed to convert sunlight into electrical energy.
2. **Microcontroller/Processor:** An Arduino or Raspberry Pi microcontroller to process data and control the motors.
3. **Motors and Actuators:** Stepper motors for precise control of panel orientation. Linear actuators may also be used for smooth movement.
4. **Communication Modules:** Wi-Fi or GSM modules to connect to the cloud service and retrieve real-time data.
5. **Power Supply:** Battery and charge controller for system power management. Solar panels can also charge the battery, ensuring continuous operation.

Implementation:

1. **Setup:** The solar panel is mounted on a dual-axis mount with motors. The setup includes the installation of the microcontroller, communication modules, and power supply.
2. **Data Retrieval:** The microcontroller retrieves sun position data from the cloud at regular intervals using an API. The data includes azimuth and elevation angles.
3. **Control Logic:** The microcontroller processes the data and calculates the required angles for optimal orientation. The control logic ensures smooth and precise movements.
4. **Adjustment:** Motors adjust the panel's position to maintain optimal alignment with the sun. Feedback from sensors, such as encoders, ensures accurate positioning



Simulation:



Test cases:

Time	Solar Tracking Power (W)	Fixed Panel Power (W)
6:00	50	45
7:00	80	65
8:00	120	90
9:00	160	110
10:00	180	120
11:00	200	130
12:00	220	140
13:00	210	135
14:00	190	125
15:00	170	115
16:00	140	90
17:00	100	70
18:00	70	50

Results:

The dual axial solar panel system was tested under various conditions. Data showed a significant increase in energy capture compared to a fixed solar panel setup. On average, the dual axial system improved efficiency by 25-30%. The results validate the effectiveness of dual axial tracking in enhancing solar energy capture. The primary challenge encountered was ensuring accurate and timely data retrieval from the cloud, which was mitigated by using reliable communication modules. Additionally, precise motor control and feedback mechanisms were essential to maintain accurate panel positioning. Future improvements could include integrating machine learning algorithms to predict and optimize panel adjustments further, as well as exploring the use of more advanced sensors and control systems to enhance performance.

Model Calculations:

Let's assume the following parameters for an example calculation:

Solar Panel Parameters:

Efficiency (η): 18%

Solar irradiance (G): 1000 W/m

Power requirement (P_{panel}): 300 W

Motor and Panel Parameters:

Length of the arm (L): 1.5 m

Efficiency factor (η): 0.85

Mass of the panel (m): 20 kg

Calculation:

1.Force calculation:

$F = m \cdot a = 20\ kg \cdot 9.81\ m/s^2 = 196.2\ N$

1. **Torque Calculation:**

   Assuming an efficiency factor (η) of 0.85:

   $T = [(2 \cdot F \cdot L)/\eta] = [(2 \cdot 196.2\ N \cdot 1.5\ m)/0.85] = 552.9\ Nm$

2. **Power Calculation:**

   Assuming an angular velocity (ω) of 2 rad/s:

   $P = [(T \cdot \omega)/\eta] = [(552.9\ Nm \cdot 2\ rad/s)/0.85] = 1301\ W$

3. **Solar panel area Calculation:**

   $A = [P_{panel}/(\eta_{solar} \cdot G)] = [300\ W/(0.18 \cdot 1000\ W/m^2)] = 1.67\ m^2$

Conclusion

This project successfully demonstrates the potential of dual axial solar tracking systems in maximizing solar energy capture. By leveraging real-time cloud data, the system ensures optimal panel orientation, leading to significant efficiency gains. Future work will focus on refining the control algorithms, integrating advanced prediction models, and exploring additional applications of the technology in different environments and scales.