Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 7s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Self-Adaptive Solar Panel

Dr. M. Sangeetha[1], Ms. C. Jayalakshmi[2], Ms. K.K. Janani Shree[3], Ms. M. Kabila[4], Ms. G. Kamalika[5], Ms. C.V. Vasishta[6]

[1]Professor, Department of Computer Science, Dr. N.G.P Arts and Science College, Coimbatore

Email ID: sangeethaseenivasan@gmail.com

[2,3,4,5,6] Student, Department of Computer Science, Dr. N.G.P Arts and Science College, Coimbatore

[2]Email ID: jayalakshmichandramouleeswaran@gmail.com,

[3]Email ID: jananishreekk2606@gmail.com,

[4]Email ID: mkabila2003@gmail.com,

[5]Email ID: kamalikag231cs022@gmail.com,

[6]Email ID: vasishtavairamani31@gmail.com

Cite this paper as: Dr. M. Sangeetha, Ms. C. Jayalakshmi, Ms. K.K. Janani Shree, Ms. M. Kabila, Ms. G. Kamalika, Ms. C.V. Vasishta, (2025) Self Adaptive Solar Panel. *Journal of Neonatal Surgery*, 14 (7s), 700- 707.

ABSTRACT

This project focuses on designing a self-adaptive solar panel system that optimizes energy efficiency by using Internet of Things (IoT) technology. The system integrates sensors, servo motors, and a microcontroller, allowing the panel to adjust its orientation dynamically in response to varying sunlight intensity and environmental conditions. Through real-time monitoring and control, enabled by an IoT platform, users can track and manage energy performance remotely. By overcoming the limitations of traditional fixed-position solar panels, this scalable solution enhances renewable energy utilization and contributes to environmental sustainability.

Keywords: *Solar energy, Arduino UNO, Light Dependent Resistor (LDR), servo motor, solar tracking system, photovoltaic system, Maximum Power Point Tracking (MPPT), real-time data processing, smart grid integration, sustainability, solar optimization, tilt angle adjustment.*

1. INTRODUCTION

The growing global energy demand and environmental concerns have led to the search for efficient renewable energy sources. Solar power is one of the most promising solutions due to its abundance and low environmental impact. However, conventional solar panels often lack dynamic adaptability to changing sunlight conditions [1]. To optimize energy generation, there is a need for an intelligent, self-adaptive solar panel system. This project aims to design a self-adjusting solar panel system using Arduino, which automatically adjusts its orientation based on real-time sunlight intensity, thus maximizing energy production and enhancing efficiency.

LITERATURE SURVEY

Several studies have explored methods for improving the efficiency of solar energy systems. Traditional solar panels are designed to operate at fixed orientations, which are suboptimal for maximizing sunlight capture throughout the day. Recent advancements have introduced tracking systems that adjust panel positions based on the sun's movement. These tracking systems are either manual or automatic, with the latter being more efficient [5].

Some studies have used sensors like Light Dependent Resistors (LDR) for automatic solar tracking. For instance, solar panel systems integrated with Arduino-based control systems have been employed to adjust the tilt angle based on LDR readings [2]. Additionally, IoT-enabled systems have been proposed for remote monitoring and control of solar energy systems, allowing for real-time performance tracking and system diagnostics.

3. RESEARCH METHODOLOGY

The project utilizes a combination of hardware and software components to build a self-adaptive solar panel system. The methodology involves the design of a solar panel that adjusts its tilt dynamically using feedback from light intensity sensors (LDRs). The system uses an Arduino UNO microcontroller, which processes sensor data to control servo motors that alter the panel's position [2]. The system also incorporates basic energy storage mechanisms, with a small solar panel to charge a 9V battery, providing power for the system.

To track the sun's position, two LDR sensors are employed. These sensors measure the intensity of sunlight on different sides of the solar panel, allowing the system to determine whether the panel needs to rotate to align with the sun. The Arduino is responsible for reading sensor data, calculating the panel's optimal angle, and commanding the servo motors to adjust its position accordingly [5].

2. OBJECTIVES

- **Design and Development:** Develop a self-adjusting solar panel system using an Arduino-based platform that can track the sun and optimize energy harvesting.
- **Automation:** Achieve automatic adjustments of the solar panel's orientation based on sunlight intensity, without human intervention.
- **Real-time Feedback:** Implement a system that uses LDR sensors to provide real-time data, enabling accurate adjustments for optimal solar energy capture.
- **Cost-Efficiency:** Build a solution that is affordable and scalable, with the potential for widespread use in residential and small-scale commercial applications.
- **Energy Independence:** Create a system that is energy-efficient and capable of operating off-grid, powered by the solar energy it generates.

3. METHODOLOGY

The project employs a microcontroller-based design using Arduino UNO for system control. The methodology includes the following steps:

i) Hardware Setup:

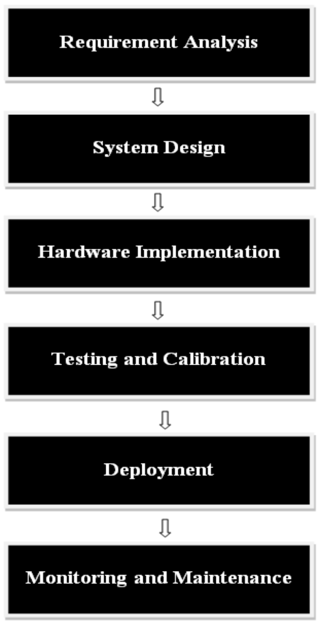
- The solar panel is used to generate electricity, which is then stored in a 9V battery.
- Two LDR sensors are placed on opposite sides of the solar panel to detect the intensity of sunlight. The sensors provide real-time data, which the Arduino processes.
- The servo motor adjusts the angle of the solar panel based on input from the LDR sensors. If one side detects more sunlight than the other, the servo motor rotates the panel to align with the sun.

ii) Data Processing and Control:

- The Arduino UNO reads data from the LDR sensors and uses a basic algorithm to calculate the appropriate tilt angle.
- The system uses PWM (Pulse Width Modulation) signals to control the servo motor, ensuring precise movements of the solar panel.

iii) Power Management:

- A 9V battery provides power to the system, which is recharged by the solar panel.A battery cap and power jack are used to connect the battery and ensure stable power supply for the Arduino and servo motor.



4. HARDWARE MODULES

i) Arduino UNO:

The heart of the project, used to process sensor data and control actuators. Arduino's open-source platform makes it cost-effective and easy to program. Power Supply: Powered by the 9V battery.

ii) Small Solar Panel:

Captures solar energy and converts it into electrical energy. The energy is stored in the 9V battery.

iii) Servo Motor:

A DC motor that is controlled by the Arduino to adjust the position of the solar panel, enabling the panel to track the sun's movement.

iv) Two LDR Sensors:

Measures the intensity of sunlight on the solar panel. The difference in intensity is used to adjust the panel's orientation.

v) Male to Male Jumper Wires:

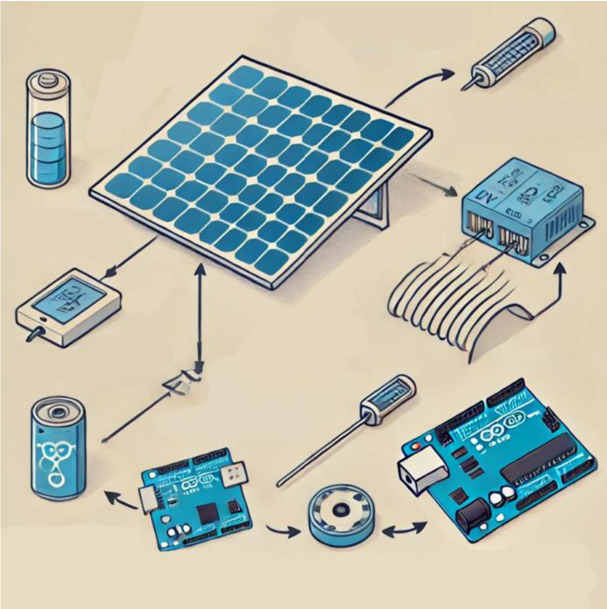
Used for making connections between the components (sensors, Arduino, servo motor).

vi) 9V Battery:

Provides the power for the system. It is charged by the solar panel and powers the microcontroller and servo motor.

vii) 9V Battery Cap and Power Jack:

Used to securely connect the battery to the circuit and provide stable power.



5. SOLAR POWER EFFICIENCY AND OPTIMIZATION TECHNIQUES

- **Solar Tracking Systems:** Detailed discussion on the two main types of solar tracking systems: single-axis and dual-axis. Explain how adjusting the panel's orientation toward the sun improves energy absorption [3].
- **Maximum Power Point Tracking (MPPT):** Discuss this advanced technique, which maximizes energy output by adjusting the load on the panel according to varying sunlight conditions [3].
- **Tilt Angle Optimization:** How different angles of tilt can affect energy generation based on geographic location and the time of year.

6. ENVIRONMENTAL IMPACT AND SUSTAINABILITY

This topic explores the broader benefits of solar power systems, especially in terms of sustainability. It can include:

1. **Reduction of Carbon Footprint:** Explain how solar energy can significantly reduce the dependence on fossil fuels and lower carbon emissions [1].

2. **Sustainable Design:** Discuss how using Arduino and small, self-contained systems reduces the environmental impact by eliminating the need for large-scale power generation infrastructure.
3. **Energy Storage for Off-Grid Systems:** Examine the importance of energy storage (using batteries) in off-grid applications and how it supports rural areas with no access to the electrical grid [5].

7. CHALLENGES AND LIMITATIONS

In this section, you can discuss the potential challenges faced when deploying self-adjusting solar panel systems

i) Power Consumption: The power consumption of the sensors, servo motors, and microcontrollers can sometimes be a limiting factor in battery-powered systems [2].

ii) Environmental Factors: How weather conditions, such as clouds or rain, could affect the performance of the solar tracking system [2].

iii) Cost and Complexity: While Arduino and sensors are affordable, the complexity of wiring, calibration, and maintenance could become challenges in larger systems [5].

iv) Maintenance: Considerations for maintenance, such as cleaning solar panels, checking servo motor functionality, and recalibrating sensors over time [5].

8. EXPERIMENTS AND RESULTS

Experiment 1: Solar Panel Orientation Adjustment Based on LDR Sensors

Objective:

To test whether the solar panel can dynamically adjust its orientation based on sunlight intensity detected by the LDR sensors.

Setup:

- Two LDR sensors are placed on opposite sides of the solar panel.
- The Arduino UNO is programmed to read the data from the sensors and adjust the servo motor's position accordingly.
- A small solar panel is connected to a 9V battery to power the system.

Procedure:

1. Set the solar panel at an initial position facing north.
2. Vary the light intensity on each sensor (e.g., by moving a light source) and monitor the servo motor's adjustment.
3. Observe if the servo motor adjusts the panel's position to maintain optimal sunlight exposure.

Expected Results:

- The system should dynamically adjust the solar panel's position, keeping it aligned with the maximum light intensity.
- The servo motor should rotate the panel towards the brighter side, improving the energy capture.

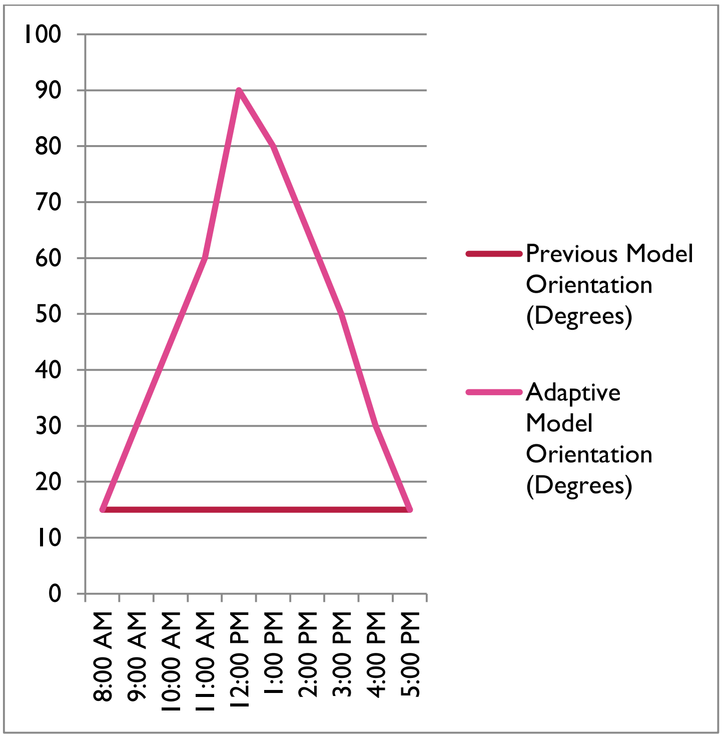
Table 1:

Time (Hours)	Previous Model Orientation (Degrees)	Adaptive Model Orientation (Degrees)
8 AM	15	15
9 AM	15	30
10 AM	15	45
11 AM	15	60
12 PM	15	90
1 PM	15	80
2 PM	15	65
3 PM	15	50

4 PM	15	30
5 PM	15	15

This table 1 compares the orientation of the **fixed solar panel** (previous model) and the **self-adaptive panel** at different times of the day.

Figure 1:



This figure 1 illustrates the differences in panel orientation between the fixed and adaptive models.

- The X-axis represents time of the day (hours).
- The Y-axis represents the panel's tilt angle (degrees).
- The self-adaptive model dynamically adjusts its orientation based on sunlight intensity, while the fixed model remains static at 15°.

Experiment 2: Energy Output Comparison: Fixed vs. Adaptive Solar Panel

Objective:

To compare the energy output of a fixed solar panel vs. an adaptive solar panel system that adjusts its orientation.

Setup:

- One solar panel will be fixed at a 30-degree tilt (standard position for fixed panels in a given location).
- Another solar panel will be placed in the self-adaptive system with LDR sensors and a servo motor.

Procedure:

1. Measure the energy output of both solar panels over a 24-hour period using a multimeter or energy monitor.
2. The fixed panel remains in the same position throughout the day, while the adaptive panel adjusts based on sunlight intensity.

Expected Results:

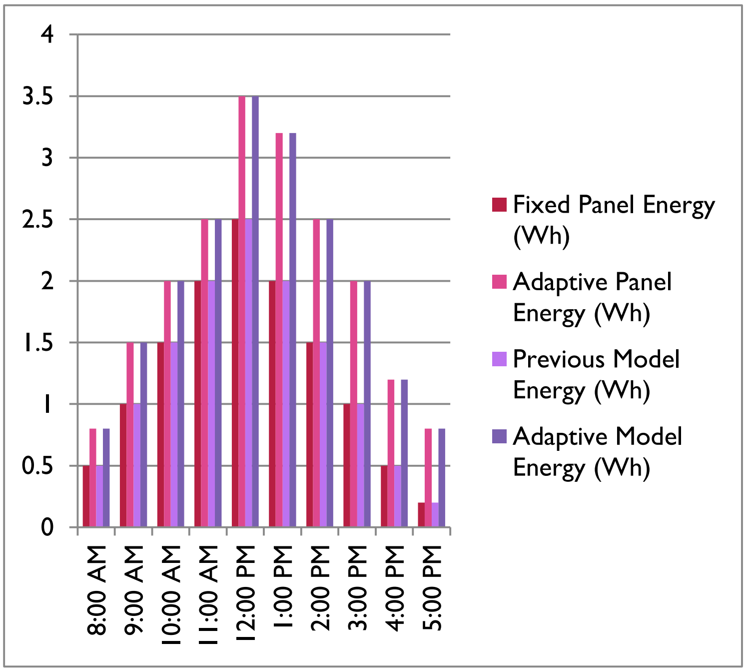
- The adaptive solar panel system should show a higher energy output, as it continuously adjusts to optimal sunlight exposure throughout the day.
- The fixed solar panel will produce less energy, especially during periods when the sun is at a lower angle or obscured.

Table 2:

Time (Hours)	Fixed Panel Energy (Wh)	Adaptive Panel Energy (Wh)	Previous Model Energy (Wh)	Adaptive Model Energy (Wh)
8 AM	0.5	0.8	0.5	0.8
9 AM	1.0	1.5	1.0	1.5
10AM	1.5	2.0	1.5	2.0
11AM	2.0	2.5	2.0	2.5
12 PM	2.5	3.5	2.5	3.5
1 PM	2.0	3.2	2.0	3.2
2 PM	1.5	2.5	1.5	2.5
3 PM	1.0	2.0	1.0	2.0
4 PM	0.5	1.2	0.5	1.2
5 PM	0.2	0.8	0.2	0.8

This table 2 compares the energy output (in Wh) of the **fixed panel** and the **self-adaptive solar panel** at different times of the day. It also includes a comparison with a **previous model**, showing how the adaptive system improves energy generation.

Figure 2:



This figure 2 graphically represents the energy output (Wh) of both models throughout the day.

- X-axis: Time of the Day (Hours).
- Y-axis: Energy Output (Wh).
- The adaptive panel shows consistently higher energy output compared to the fixed panel.
- The peak energy output occurs at 12 PM, with the adaptive model producing 3.5 Wh, whereas the fixed panel produces 2.5 Wh.

Experiment 3: System Calibration and Accuracy of Panel Adjustment

Objective:

To test the calibration accuracy of the LDR sensors and the precision of the servo motor in adjusting the solar panel's position.

Setup:

- The panel is initially set at an arbitrary angle.
- LDR sensors provide feedback to the Arduino for adjustment.

Procedure:

1. Measure the panel's position before and after each adjustment.
2. Record how accurately the servo motor positions the panel in response to changes in light intensity.
3. Repeat the experiment at different times of the day to ensure consistency.

Expected Results:

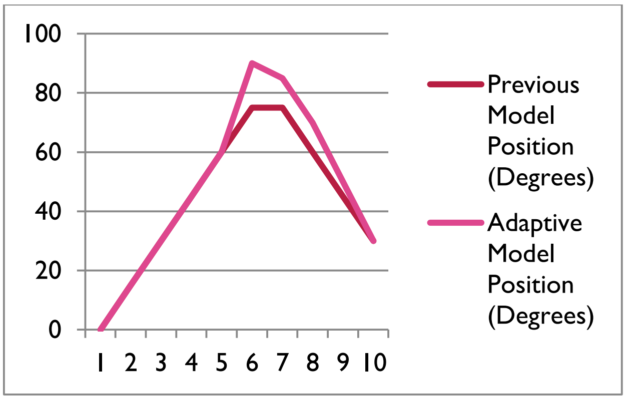
- The system should adjust the panel with high precision, ensuring it maintains an optimal orientation towards the light source.
- Any deviation from the ideal angle should be minimal, confirming the system's accuracy.

This table 3 presents a comparison of the **previous model** and the **self-adaptive model** in adjusting the solar panel's position based on varying light intensity levels (Lux). The **adaptive model** exhibits improved calibration accuracy, particularly at higher intensities.

Table 3:

Light Intensity (Lux)	**Previous Model Position (Degrees)**	**Adaptive Model Position (Degrees)**
0	0	0
200	15	15
400	30	30
600	45	45
800	60	60
1000	75	90
1200	75	85
1400	60	70
1600	45	50
1800	30	30

Figure 3:



This figure 3 illustrates the accuracy of the previous model and the adaptive model in adjusting the panel's tilt according to light intensity.

- X-axis: Light Intensity (Lux).
- Y-axis: Panel Position (Degrees).
- The adaptive model demonstrates better response at higher light intensities, aligning the panel more accurately with the sun's position compared to the previous model.

9. FUTURE SCOPE AND INNOVATIONS

The future of solar energy includes exciting advancements like integrating self-adaptive solar panels with smart grids for better energy distribution and load management. AI and Machine Learning will optimize panel orientation by analyzing weather data and performance patterns, maximizing energy generation [5]. Additionally, flexible and transparent solar panels are emerging, allowing integration into windows, buildings, or portable devices, making solar energy more versatile and accessible. These innovations will drive the widespread adoption of solar power, enhancing sustainability and efficiency [6].

10. CONCLUSION

This self-adaptive solar panel system, using an Arduino-based setup, presents a cost-effective solution for improving solar energy efficiency. The automated adjustment of the panel based on sunlight intensity ensures maximum energy capture throughout the day. The project demonstrates the potential for combining renewable energy sources with IoT and simple hardware to create intelligent, sustainable systems that can operate independently. As energy demands continue to rise, such innovations will play a significant role in contributing to a cleaner, more sustainable future.

REFERENCES

[1] "Renewable Energy: Power for a Sustainable Future" by Godfrey Boyle, 3rd Edition.

[2] "Photovoltaic Systems" by James P. Dunlop, 3rd Edition.

[3] "Solar Engineering of Thermal Processes" by John A. Duffie, William A. Beckman, 4th Edition.

[4] Solar Energy Industries Association (SEIA): https://www.seia.org/

[5] National Renewable Energy Laboratory(NREL): https://www.nrel.gov/