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Advancements in Dual-Axis Sun Tracking Solar Panels: Integration and Impact of Weather Sensors

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Abstract

In this document, the project suggests this article offers a thorough analysis of the technology, design, and control schemes of a rigid sensor-based dual-axis solar energy tracking system. The results of this inquiry will be valuable to solar energy technology scientists, engineers, and policy makers since they provide information about the most sophisticated dual-axis solar tracking system using hard sensors. Its potential to enhance solar tracking performance is also explored, opening the door for more study and advancement in this area. When the output of the solar tracking system was examined and contrasted with the stationary or mounted solar panel, higher performance was discovered in terms of voltage, current, and power. It is shown that the sun tracking system makes even more sense in terms of optimising daylight for applications related to stargazing. The results showed that the dual axis solar tracking system produced an extra 10.53 watts of power when compared to installed (fixed) and single axis systems. components of computer code and hardware.

Keywords: Solar panels, servo motors, LDR (light dependent resistor), solar tracking devices, environmental conditions, declination angle

INTRODUCTION

By delivering real-time data on climatic variables including cloud cover, relative humidity, wind speed, and precipitation, these sensors enable solar tracking devices to adapt to changing environmental conditions. This integration is an essential breakthrough for both residential and industrial applications since it increases the efficiency and dependability of solar energy output. The technical details of weather sensor integration, dual-axis solar tracking, and their combined effects on energy generation will be covered in detail in the following sections of this study. It will also look at the benefits to the economy and environment, as well as the challenges and potential areas for advancement in this rapidly developing technology. The panel or reflector is moved by the positioning mechanism to face the sun at the best angles.

A concise and thorough review of the literature on dual-axis sun tracking solar panels with weather sensors is presented in this work. The following subjects are covered in the survey:

- *Analysis of requirements and research:* Collect specifications such as required tracking precision, reaction time, power consumption limitations, and requirements for weather monitoring.
- *Components of software and hardware:* The many software and hardware elements that make up the dual-axis sun tracking solar panel with weather sensor.

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- *Implementing the system:* Make thorough design drawings for all of the mechanical parts, such as the actuators, supports, and frame.
- *System performance:* Compare the solar panel system's energy output to that of fixed panels in various settings.

HOW THE EXCITING SYSTEM OPERATES

Since conductors are attached to both the positive and negative sides of a solar cell, when photons strike the cell they shake loose electrons from their atoms, creating an electrical circuit. In a circuit like this, electrons move, and we generate electricity. A solar array can be created by connecting multiple solar panels, or modules, together. A solar panel is made up of multiple cells. PV solar panels use direct current (DC) to generate electricity. Electrons flow in a single direction via a circuit to produce DC electricity. This illustration shows a lightbulb that is battery-operated. From the negative side of the battery to the positive side, the electrons move through the appliance and back. Similar to an engine cylinder in an automobile, electrons are pushed and pulled to produce AC (alternating current) energy. This motion occurs on a regular basis. Generators spin a coil of wire near to a magnet to produce AC electricity. The generator will switch the handle using a variety of energy sources, including hydroelectricity and petrol or diesel fuel [1].

PARTS AND THEIR FUNCTIONS

Solar energy is developing to fulfil our ever-increasing energy needs as a sustainable, non-polluting energy source for the future. The Arduino Microcontroller, four LDRs, and three stepper motors are the key components of the Arduino prototype-based automatic sun tracking system. The machine is operated by a combination of firmware programming and hardware [2–4]. In hardware manufacture, four light-based resistors (LDRs) are employed to catch the maximum amount of incident light. Three stepper motors are utilised to move the solar panel in accordance with the amount of incident light detected by the LDRs.

Selection of Components

For dual-axis movement, select the right actuators by taking torque, speed, and precision into account [5]. Choose sensors to monitor the weather (temperature, humidity, wind speed), as well as the position of the sun (light sensors, GPS, etc.).

Sunlight Panels

Turn sunlight into electrical power is your role.

Direct current (DC) power is produced by photovoltaic cells when they are exposed to sunlight.

Two-Axis Tracker

Role: Modify the solar panels' orientation to track the sun's path.

This mechanism maintains the panels at their ideal angle to the sun by allowing rotation around two axes: elevation and azimuth.

Tiny Controller

Using the input data, control the dual-axis tracker's movement. A central processing unit (CPU) is responsible for analysing sensor data and sending commands to the motors that drive the tracker.

Actuators, or Motors

Function: Move the solar panels physically in response to commands from the microcontroller.

Description: Precise orientation adjustments of the panel are made possible by electric motors attached to the tracker [6–8]. The solar azimuth and zenith angles are determined by this algorithm. The solar panel or reflector is then positioned to face the sun using these angles. While some algorithms use real-time light-intensity observations, others are entirely mathematical and based on astronomical references.

Photodiodes, or Light Sensors

Sensors positioned on the panel's various sides track the sun's position and measure the amount of sunlight it receives. A basic overview of solar PV cells and the materials utilised in their manufacturing is given at the outset of this publication. The varieties of solar PV systems and solar tracking systems are also covered [9–11]. It primarily focusses on the numerous dual-axis tracking solar systems that have been developed recently, including their design and performance analysis. While the decision to employ trackers is primarily based on the topography of the area, this system has generally shown to be more effective and beneficial than its fixed and single-axis equivalents.

Sensors for the Weather

Function: Keep an eye on meteorological factors like temperature, humidity, wind direction, and precipitation. A group of sensors that feed the microcontroller with data in real time so that it can take preventative action in the event of bad weather.

Energy Source

Function: Supply power to the motors, sensors, and microprocessor. Described as a dependable power supply that frequently has a battery system to guarantee ongoing operation.

Module for Communication

Function: Enable data transmission between distant monitoring stations and system components. Wireless modules, like GSM or Wi-Fi, are used to send and receive commands. There are two types of positioning systems: hydraulic and electrical. Electrical systems move to intended functions by using encoders, linear actuators, and variable frequency motors to monitor the panel's present location.

THE LEVEL OF FREEDOM / THE DEGREE OF FREEDOM

The number of directions that independent movement is possible is represented by the degree of freedom. This has led to the classification of tracking systems into two categories: single-axis and double-axis solar tracking systems. However, let's first examine the many axes and angles that are significant to these tracking systems before moving on to this classification. These characteristics are crucial in determining the proper placements and directions.

Latitude is a measurement of a point's location on the surface of the earth that indicates how far north or south it is from the equator. As shown in Figure 1, it is measured in angles that range from 0° at the equator to 90° at the poles.

- The angle formed by the horizon and the line connecting the sun's and the earth's centres is known as the elevation/altitude angle.

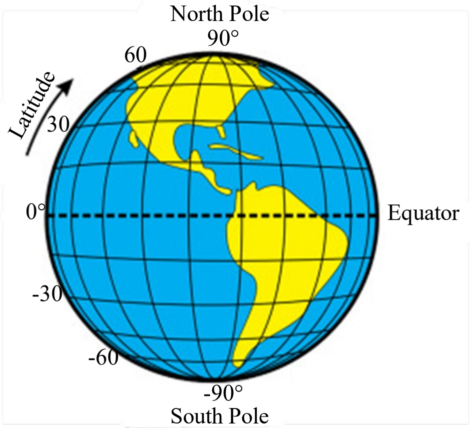

Figure 1. Latitude affecting sensor [12].

- The term "declination angle" refers to the angle that the equator of the earth is slanted with respect to the earth's orbit around the sun.
- The zenith angle, or simply z, is the angle formed by the vertical axis and the line connecting the sun's and the earth's centres.
- *Tilt Angle:* this is the angle formed by the PV solar panel and the horizontal axis.

PROPOSED METHODOLOGY

To guarantee the effectiveness and dependability of a dual-axis sun tracking solar panel with a weather sensor, a systematic approach is needed. The suggested approach for the proposed system is shown in Figure 2.

Our solution communicates the power output to the IoT system via the internet while continuously monitoring the solar panel. In this case, we use IOT to send solar power parameters to IoT via the internet. Now, it uses a user-friendly graphical user interface (GUI) to show these parameters to the user and warns them when the output drops below predefined thresholds. This guarantees the optimal power output and makes remotely monitoring solar systems very simple. A layer of omniphobic material will be placed to the solar panels to protect them from dust and wind, resulting in lower maintenance costs and downtime.

Ultimately, the goal of the project is to develop and put into use a hybrid dual-axis solar tracking system that tracks precisely and uses less motor power. After comparing the light intensity, the microprocessor generates the appropriate control signals to move the motors in the desired direction.

We incorporated weather prediction and online data display, including temperature and humidity, into our model. These components are connected via a Wi-Fi module, allowing us to view all kinds of data on our mobile application. It recognise the fundamentals of dual axis tracking systems and solar tracking and collect specifications such as required tracking precision, reaction time, power consumption

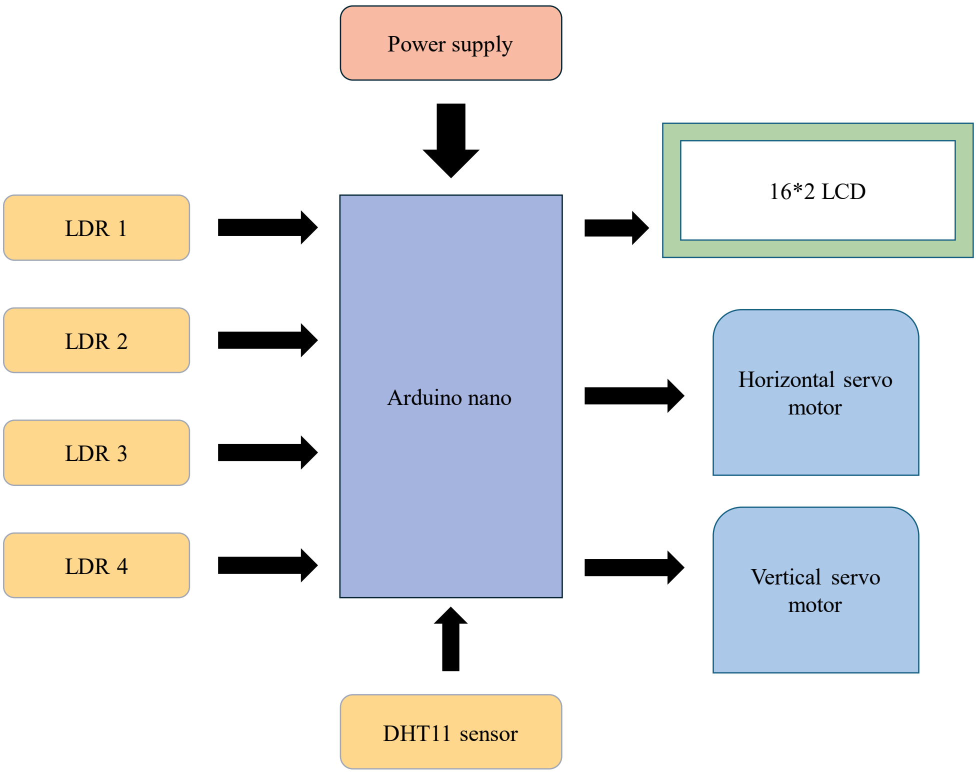

Figure 2. Block diagram of the project.

limitations, and requirements for weather monitoring. Produce comprehensive design drawings for all mechanical parts, such as actuators, supports, and frames. Construct a solar panel system prototype that combines electrical and mechanical components. Using sensor data, creation of software algorithms for tracking the sun could be done. Optimisation and Refinement of the system for determine areas in which user can improve depending on the findings of user performance review.

Component Choice

Select high-efficiency solar panels that are appropriate for the anticipated levels of sunshine. Choose a dual axis tracking system that is sturdy and has dependable actuators and motors. Incorporate precise weather sensors and light sensors with great sensitivity.

Designing Circuits and Programming Microcontrollers

Create the control circuit that links the motors, sensors, and microcontroller. It involves creation of software for the microcontroller so it can process sensor data and move the tracker in the desired directions. We could put weather condition reaction and sun tracking algorithms into practice.

Testing and Prototyping

Put together a prototype to evaluate the functionality of the system. Tests should be carried out to guarantee precise tracking of the sun and appropriate reaction to weather. On the basis of test findings, modify and improve the system. Based on test findings, modify and improve the system.

Combination and Setup

Combine the completed system's parts. Choose a spot for the system installation that receives plenty of sunshine. Make sure every component is installed firmly and shielded from the elements.

RESULTS

Install a monitoring system to keep tabs on operations and get maintenance requirement notifications. Plan routine maintenance to guarantee the longevity and effectiveness of the system. The upper view of the proposed system is shown in Figure 1. LCD is showing a message to welcome the user. The final attached prototype presented in Figure 3. While after experiment the LCD is showing the result as shown in Figure 4.

Because of its abundance and sustainability, solar power continues to be a top choice as the need for renewable energy sources grows globally. However, because they can't constantly line up with the position of the sun, conventional fixed solar panels sometimes have subpar efficiency. In order to solve

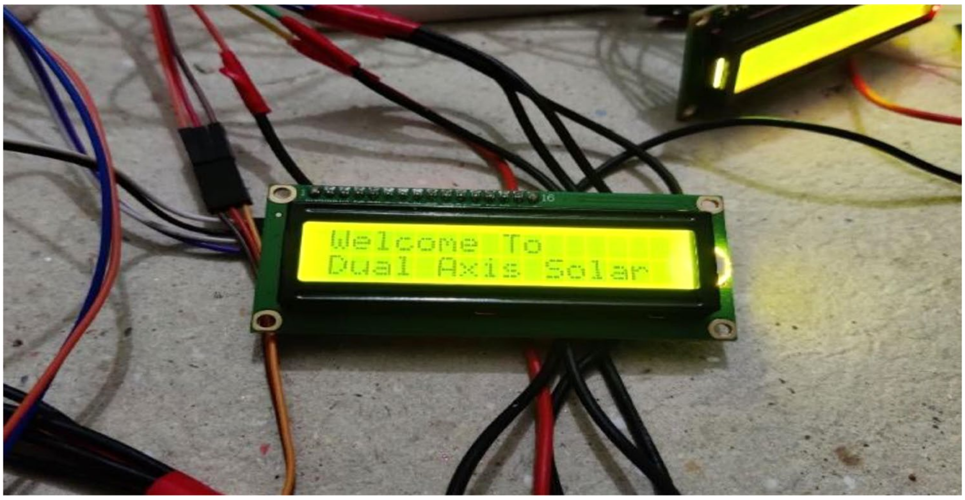

Figure 3. Upper view starting of the system.

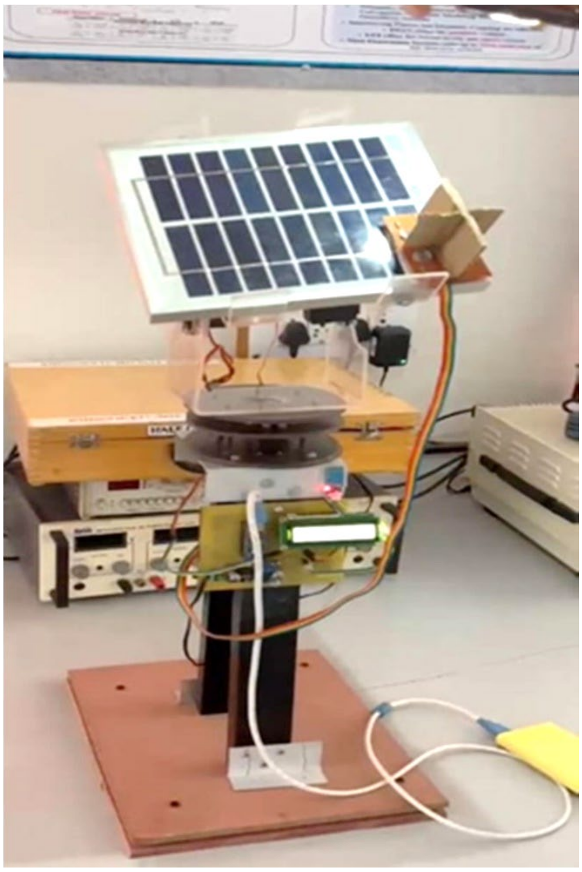

Figure 4. Output of dual axis solar panel.

Figure 5. Hardware results.

this problem and guarantee that the solar panels are always perpendicular to the sun's beams, dual-axis sun tracking systems allow the panels to rotate along two axes. By offering real-time data on external conditions, weather sensors integrated into these systems enable modifications that safeguard the panels and preserve energy production efficiency, significantly improving their performance.

ANALYSING AND MODELLING

The dual axis solar tracking system spins a stationary solar panel on a structure according to the sensor's determination of the sun's location. The Arduino's four analogue pins, A1, A2, A3, and A4, are connected to four resistors and four light-dependent resistors, accordingly, that are internally connected in a voltage divider arrangement. PWM inputs for the two servo motors are obtained from the Arduino's digital pins 9 and 10. LDRs are the main light detection devices. The servo motor is supported by two solar panels that are fixed to the structure. The Arduino program is uploaded to the microcontroller. The following is how the model functions: All the LDRs sense in the following ways: top, bottom, left, and right. It also detects the amount of sunlight falling on each LDR. To track north-south, the analogue values from two top and two bottom LDRs are compared. The direction of motion for the vertical servo is determined by how much light is received by the bottom set of LDRs. If more light is detected by the top LDRs, the servo motor moves in that direction.

CONCLUSION

After investigating a variety of technologies, technology in the contemporary day is always changing. The ease and comfort of our lives have increased with the development of technology. The energy crisis is among the most urgent problems facing Bangladesh, a rising nation. The production and demand of electrical energy differ significantly. A significant portion of the populace is completely excluded from this boon. The exclusive use of renewable energy can solve this issue. One of the most potent and promising renewable energy sources that has the potential to partially offset energy demand is solar energy. The proposed technology significantly enhances the performance of a dual axis tracker by accurately aligning with the sun's direction and recording its movement. Dual axis solar trackers maximise the conversion of solar irradiance into electrical energy output by maintaining high power capture rates throughout the observing period. Because a small modification to the single axis tracker led to a discernible improvement in system power, the suggested system is also reasonably priced. The simulation and testing of a dual axis solar tracker were successful, leading to an increase in the overall power collecting efficiency from the tracking devices using the same panel. Realistically speaking, this means that a system's total cost can be much lowered as a solar array and a solar tracking device together can provide a lot more power.

REFERENCES

1. V Mohanapriya, V Manimegalai, V Praveenkumar and P Sakthivel. "Implementation of Dual Axis Solar Tracking System" First International Conference on Circuits, Signals, Systems and Securities (ICCSSS 2020) 11th-12th December 2020, Tamil Nadu, India.
2. Awasthi A, Shukla AK, SR MM, Dondariya C, Shukla KN, Porwal D, et al. Review of sun tracking technology in solar PV system. Energy Reports. 2020; 6:392-405.
3. Amul Ghodasara, Manish Jangid, Hrishikesh Ghadhesaria, Harshil Dungrani Prof. Brijesh Vala, Prof. Ravi Parikh. "A IOT Based Dual Axis Solar Tracker with Power Monitoring System" Easy Chair preprints are intended for rapid dissemination of research results and are integrated with the rest of Easy Chair. February 27, 2021.
4. Tabassum Kanwal, Saif Ur Rehman, Tariq Ali, Khalid Mahmood, Santos Gracia Villar, Luis Alonso Dzul Lopez and Imran Ashraf. "An Intelligent Dual-Axis Solar Tracking System for Remote Weather Monitoring in the Agricultural Field". Published in 13 August 2023.
5. Arpita Borgave, Anirudh Yadav, Vrushabh Patil, Chetan Magdum,, Prasad Kumbhar, Prof. A. A. Malgave. "Dual Axis Solar Tracking System with Weather Sensors". International Journal of Scientific Research in Engineering and Management (IJSREM) | Volume: 07 Issue: 05 | May – 2023.
6. Manosroi W, Prompattra P, Kerngburee P. Performance improvement of two-axis solar tracking system by using flat-mirror reflectors. Energy Reports. 2020; 6:9-14.
7. Munanga P, Chinguwa S, Nyemba WR, Mbohwa C. Design for manufacture and assembly of an intelligent single axis solar tracking system. Procedia CIRP. 2020; 91:571-576.
8. Wissam Antoun, Ali Abdo, Suleiman Al-Yaman, Abdallah Kassem, Mustapha Hamad and Chady El-Moucary, "Smart Medicine Dispenser (SMD)", 2018 IEEE 4th Middle East Conference on Biomedical Engineering (MECBME), pp. 20-23, 2018
9. V. Dhukaram and C. Baber, "Elderly Cardiac Patients' Medication Management: Patient Day-to-Day Needs and Review of Medication Management System," 2013 IEEE International Conference on Healthcare Informatics, pp. 107- 114, 2013
10. World Health Organiztion, http://www.who.int/medicines/en/, accessed on Juy 21, 2017.
11. S. L. Gray, J. E.Mahoney, and D. K.Blough, "Medication Adherence in Elderly Patients Receiving Home Health Services following Hospital Discharge." Annals of Pharmacotherapy, 35(5), pp. 539-545, 2001
12. Stern DP. Latitude and longitude. Web page, NASA, Goddard Space Flight Center, Greenbelt, Maryland. 2004 Sep;17.

