Journal of Artificial Intelligence and Computing (JAIC)
ISSN (e): 3005-3358
Volume: 2, Number: 1, Pages: 19- 22, Year: 2024

Solar Monitoring and Controlling Application using Light Dependent Resistor

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***Abstract*—Highly efficient solar panel operations are possible via a real-time sun-tracking orientation, which always allows and rotates the panels to the sun's direction. Even though conventional methods trace the sun with microcontrollers and LDR sensors, they perform the function with minimal effectiveness because of low sensitivity and light interference. This paper introduces a new method that couples the principles of sensor systems and image processing, in which an automatic solar tracker is designed. Through using image processing software, the system combines processed sun images with sensor data to bring an effective functionality for solar panel self-orientation. Considering both hardware and system software, this approach is better for the photo voltaic power in terms of reliability and efficiency. It can carry out this task perfectly; it can simply manage different panels within a power plant, while on the other hand, it can ensure the best utilization of energy. Whereas microcontrollers are now being employed and sensors with limited effectiveness as measured by LDR are pervasively used, our proposed method employs the interaction of LDR sensors and image processing in a well-organized and effective manner. Unlike previous systems, this intelligent device provides an improvement on the solar tracking method through the real-time combination with data from sensors and sun images, presenting the flawless guidance of a vast number of solar panels in solar power stations.**

***Index Terms*—Artificial intelligence, machine learning, neural network, image processing.**

I. Introduction

Fossil fuels are now very expensive to use in the production of energy, especially in rural areas of the nation. Additionally, using fossil fuels has caused environmental pollution, which is harmful to our health. The greenhouse effect is brought on by the carbon dioxide it emits. This causes soil erosion and air, water, and other pollution. Solar energy doesn't emit any greenhouse gases and can only be obtained from the Sun. NET Power has invented a revolutionary oxy-fuel power cycle that operates on hydrocarbon fuels. It captures all air pollution, including carbon dioxide, and costs about the same as today's cleanest energy systems that don't remove CO_2. This is achieved through a closed-loop, high-pressure Brayton cycle that uses supercritical CO_2 instead of steam. It avoids energy losses seen in steam cycles because of the unique properties of CO2 as a working fluid. The system is financially viable due to its high-efficiency targets of 59% for natural gas and 51% for coal [1].

Nigerian solar energy development has the potential to generate employment. Occupational risks will be lower in the renewable energy industry [2], particularly when compared to coal mining and oil extraction. Solar energy's benefits and environmental friendliness make it the most dependable energy source available today. To effectively monitor people, this system needs to be checked frequently. Techniques for logging data are necessary for the solar system to operate more efficiently. By using this technique, you can learn everything there is to know about a system failure without causing any harm. Another paper suggests a flexible solar panel program that uses Arduino to integrate components. Regular statistics are also made available by the system via its website. Record voltage, current, humidity, and temperature in the data log. The diagnostic tool, which is stored once in the remote output, assists in locating or identifying potential system errors. For optimal performance, solar power plants require routine monitoring. The AT mega controller is used by the system in the research paper to control the parameters. This system continuously evaluates the effectiveness of solar energy and uploads parameters. This system keeps track of various solar panel parameters. power, temperature, current, voltage, and intensity [3].

To regulate the amount of light, they combined an LDR sensor and an Arduino UNO controller. For unskilled individuals, manually monitoring the system is a time-consuming and challenging task. Therefore, the monitoring process can be made simpler by utilizing multiple sensors and their ancillary units. In essence, the sensor is compact and uses less power to function in all kinds of weather. Therefore, do not have to worry about heating and other limitations in the sensor module. Sensor outputs are usually digital and binary, so analyzing sensor readings in person is important. Due to the development of several computer algorithms, human efforts to analyze the observed readings are reduced by setting limit values to identify emergency or emergency conditions. Currently, algorithms are widely implemented in sensor-based control systems, with several actions ready. People to avoid delays in service work. Therefore, the occurrence of damage and defects is reduced to it extent possibility of our approach. The Weather API will be used to alert users to receive weather information. As we know today, dry batteries are used, so this will monitor the health of the battery throughout its life and give immediate warnings to the end user [4].

This paper contributes to the sustainability of solar energy systems, which can contribute to a more sustainable and ecologically friendly future by reducing total carbon emissions and reliance on traditional energy sources. Monitoring software can help consumers make the most of their solar installations by increasing efficiency and reducing waste.

The paper based on solar monitoring and controlling applications is structured to provide a comprehensive exploration of advancements in the field. In the introduction section, the paper establishes the significance of solar energy within the broader context of renewable resources and articulates the need for effective monitoring and control systems. In literature review critically examines the current state of solar monitoring and control technologies, highlighting recent innovations and addressing existing challenges. The methodology section explains the current infrastructure and LDR arrangement. The Conclusion and Future Work section discusses future directions and challenges and outlines potential research avenues and areas requiring further investigation.

II. LITERATURE REVIEW

Tracking systems have been the subject of experiments to increase the effectiveness of solar energy systems. Three different systems are used to build mobile devices, and the same conditions are used to ensure their production. The results obtained are examined and contrasted. The fixed system, single-axis day tracking system, and dual-axis day tracking system are all included in the research scope. For each of them, mobile products are created specifically. The objective is to compare the daily production statistics of these three diverse solar panel structures operating in the same environment and conditions [5] to ascertain which system is more efficient. Solar panels, a solar tracking motor, Arduino software and circuit components [6], an energy analyzer, and an LDR sensor for tracking the sun's position.

Production data is collected to maximize solar energy utilization and improve electricity generation efficiency. The solar panels are mounted on a fixed mount because the first of these three systems is a stable system, and measurements are made using an inverter and a charge controller. Secondly, a mechanical component fixed on the carrier and a sun-tracking device allows the panel to move in both the east and west directions [7].

Arduino specifically programmed and controls this actuator. It has been discovered through applied research that solar energy systems can produce more electricity if solar energy is used more effectively. Show the most effective system and the difference in production in percent. Three different systems were compared in this study. Considering everything, it is thought that a tracking system, as opposed to a fixed system, will be more appropriate for the solar power plant that is intended to be installed in the study area [8].

Since the area's terrain is mostly flat, it will be easy to build and operate a single-axis system for the planned solar power plant. It is recommended to transform existing roof models used in industrial manufacturing zones to install solar tracking systems, taking into account the appropriate roof angle. The implementation of tracking systems for solar modules has been a long-term objective for many research centers. Strict environmental regulations are in place for electronics recycling. It does this by having three different systems installed and treating the machines with the same conditions. The findings compared to these are analyzed, and the differences are observed [9].

The major improvement in the effectiveness of solar energy systems is the study of portable tracking system demonstration. It covers every aspect of a solar energy system, for example, a stable system, a single-axis day tracking system, and a dual-axis day tracking system. Each one of them is looking to build their customizable products around it. The study aims to compare the daily operation information of these three different solar panel systems working under the same environmental steadiness and conditions and discover which system is more effective [10]. The study is intended to collect production data to achieve solar energy utilization optimization and electric infrastructure efficiency. We are installing the solar panels on the fixed mount because the first system is a stable system, where you can make measurements using an inverter and a charge controller. In the first system, a mechanical system mounted on the carrier, a sun-tracking device [11], allowed the panel to move in the east and west, directing indirect motion. In the second system, a unique mechanical device just for this system and a sun-tracking device made the panel move in, venting the sun from the east, west, and north-south directions. The author developed an affordable and computer-controlled educational setup called Solar Insight. It uses Arduino technology and is intended for undergraduate courses in electrical engineering and physics. This system aims to teach students key semiconductor physics principles through hands-on experiments. It includes a data acquisition board, power supply, sensors, a user-friendly interface, and data analysis software. Arduino, an open-source electronics platform, is used in the data acquisition board specifically to program all the devices and to simulate customized results [12].

The applied research has come to show that solar energy systems give more electricity if solar energy is utilized much more effectively. The best system and the difference in production in percent were also presented. The present research examines three alternative systems in their entirety. Moreover, it is assumed that a tracking system, rather than a fixed system is more appropriate for the solar power plant, shall be installed in this study area [13].

III. Proposed Methodology

Clear goals and requirements must be established before designing the system architecture for the control and monitoring software dashboard. A centralized monitoring system [14] with data processing and analysis capabilities must be created, as well as a data collection and communication system and a sensor selection and placement strategy. Control logic optimizes solar panel performance, resulting in solar panels performing better than expected. There are numerous advantages to using tracking solar panels for energy production. They capture the most sunlight exposure by actively following the sun's path throughout the day, which leads to higher energy efficiency than fixed panels. Fixed panels miss out on the full potential of sunlight, especially in the morning and evening, despite being easier to install and maintain. To maximize energy production, the program gives the tracking system [15] priority.

Micro-controlled systems are extensively validated by the process [16]. This is a constant process, and the users' training and instructions are available as well. Moreover, there is a data backup and disaster recovery plan, and sustainability is considered fully through the system's lifetime. This universal approach guarantees effective operation and management of PV panels; instrument tracking technology shown in Fig. 1 is the only option for optimizing system performance and reliability.

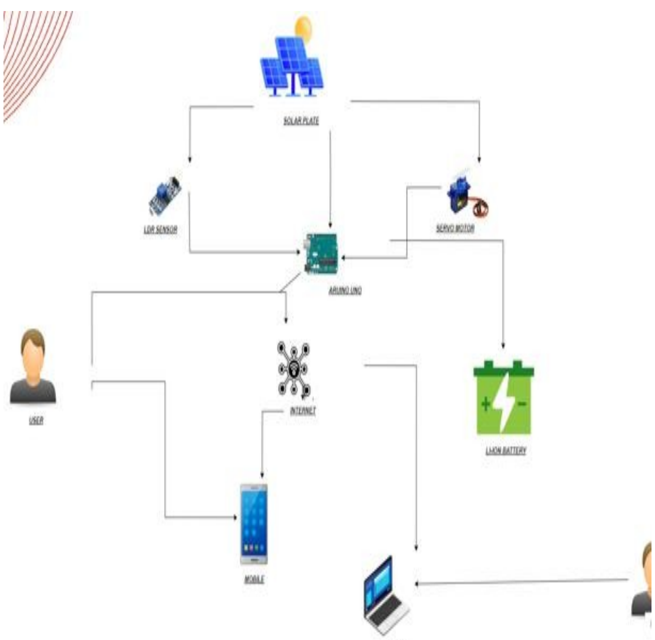

Figure 1: Instrumentation and tracking system.

A. *Parameters of the Material of the Solar Tracking System*

One of the fundamental parts of light sensors is the "light sensitive resistor (LDR)," [17] which is a passive circuit element that detects light falling on it or its surroundings and modifies resistance values by the intensity of the light. The LDR, which is also used as a photoresistor, is similar in operation to the photodiodes and phototransistors found in sensors. But its structure is different from theirs. Light detection and refraction (LDR) are passive and results in a change in resistance. PN junctions enable the perception of lighting photodiodes and phototransistors. Due to their sensitivity to light, LDRs have extremely high resistance values in the M range in the dark. The wavelength sensitivity of each semiconductor material used in LDR varies. There is no change in the resistance value if the wavelength sensitivity range of the material is not affected by the applied light. As a result, each semiconductor material has a different amount of resistance change and a range of light wavelengths. The resistance variation according to light intensity is shown in Fig 2.

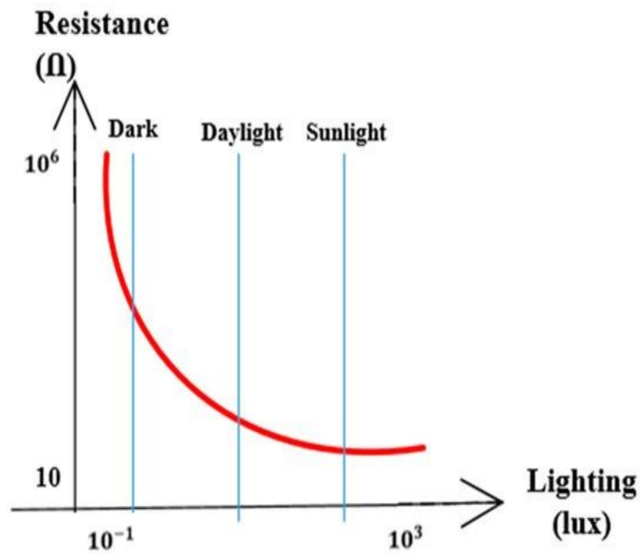

Figure 2: Resistance variation.

Building basic solar tracking systems [18] or creating light-based sensors for energy-related studies. While LDRs can be a cost-effective and accessible approach to solar monitoring in certain circumstances, it's important to note that for larger and more advanced solar energy systems, professional-grade sensors and tracking solutions are typically preferred for accuracy and dependability. The energy and time variance graph can be seen in Fig 3.

						Sun		tilt angle of pv panel
year	latitude	longitude	Month	date	karachi time	Azimuth	Altitude	from E-W
2023	24.93289	67.11361	9	1	7	98	1	89
			9	1	7.1	99	2	88
			9	1	7.2	100	3	87
			9	1	7.3	100	5	85
			9	1	7.4	101	6	84
			9	1	7.5	101	7	83
			9	1	8	105	14	76
			9	1	8.1	106	15	75

Figure 3: Energy and time variance.

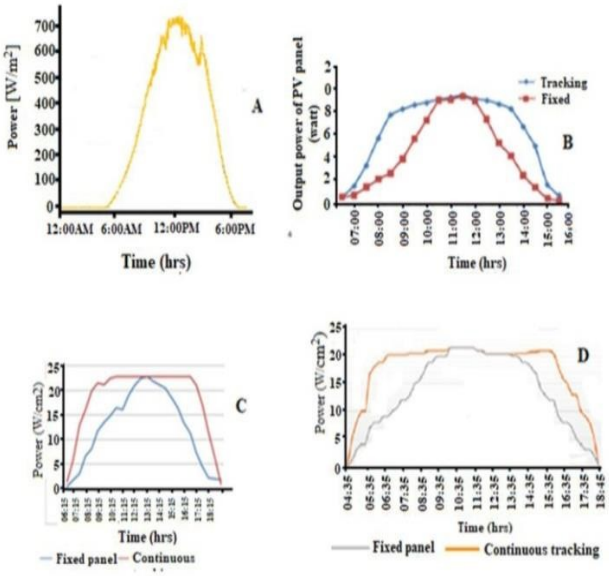

Figure 3: Resistance variance according to light intensity.

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