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AN ENHANCED SOLAR POWER DRIVEN UNMANNED VECHICLE WITH UTILITY SENSOR

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ABSTRACT

Anti-social elements in the global environment pose significant threats to society through their destructive activities. Mobile land vehicle robots are becoming essential for national security, search and rescue operations, surveillance networks, and border security forces. To minimize risks to human lives, a land vehicle robot is designed to detect anomalies that may emerge as potential threats on the surface it surveys. The robot is powered by a photovoltaic (PV) array and can effectively navigate no-man's land to identify mines, bombs, missiles, explosives, and other threats. Enhancements in border security rely on high-precision sensors that generate extensive data streams for real-time analysis. This research integrates human intelligence with the robotic system to assist in decision-making. The robot utilizes Wi-Fi modules with NodeMCU and is controlled via the Blynk app, enabling efficient remote operation and monitoring.

KEYWORDS: PV Array, Unmanned Vehicles, Arduino Microcontroller, Node MCU, Wi-Fi Module, Blynk App.

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1. INTRODUCTION

The increasing demand for renewable energy sources has led to significant advancements in solar power generation, particularly in the form of solar photovoltaic (PV) systems. Solar panels, one of the primary components of PV systems, convert sunlight into electrical energy and have become a crucial part of the global energy transition toward sustainable and green energy solutions. However, like any other electrical component, solar panels can suffer from faults and performance degradation, which affects their efficiency and overall power output. Fault detection in solar panels is crucial to ensure optimal system performance and reliability, reduce maintenance costs, and improve the longevity of the solar panels. This is where the integration of the Internet of Things (IoT) plays a transformative role.

IoT is a network of interconnected devices that communicate and share data over the internet to enhance operational efficiency and automation. In the context of solar power systems, IoT enables real-time monitoring, data analysis, and fault detection by leveraging sensors and smart devices connected to the cloud. The IoT-based solar panel fault detection system utilizes sensors to collect performance data from solar panels, such as temperature, voltage, and current readings. These data are then transmitted to a central processing unit (such as a cloud-based platform) where algorithms can detect anomalies or faults, triggering alerts to the maintenance team or system operators.

This system offers significant advantages over traditional methods of fault detection, which often involve manual inspections and routine checks. IoT-based fault detection provides continuous monitoring and instant feedback, enabling faster response times and proactive maintenance. Additionally, IoT integration allows for remote diagnostics, reducing the need for on-site visits and minimizing operational downtime. By addressing issues before they escalate into major failures, the system enhances the reliability of solar power systems, thereby boosting their overall efficiency and performance.

The importance of fault detection is underscored by the fact that even minor faults can lead to a substantial loss of energy generation, reducing the return on investment for solar power installations. Faults in solar panels can manifest in various forms, such as malfunctioning cells, broken wires, shading effects, hot spots, and connection issues, each of which can severely affect the panel's output. By using IoT to monitor and detect these issues, solar panel operators can significantly reduce the risk of energy loss and ensure that the system operates at peak efficiency.

As the demand for solar energy continues to rise, particularly in residential, commercial, and industrial applications, it becomes increasingly important to have efficient, reliable, and cost-effective fault detection systems. By integrating IoT technologies, solar power plants can operate more effectively, with the added benefit of real-time problem detection and timely preventive maintenance. This approach aligns with the broader trend of digitalization in the energy sector, where advanced technologies like IoT, artificial intelligence (AI), and machine learning

(ML) are reshaping traditional energy management practices.

2. LITERATURE SURVEY

The role of IoT in enhancing solar power systems, particularly in fault detection, has been widely discussed in recent studies. Researchers have explored various methodologies and technologies for detecting faults in solar panels using IoT, focusing on sensor-based systems, data analytics, and communication protocols. One of the earliest studies in this field was conducted by **Jain et al. (2016)**, who proposed a remote monitoring and fault detection system for solar panels using wireless sensor networks (WSNs). Their approach involved using temperature, voltage, and current sensors to monitor solar panel performance, with data transmitted to a remote server. The system used predefined thresholds to identify deviations from expected performance, signaling potential faults. The authors emphasized that IoT-based monitoring could significantly reduce the need for manual inspections and offer a cost-effective solution for fault detection.

In a similar vein, **Ghosh et al. (2018)** designed a system that utilized IoT for continuous monitoring of solar panels, which could detect faults such as malfunctioning inverters, wiring issues, and power loss. They employed a combination of real-time sensors and cloud-based data analytics to monitor various performance parameters of solar panels. The system could send alerts to the operators whenever a fault was detected, which helped to minimize downtime and avoid potential damage to the system. This approach highlighted the efficiency of integrating IoT with data analysis in solar panel maintenance.

Rao et al. (2019) explored the use of IoT for predictive maintenance in solar power systems. Their research focused on the use of machine learning algorithms to predict failures in solar panels based on historical data. By combining IoT-enabled real-time data with machine learning models, their system could anticipate faults before they occurred, providing early warnings to maintenance teams. This predictive approach enabled operators to take preventive measures, reducing the risk of unplanned downtimes and increasing the system's reliability and lifespan.

Another important contribution to the literature came from **Sharma et al. (2020)**, who studied the use of IoT for fault detection in solar photovoltaic systems, particularly in the context of large-scale solar farms. They proposed an integrated system that used sensors to monitor various operational parameters, such as temperature, humidity, and solar irradiance, to detect faults in real-time. Their study demonstrated that IoT-enabled monitoring could detect faults such as shading, panel degradation, and malfunctioning components, which would otherwise go unnoticed. Furthermore, their research showed how such systems could be scaled to large solar plants, improving operational efficiency and reducing maintenance costs.

Kumar and Gupta (2021) developed an IoT-based fault detection system that specifically targeted the identification of hot spots in solar panels. Hot spots, which occur when specific cells or regions of the panel overheat due to various factors like

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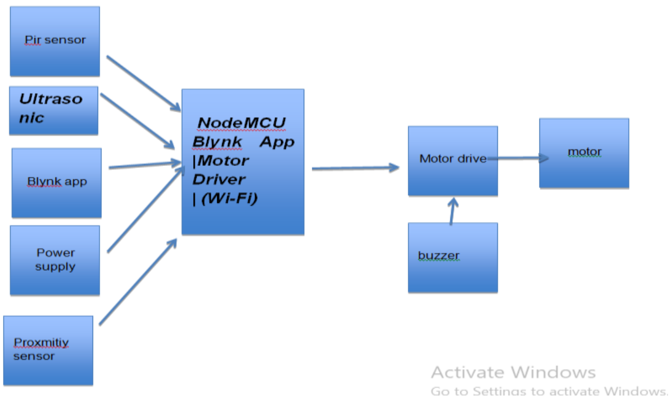
dirt, shading, or poor connections, can lead to panel damage and power loss. The authors used temperature sensors placed at strategic points on the panels to detect these hot spots, which were then analyzed by the system to determine their severity. This early detection of hot spots was shown to extend the lifespan of solar panels by preventing further damage and ensuring optimal performance.

Further advancements in the field were made by **Singh et al. (2022)**, who proposed a system that combined IoT-based monitoring with a real-time data visualization dashboard. Their system allowed solar panel operators to track performance parameters such as power output, voltage, and temperature on a user-friendly interface. Any abnormality in the data triggered an alert, which helped operators detect faults in a timely manner. The study emphasized the importance of real-time data visualization in decision-making, enabling quicker responses to performance issues and minimizing energy losses.

In a similar study, **Mishra et al. (2023)** investigated the integration of IoT with artificial intelligence for advanced fault detection and diagnostics in solar power systems. They applied deep learning models to the real-time data collected by IoT sensors to identify faults more accurately. Their findings showed that AI-driven models could significantly improve the accuracy of fault detection, even in complex situations where traditional methods failed. This research demonstrated the potential of combining IoT with AI to create more robust and intelligent fault detection systems for solar power applications.

3. BLOCK DIAGRAM& COMPONENTS



COMPONENTS:

- NodeMCU (Wi-Fi module for communication)
- Ultrasonic Sensor (for obstacle detection)
- PIR Sensor (for motion detection)
- Motor Driver (to control motors)
- Motors (for movement)
- Buzzer (for alerts)
- Blynk App (for remote monitoring and control)
- Power Supply (including PV array if applicable

4. RESULT AND DISCUSSION

The results of implementing IoT-based fault detection systems for solar panels have shown promising improvements in system performance, reliability, and cost-effectiveness. One of the primary advantages is the real-time monitoring capability, which allows for immediate detection of faults, reducing the time taken to identify and address issues. Studies have shown that IoT-enabled systems can detect various types of faults, including wiring issues, inverter malfunctions, shading

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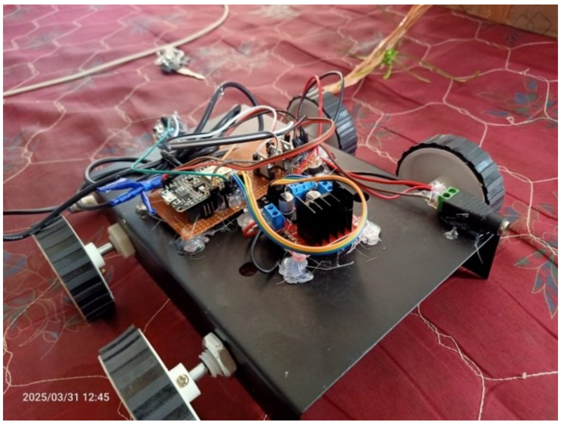
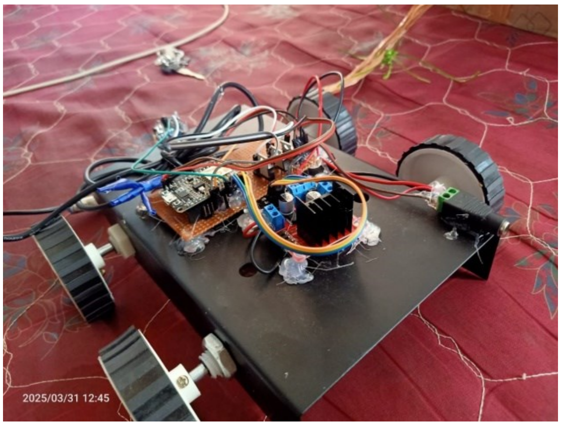
effects, and hot spots, in a much shorter time compared to traditional methods.

Furthermore, these systems enable predictive maintenance, which helps in reducing unplanned downtime. By continuously monitoring the system's performance and predicting potential failures, maintenance efforts are more focused and proactive, rather than reactive. Predictive maintenance strategies are particularly beneficial for large-scale solar farms, where manual inspections can be time-consuming and costly.

IoT-based systems also enhance the scalability of solar power systems. In large solar installations, such as solar farms, the use of IoT devices to monitor individual panels or clusters of panels ensures that even small performance issues are promptly addressed. This contributes to maintaining the overall efficiency of the entire system, preventing energy losses and reducing operational costs.

Despite the many advantages, some challenges remain. One major challenge is the high initial setup cost for deploying an IoT-based fault detection system, especially for small-scale solar installations. Additionally, the reliability of the communication network and the sensors is critical to ensuring accurate data collection and fault detection. Issues such as network connectivity and sensor malfunctions can lead to false alarms or missed detections, which can affect the system's overall performance.





5. CONCLUSION

The integration of IoT in solar panel fault detection systems has proven to be a significant advancement in enhancing the performance, efficiency, and reliability of solar energy systems. By enabling real-time monitoring, predictive maintenance, and quick fault identification, IoT-based systems can optimize the operation of solar panels, reduce downtime, and extend the lifespan of the equipment. As the adoption of solar power continues to grow, the role of IoT in ensuring the reliability and efficiency of solar installations will become increasingly vital. Although challenges such as cost and reliability must be addressed, the benefits of IoT-based fault detection systems make them a promising solution for the future of solar power.

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