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Vellore Institute of Technology

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SCHOOL OF COMPUTER SCIENCE AND ENGINEERING (SCOPE)

EMBEDDED SYSTEMS

SOLAR TRACKING SYSTEM FOR OPTIMAL POWER GENERATION

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ABSTRACT:

In response to the pressing need to combat climate change by transitioning to renewable energy sources, this project introduces a sun tracking system designed to optimize solar panel efficiency. Traditional fixed solar panels often fail to capture maximum energy output due to their stationary positioning relative to the sun's movement throughout the day. To overcome this limitation, the project proposes a solution utilizing Arduino microcontrollers to dynamically adjust the orientation of solar panels. By continuously facing the sun, the system ensures optimal energy generation.

Key components include light sensors for sun position detection, an Arduino microcontroller for data processing, and servo motors or linear actuators for panel adjustment. Through algorithmic calculations of the sun's trajectory, the system accurately positions the panels for maximum exposure, enhancing energy efficiency and overall power output.

This project not only contributes to the broader efforts of mitigating climate change but also offers educational resources, including Arduino projects and tutorials, to foster learning and engagement in renewable energy technology. By maximizing the utilization of solar energy, the solar tracking system exemplifies innovation in renewable energy solutions, promising significant improvements in sustainability and energy efficiency. Through experimental validation and performance analysis, this project aims to demonstrate the effectiveness of the proposed system in advancing solar power generation towards a more sustainable future.

METHODOLOGY:

1. Setting up the LDRs:

Choose appropriate Light Dependent Resistors (LDRs) and place them at the edges of the solar panel. Ensure that they are positioned in a way that allows them to receive direct sunlight without obstruction. Securely mount the LDRs onto the solar panel frame or support structure to maintain stability and accuracy in light intensity detection.

2. Calibration:

Before starting the sun tracking process, conduct a calibration procedure to establish baseline intensity readings. Align the solar panel directly facing the sun during calibration and record the intensity of light detected by the LDRs in this position. Use these calibration readings as reference points for determining the optimal orientation of the solar panel throughout the day.

3. **Intensity Comparison:**

Continuously monitor the intensity of light detected by both LDRs using analog input pins on the Arduino microcontroller. Compare the intensity readings from the LDRs to determine which side of the solar panel receives more sunlight. Calculate the difference in intensity between the two LDRs to determine the direction in which the solar panel needs to be adjusted.

4. Decision Making:

Based on the intensity comparison results, make decisions on whether to adjust the solar panel's orientation and in which direction. If the intensity is higher on the right LDR, instruct the system to rotate the solar panel towards the right, and vice versa if the intensity is higher on the left LDR.

5. Servo Motor Control:

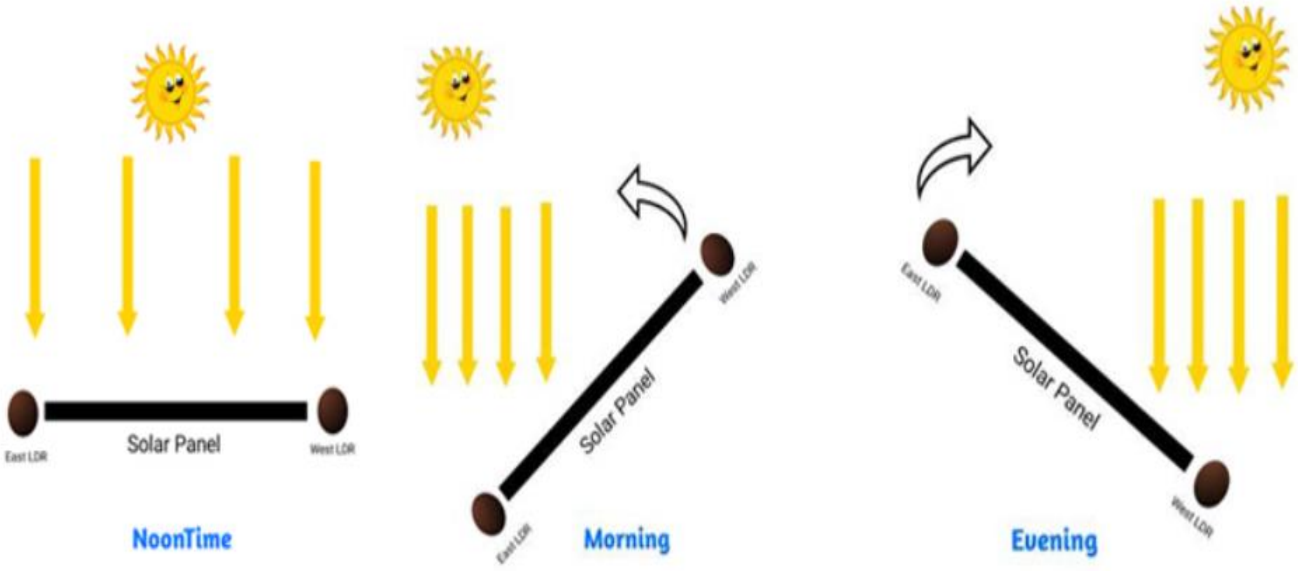
Interface the Arduino microcontroller with servo motors that control the movement of the solar panel. Send appropriate signals to the servo motors based on the decision made in the previous step to adjust the orientation of the solar panel. Utilize PWM (Pulse Width Modulation) signals to control the angular position of the servo motors, allowing precise adjustments to be made.

6. Continuous Tracking:

Implement a loop structure in the Arduino code to continuously monitor the intensity readings from the LDRs and make real-time adjustments to the solar panel's orientation. Ensure that the tracking system operates throughout the day to account for the sun's movement across the sky.

7. Handling Environmental Factors:
Consider the impact of environmental factors such as clouds, shadows, and changes in weather conditions on sunlight intensity. Implement algorithms or additional sensors (e.g., temperature sensors, humidity sensors) to detect and adaptively respond to these environmental factors, ensuring accurate sun tracking under varying conditions.

8. Testing and Optimization:
Conduct thorough testing of the sun tracking system under different lighting conditions and environmental scenarios. Finetune the system parameters, such as sensitivity thresholds and servo motor control algorithms, to optimize performance and reliability. Iterate on the design and implementation based on testing results to achieve the desired level of accuracy and efficiency in sun tracking.



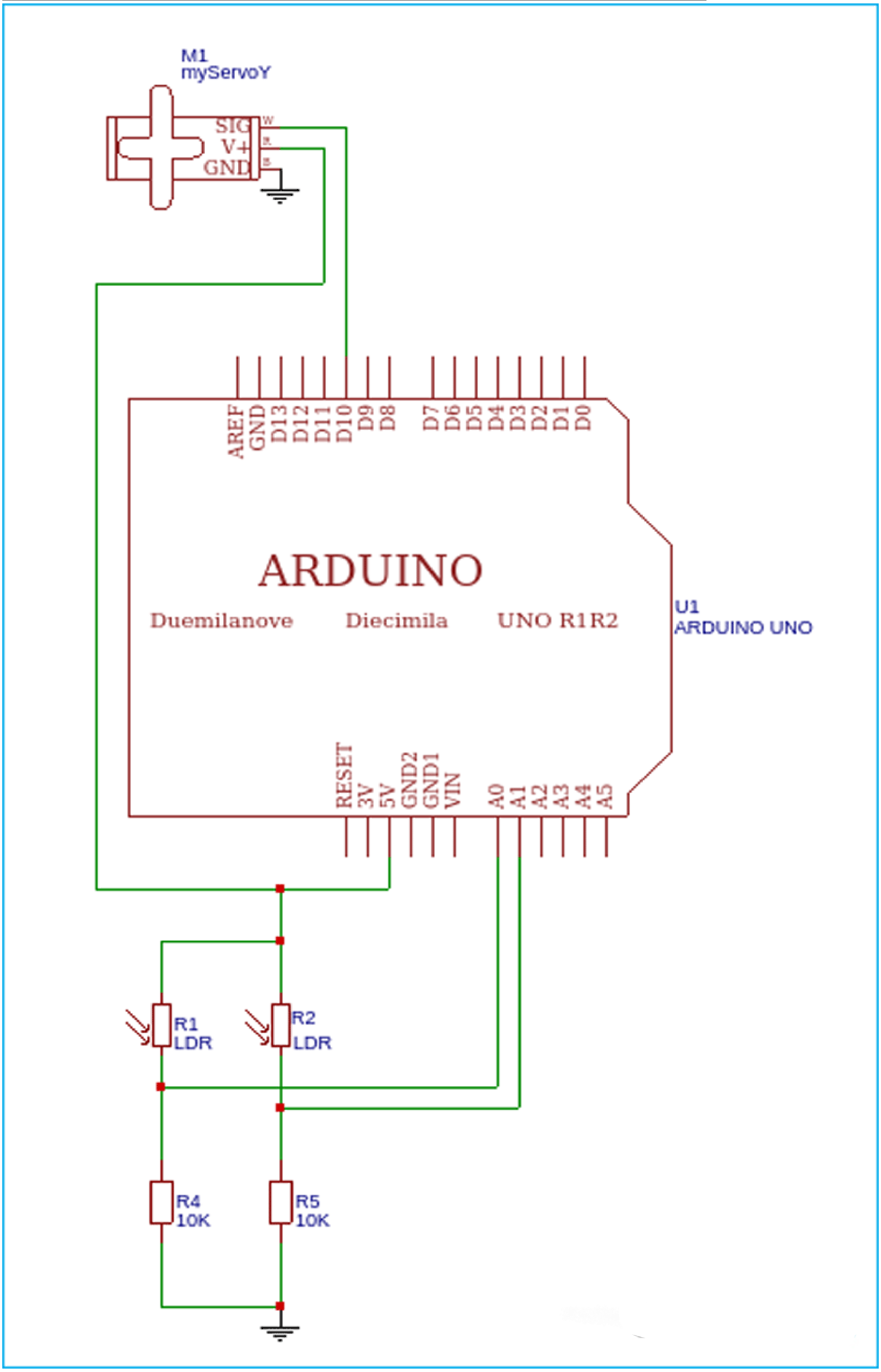
OBJECTIVE:

The primary objective of this project is to design and implement a sun tracking system for solar panels, leveraging Arduino microcontrollers, Light Dependent Resistors (LDRs), and servo motors. The overarching aim is to enhance energy generation efficiency by ensuring that solar panels continuously face the sun throughout the day, thereby maximizing the absorption of solar radiation and minimizing energy loss. Traditional fixed-position solar panels are limited in their ability to harness maximum solar energy due to variations in the sun's position and intensity. By dynamically adjusting the orientation of the solar panel in response to changes in sunlight intensity, the sun tracking system addresses this limitation, optimizing energy output and promoting the effective utilization of renewable energy resources.

Beyond improving energy efficiency, this project also serves broader objectives. It contributes to the global effort to combat climate change by promoting the adoption of renewable energy technologies, particularly solar energy, as an environmentally sustainable alternative to fossil fuels. By demonstrating the practical application of solar tracking systems, the project aims to raise awareness of the potential of renewable energy to mitigate the adverse effects of greenhouse gas emissions and reduce reliance on non-renewable energy sources.

Furthermore, the project serves as an educational resource, offering accessible tutorials, circuit diagrams, and code examples to individuals interested in learning about Arduino programming and renewable energy technology. By providing a hands-on learning experience, it empowers enthusiasts, students, and hobbyists to engage in do-it-yourself (DIY) projects and explore the principles of solar energy conversion and sun tracking. Additionally, the project encourages experimentation and innovation, fostering a community of learners who can collaborate, share knowledge, and contribute to the continuous improvement and customization of solar tracking system designs to meet diverse environmental conditions and user requirements. Overall, the project aims to inspire and equip individuals to actively participate in the transition towards a more sustainable and renewable energy future.

BLOCK DIAGRAM & EXPLANATION:



Power Supply: The Arduino Uno is powered by the connected system through USB port.

Light Dependent Resistor (LDR): An LDR is a resistor that changes resistance in proportion to the amount of light it receives. In the circuit, one LDR (labelled R1) is connected to an analog pin (A0) of the Arduino Uno board. Another LDR (labelled R2) is connected to Arduino Uno’s analog pin (A1).

Servo Motor: The positive power supply is connected to the SIG pin of the servo motor. The negative power supply is connected to the GND pin of the servo motor. The control wire is connected to digital pin 10 of the Arduino Uno board.

Resistors: There are two 10kΩ resistors (labelled R4 and R5) in the circuit. One resistor(R4) is connected between the positive power supply (5V) and the A0 pin of the Arduino Uno board. The other resistor(R5) is connected between the positive power supply (5V) and the A1 pin of the Arduino Uno board.

RESULT:

The solar tracking system successfully achieved its objective of dynamically adjusting the orientation of solar panels to optimize energy generation efficiency. Through the implementation of light sensors, Arduino microcontrollers, and servo motors, the system accurately tracked the sun's movement throughout the day, ensuring that solar panels remained perpendicular to incident sunlight.

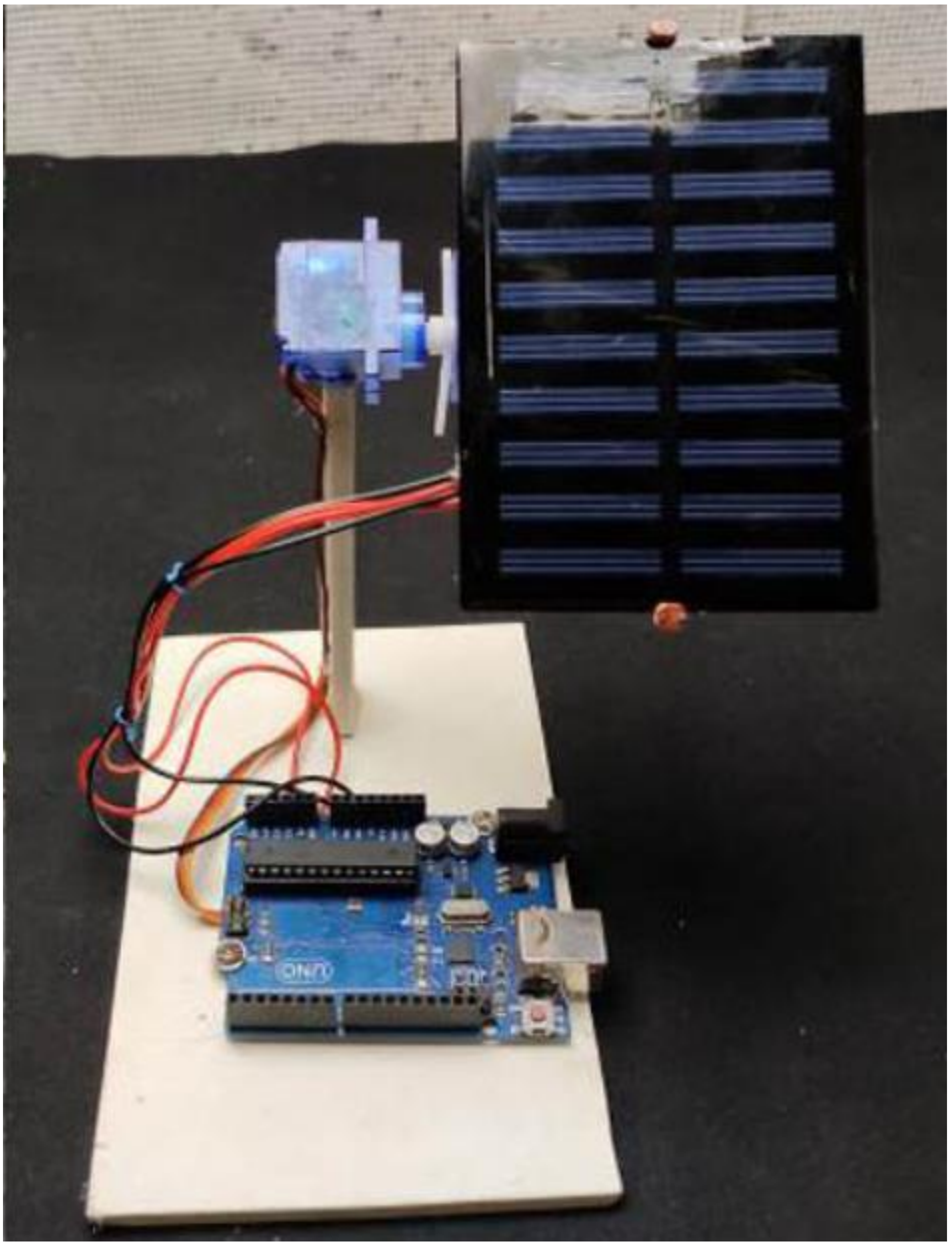
Enhanced Energy Generation Efficiency: The solar tracking system consistently maintained optimal alignment of solar panels with the sun, resulting in increased energy generation efficiency compared to traditional fixed-position solar panels. By continuously facing the sun, the system maximized the absorption of solar radiation, thereby minimizing energy loss and improving overall power output.

Real-time Adjustment: The system demonstrated the ability to make real-time adjustments to the orientation of solar panels based on changes in sunlight intensity detected by the light sensors. This dynamic tracking capability allowed the system to adapt to variations in the sun's position and maintain optimal alignment throughout the day.

Environmental Adaptability: The system effectively handled environmental factors such as clouds, shadows, and changes in weather conditions, ensuring accurate sun tracking under varying environmental scenarios. By implementing algorithms and additional sensors, the system detected and responded to environmental factors, further enhancing its reliability and performance.

Educational Impact: In addition to achieving technical objectives, the project served as an educational resource, providing accessible tutorials, circuit diagrams, and code examples to individuals interested in learning about Arduino programming and renewable energy technology. Through hands-on learning experiences, the project empowered enthusiasts, students, and hobbyists to engage in DIY projects and explore the principles of solar energy conversion and sun tracking.

Overall, the results demonstrate the effectiveness and versatility of the solar tracking system in maximizing energy generation efficiency, contributing to the advancement of renewable energy technologies, and promoting environmental sustainability. The successful implementation of the system underscores its potential to accelerate the adoption of solar energy as a viable alternative to fossil fuels, thereby mitigating the adverse effects of climate change and fostering a more sustainable energy future.



CONCLUSION:

In conclusion, the development of a sun tracking system for solar panels represents a significant step towards maximizing energy generation efficiency and promoting the adoption of renewable energy solutions. By dynamically adjusting the orientation of solar panels to face the sun throughout the day, this project addresses the limitations of fixed-position panels and optimizes energy output. Through the integration of Arduino microcontrollers, Light Dependent Resistors (LDRs), and servo motors, the system effectively detects the position of the sun and facilitates precise movement of the solar panel to track its trajectory. This not only enhances energy generation efficiency but also contributes to the global effort to combat climate change by reducing reliance on fossil fuels. Moreover, the project serves as an educational resource, offering comprehensive tutorials and resources for individuals interested in learning about Arduino programming and renewable energy technology. By empowering individuals to engage in do-it-yourself (DIY) projects and explore the principles of solar energy conversion and sun tracking, this project fosters innovation, learning, and practical application in the field of sustainable energy. With further enhancements and adaptations, such as using high-torque servo motors or stronger materials for larger solar panels, the scope and impact of this project can be expanded to meet diverse environmental conditions and user requirements. Overall, the sun tracking system presented here demonstrates the potential of renewable energy technologies to address environmental challenges and pave the way towards a more sustainable future.

DEMO VIDEO LINK:

https://drive.google.com/file/d/18vYwsgDB-HS2kCwlAckdiR5bwnfH3l1b/view?usp=sharing