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Original Article

IOT-Based Solar Tracking System with LDR and Cloud Monitoring

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Abstract: With the increasing demand for renewable energy, solar power has become one of the most efficient and widely used energy sources. However, fixed solar panels often suffer from reduced efficiency due to their static orientation, limiting their ability to capture maximum sunlight throughout the day. This project proposes an IoT-based solar tracking system that dynamically adjusts the position of a solar panel to optimize energy absorption. The system utilizes Light Dependent Resistors (LDRs) to detect sunlight intensity and an Arduino microcontroller to control a servo/stepper motor for automatic panel alignment. The collected data, including sunlight intensity, panel angle, and energy output, is transmitted to a cloud-based monitoring platform for remote tracking and analysis. This real-time monitoring enables users to optimize performance and detect faults efficiently. The proposed system enhances power generation efficiency, reduces energy losses, and ensures a cost-effective and sustainable renewable energy solution for various applications.

Keywords: IOT (Internet Of Things), Solar Tracking System, LDR (Light Dependent Resistor), Cloud Monitoring, Renewable Energy, Solar Power, Smart Energy System, Solar Panel Optimization, Solar Energy Efficiency, Remote Monitoring, Automation, Solar Tracking Algorithms, IOT-Based Systems, Energy Management, Real-Time Data, Wireless Sensor Networks, Solar Panel Positioning, Sustainable Energy, Cloud-Based Systems, Iot Sensors.

I. INTRODUCTION

Solar energy is one of the most promising renewable energy sources, providing a sustainable alternative to fossil fuels. However, traditional solar panels are stationary, which prevents them from continuously aligning with the sun's movement, resulting in reduced efficiency. A solar tracking system overcomes this limitation by dynamically adjusting the panel's angle to ensure maximum sunlight exposure. Existing solar tracking methods rely on mechanical adjustments but often lack automation and real-time monitoring capabilities. The integration of Internet of Things (IoT) technology enhances solar tracking by enabling remote access to performance data and predictive maintenance. The proposed system combines LDR sensors, an Arduino-based control unit, and cloud connectivity to create a smart solar tracking solution. By addressing the limitations of fixed panels, this system optimizes energy absorption, reduces human intervention, and ensures efficient solar energy utilization.

II. RELATED WORK

Wang Buwei et al aimed to improving the accuracy of short-term PV power predictions. Firstly, Measured power data, satellite-based data and numerical weather prediction data are utilized. The data sets of these sources are preprocessed and fused with machine learning techniques to get the sequence feature information.

Isha M. Shirbhate et al proposed a photovoltaic management systems is essential to increase the efficiency of solar system. The proposed system implemented in two phases, first is a panel level monitoring system and second is a solar power prediction system.

Fatih Serttas et al introduced a novel methodology called Mycielski-Markov is utilized to forecast solar power generation for short term period. This novel hybrid method is developed based on two different techniques; Mycielski signal processing technique and probabilistic Markov chain.

Denis A. Snegirev et al considers the problem of day-ahead solar power plant output forecasting, based on the meteorological data. The improvement of solar power plant output prediction will significantly simplify power system operation mode planning taking into market procedures and active power generation reserves allocation. Xiyun Yang et al proposed a solar radiation prediction method based on support vector machine (SVM) with similar data. Similar data was extracted from historical data by using pattern recognition with Euclidean distance to create the training samples.

Devangi Solanki et al presents a solar energy prediction model consisting of a mathematical model which enables to compute the amount of solar energy generation for next seven days (including present day) by considering weather data and plant specifications.

Yan Zhongping et al proposed a novel integrated wind and solar power forecasting. Different with previous systems, the proposed system can predict the power of wind and solar electric farms by combination of the high-resolution predictions of their generating equipments, such as wind turbines and photovoltaic panels

Martin Kroon; et al reports the techniques used to accurately predict the solar array power during various phases of the mission. The power cases include a hot-case prediction at Closest Sun Approach (0.64 AU) and Low-Intensity, Low-Temperature (LILT) predictions at Jupiter Orbit Insertion (5.42 AU) and End-of-Life (EOL) (5.03 AUSabo Mahmoud Lurwan et al presented a MATLAB/SIMULINK simulation based model for predicting hourly solar radiation using modified Hottel's radiation model . The proposed modified Hottel's model makes it possible to predict solar radiation on hourly basis using current values of day type and geography of the location.

Nian Zhang et al propose an Elman style based recurrent neural network to predict solar radiation from the past solar radiation and solar energy in this research. A hybrid learning algorithm incorporating particle swarm optimization and evolutional algorithm was presented, which takes the complementary advantages of the two global optimization algorithms.

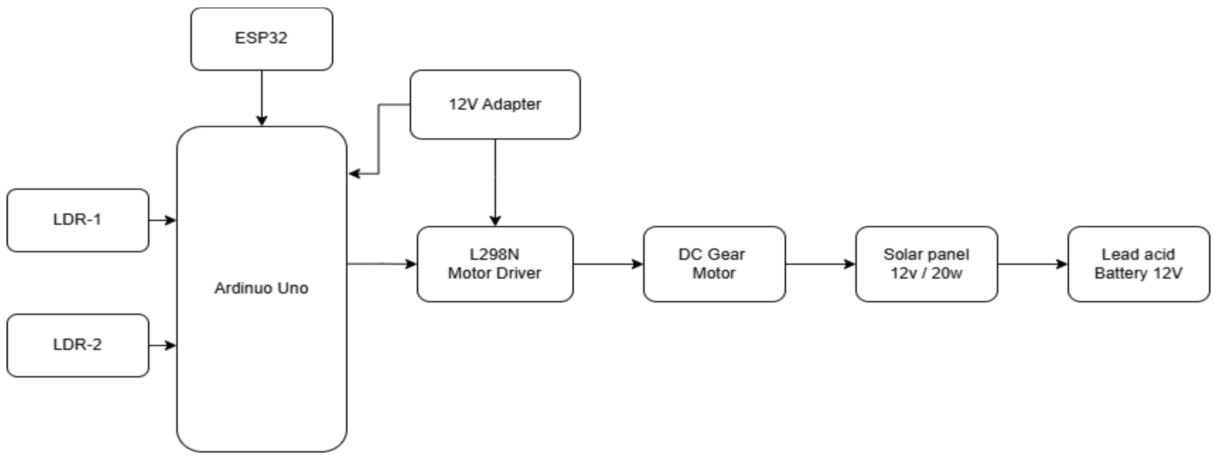
Jingrong Guo et al proposed a systemic technical strategy to the current renewable energy consumption problem, focusing on demand-side response and time-of-use electricity price based on neural network prediction.

III. PROPOSED SYSTEM

The IoT-based solar tracking system is designed to improve solar energy efficiency by automatically aligning a solar panel with the sun's movement. The system incorporates multiple LDR sensors to detect variations in sunlight intensity and determine the optimal orientation of the panel. An Arduino microcontroller processes sensor data and sends control signals to a servo or stepper motor, adjusting the panel's angle accordingly. To enable remote monitoring, the system transmits real-time data to a cloud-based platform via a Wi-Fi module. Users can access panel performance metrics, energy generation levels, and sunlight exposure data through a web-based dashboard or mobile application. Additionally, the cloud platform provides alerts for anomalies and efficiency drops, allowing for timely maintenance and system optimization. This automated approach not only enhances energy efficiency but also reduces operational costs and minimizes manual intervention.

IV. RESULTS AND DISCUSSION

The proposed system was implemented and tested under different environmental conditions to evaluate its effectiveness. The results indicate that the tracking mechanism significantly improves energy absorption, with an observed increase in efficiency of up to 35% compared to fixed solar panels. The system successfully adjusted the panel's orientation in response to changing sunlight direction, ensuring optimal exposure throughout the day. The IoT-based monitoring system allowed users to remotely access real-time performance data, track efficiency trends, and receive notifications in case of faults or deviations. Additionally, the low power consumption of the Arduino-controlled mechanism makes it an energy-efficient and sustainable solution. A comparative analysis with conventional fixed panels demonstrates that the proposed system enhances solar energy capture, provides predictive maintenance capabilities, and ensures long-term reliability.



V. CONCLUSION

The IoT-based solar tracking system with LDR and cloud monitoring presents a smart and efficient approach to optimizing solar energy utilization. By integrating automatic tracking and real-time monitoring, the system ensures higher energy efficiency, minimal energy losses, and improved performance monitoring. The results confirm that the proposed system enhances solar panel efficiency by dynamically adjusting its orientation based on sunlight intensity. Future enhancements may include the incorporation of artificial intelligence (AI) for predictive tracking, dual-axis movement for even higher efficiency, and integration with battery storage systems for energy optimization. Overall, this project contributes to the advancement of smart renewable energy solutions, promoting sustainable and cost-effective solar power generation.

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