

Solar Powered Robot

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DOI: 10.5281/zenodo.19306986

ABSTRACT

This project presents the design and development of a solar-based robot controlled using an accelerometer, aimed at achieving energy-efficient and intuitive robotic control. The robot operates on renewable solar energy, which is stored in a rechargeable battery to power the system, thereby reducing dependence on conventional power sources. An accelerometer sensor is used as the primary control interface, enabling robot movement through simple hand gestures. The tilt of the accelerometer in different directions generates control signals, which are processed by a microcontroller and transmitted wirelessly to the robot. Based on the received signals, the robot performs movements such as forward, backward, left, and right. The integration of solar power ensures continuous operation and enhances the sustainability of the system. This project demonstrates an effective combination of renewable energy utilization and human-machine interaction, making it suitable for applications in surveillance, material handling, and educational robotics.

Keywords: - Solar-Based Robot, Accelerometer Sensor, Gesture Control, Renewable Energy, Microcontroller, Wireless Communication, Embedded System etc.

1. INTRODUCTION

The rapid advancement in robotics and embedded systems has led to the development of intelligent machines capable of performing tasks with minimal human intervention. At the same time, the growing demand for clean and sustainable energy sources has encouraged the integration of renewable energy technologies into modern electronic systems. A solar-based robot controlled using an accelerometer is an innovative solution that combines renewable energy utilization with intuitive human-machine interaction. Solar energy is an abundant and eco-friendly source of power that can be effectively used to operate robotic systems, especially in outdoor environments. By employing solar panels, the robot can convert sunlight into electrical energy, which is stored in a rechargeable battery and used to power motors, sensors, and control circuits. This approach reduces dependence on conventional power supplies, lowers operational costs, and supports environmentally sustainable practices. The control mechanism of the robot is based on an accelerometer sensor, which detects tilt and motion in different directions. Instead of using traditional buttons or joysticks, the robot can be controlled through simple hand gestures. The accelerometer senses changes in orientation along different axes and converts them into electrical signals. These signals are processed by a microcontroller and transmitted wirelessly to the robot, enabling movements such as forward, backward, left, and right. The integration of solar energy with accelerometer-based control enhances both efficiency and usability. Gesture-based control offers greater flexibility, ease of operation, and reduced physical effort for the user. Such robots find applications in areas like surveillance, exploration, material handling, and educational demonstrations. Overall, the solar-based robot controlled using an accelerometer represents a step toward smart, energy-efficient, and user-friendly robotic systems suitable for future technological needs..

1.1 OBJECTIVE

- Utilize solar energy as the primary power source to reduce dependency on conventional electricity and promote renewable energy use.
- Implement accelerometer-based control to enable intuitive and gesture-driven robot movement.
- Develop a wireless communication interface between the accelerometer module (controller) and the robot for real-time motion control.
- Ensure efficient power management to maximize the performance and battery life of the solar-powered system.
- Demonstrate the feasibility of using sustainable energy and smart sensing technology in robotic applications for industrial, domestic, and educational purposes.

2. LITERATURE SURVEY

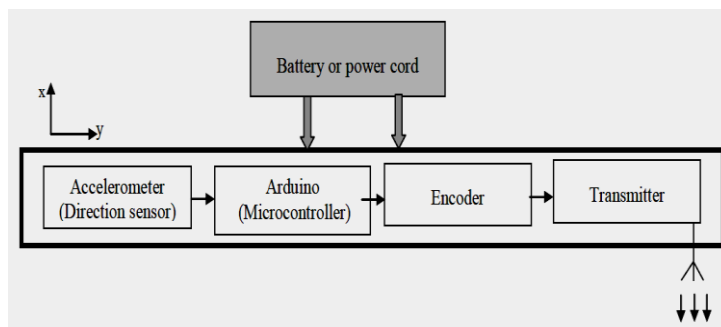
- **Blaise Ravelo et al. (2025)** This study introduces a negative group delay (NGD) circuit integrated into a mobile platform to predict the real-time position of a moving object. Using an accelerometer sensor and an Arduino UNO-based NGD digital circuit, the system anticipates the object's motion with an 80 ms time advance.

Experimental tests with a mini-vehicle prototype confirm strong agreement between predicted and actual positions. The proposed NGD predictor effectively compensates for signal propagation delays, offering potential benefits for sensor design, automation, and robotic systems.

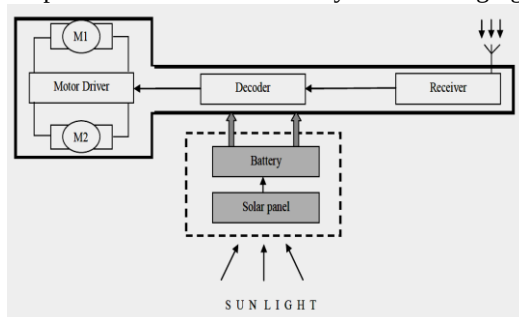
- **Cuong Van Nguyen et al. (2025)** This study presents the design of a single-axis MEMS accelerometer featuring an outer frame (M1) and an inner proof mass (M2) aimed at achieving frequency tuning and higher sensitivity. Using electrostatic tuning electrodes, the system adjusts the spring stiffness (K1 and K2) to control the resonant frequency, successfully shifting it from 40.144 kHz to 38.229 kHz. The sensor's sensitivity increased fivefold, with the output rising from 0.29 pF to 1.45 pF at 2G acceleration. This approach demonstrates an effective method for frequency tuning and performance enhancement in vibration and motion sensors.
- **Richard Pesti et al. (2025)** This paper presents a new ANN-based calibration technique for improving the accuracy of low-cost MEMS accelerometers used in inertial measurement units (IMUs). Using data from five IMUs and a calibrated UR robot for precise ground truth, the method trains an artificial neural network on dynamic measurement datasets. Compared with traditional calibration methods like ellipsoid fitting and arithmetic averaging, the proposed approach improves accuracy by 18.2% and 23.3%, respectively. The best performance is achieved when combining accelerometer data with Euler angles as ANN inputs. Overall, the study shows that ANN-based sensor fusion significantly enhances MEMS accelerometer calibration for high-precision motion sensing.
- **Rizos P. et al. (2025)** This paper presents a MEMS IMU based method for real-time estimation of friction and uncertain actuator parameters in robotic systems. While mechatronic design enables accurate modeling of mass properties, friction and actuator uncertainties limit performance due to factors like load, temperature, and wear. The proposed approach integrates adaptive control and identification algorithms using MEMS sensors to compensate for these effects in real time. Experimental results show significant reductions in tracking errors and the ability to adapt to temperature-dependent friction changes. Overall, the method enhances robotic system dynamics and opens opportunities for MEMS-based diagnostics and predictive maintenance
- **Ma Z. et al. (2025)** This study presents a safety monitoring method for magnetic adhesive crawler-type climbing wall robots used in high-altitude tasks. To prevent detachment caused by self-weight and payload, a MEMS accelerometer-based data acquisition system and a deep learning model (ICNN-LSTM) are developed to recognize the robot's attachment state in real time. The system effectively captures subtle vibrations and achieves high classification accuracy, offering a reliable solution for safe and stable robot operation.
- **Le NT. et al. (2025)** This study introduces a yaw angle measurement method for mobile robots on inclined surfaces using only accelerometers and gyroscopes, avoiding magnetic interference. A complementary filter with an optimized weighting factor, determined via golden section search and mean squared error, minimizes drift and enhances accuracy. Experiments using a reference system confirm that yaw angle errors decrease with slower directional changes and steeper slopes, proving the method's effectiveness and reliability for practical robot applications.
- **Vinay Meshram et al. (2025)** This paper presents an AI-based hand gesture-controlled robot that uses accelerometer data to convert hand movements into robot commands for intuitive, hands-free control. The system integrates components like an accelerometer, Arduino, motor driver, and gesture recognition software, enabling real-time operation. It discusses the robot's testing, accuracy, and response time, and highlights potential applications in assistive technology, industrial automation, and military systems, promoting more accessible and efficient robotics

3. WORKING & IMPLEMENTATION

The task is divided into two parts as shown in Fig. One is the transmitter session and another is receiver session. The transmitter end consists of an Accelerometer, Arduino Board, Encoder, Transmitter. The accelerometer records the hand movement in X Y directions and outputs constant analog voltage levels. These potentials are fed to the microcontroller present in the Arduino UNO board. The displacement data is processed as per the program coded in the microcontroller and is sent after encoding to receiver part via transmitter RF module. The transmission is done in ASCII data exchange in RF modules.

**Transmitter Block**

The receiver end consists of a Receiver, Decoder, Motor driver, Solar panel, Rechargeable battery. On the receiver side the robot receives the RF signals and decodes it with the help of a decoder. The decoded signal has appropriate digital HIGH/LOW signals as per the program fed on the transmitter side and flows to the enable pins of DC motor driver. The solar panel is interfaced in battery for the charging of battery.

**Receiver Block**

ACCELEROMETER

An accelerometer is an integrated device that measures proper acceleration, the acceleration experienced relative to freefall. Single- and multi-axis models are available to detect magnitude and direction of the acceleration as a vector quantity, and can be used to sense orientation, acceleration, vibration shock, and falling. Micro machined accelerometers are increasingly present in portable electronic devices and video game controllers, to detect the position of the device or provide for game input. It is capable of measuring how fast the speed of object is changing. It generates analog voltage as the output which is used as an input to the control system. The accelerometer used in this automated system is ADXL335. It is a three axis accelerometer, which senses the tilt in two directions only. The supply voltage ranges from 2 to 3.6v

Following are the major components used in gesture controlled robot

ADVANTAGES

The robot operates using solar energy, reducing dependence on conventional power sources and promoting eco-friendly, sustainable technology. Solar charging minimizes electricity usage and maintenance costs associated with frequent battery replacement or recharging. The accelerometer allows intuitive gesture-based control, eliminating the need for joysticks or manual switches. The integration of solar panels ensures continuous power supply and efficient energy utilization, increasing the robot's operating time. Wireless operation and solar power make the robot portable and suitable for remote or outdoor applications where electricity is unavailable.

4. CONCLUSIONS

The solar-based robot controlled using an accelerometer successfully demonstrates the integration of renewable energy sources with modern gesture-based control techniques. By utilizing solar power, the system reduces dependency on conventional electrical energy and promotes environmentally friendly operation. The accelerometer-based control mechanism provides an intuitive and user-friendly interface, allowing the robot to be operated through simple hand movements without the need for complex control devices. The project highlights the effective coordination between the accelerometer, microcontroller, wireless communication module, and motor driver circuit to achieve smooth and accurate robot motion. The use of solar energy enhances the efficiency and operational lifespan of the robot, making it suitable for outdoor and long-duration applications. Overall, this project proves to be a cost-effective, energy-efficient, and innovative robotic solution with potential applications in surveillance, exploration, material handling, and educational systems. It also serves as a strong foundation for further enhancements such as obstacle detection, GPS navigation, and autonomous operation.

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