

Solar Based Robot Controlled Using Accelerometer

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Abstract: *The project Solar-Based Robot Controlled Using Accelerometer aims to design and develop an energy-efficient mobile robot powered by solar energy and controlled through an accelerometer sensor. The system utilizes renewable solar power to charge the robot's battery, reducing dependency on external electrical sources and promoting sustainable operation. The accelerometer module detects the tilt and motion of the controller, converting these gestures into directional commands such as forward, backward, left, and right movements. An Arduino microcontroller processes these signals and drives the DC motors through a motor driver circuit. This project demonstrates an innovative approach to controlling a robotic vehicle wirelessly without using traditional buttons or joysticks, making the system more intuitive and user-friendly. The integration of solar energy ensures continuous operation even in outdoor environments, emphasizing eco-friendly design and low maintenance. The developed system can be further applied in remote monitoring, solar-powered automation, and assistance for physically challenged individuals.*

Keywords: Accelerometer, Wireless control, Microcontroller remote monitoring

I. INTRODUCTION

In recent years, robotics and renewable energy technologies have gained significant attention due to their potential to improve efficiency, sustainability, and automation in various fields. The solar-based robot controlled using an accelerometer is a combination of these two emerging domains robotics and solar power. This project focuses on developing a mobile robot that is not only capable of movement based on human gestures but also operates on renewable solar energy, reducing its reliance on conventional electrical sources. The main concept of this project is to control the movement of a robot using an accelerometer sensor that detects the tilt and orientation of a handheld controller. The sensor readings are transmitted to an Arduino micro-controller, which interprets the signals and drives the robot's DC motors through a motor driver circuit. When the user tilts the controller in different directions, the accelerometer detects the change in acceleration, and the robot responds accordingly moving forward, backward, left, or right. The solar panel mounted on the robot continuously charges the rechargeable battery, ensuring that the system operates efficiently even in outdoor environments without frequent manual charging. This makes the robot self-sustaining and suitable for long-duration applications. Such a system finds practical use in environmental monitoring, agriculture, material transport, and assistive mobility for differently-abled individuals. By integrating gesture-based control and renewable power, this project not only demonstrates the advancement in control techniques but also promotes the concept of green and sustainable robotics for future innovations. Due to increase in energy consumption and depletion of fossil fuels, the renewable energy sources have become rare.

Nowadays solar and wind energy power generations are rapidly growing when compared to other renewable source. In India solar potential is high and wind power generations have the limitation of medium wind profile, low plant factor and saturation of optimal wind locations. Solar irradiation is abundant in India by figures (4 -7) kw/m² per day in all over the country with 300 clear sunny days in a year. The 70% of Indian population are involved in agricultural and living in rural areas. Still 1/3rd of Indian population are not connected to grid electric supply for that reason photo



voltaic distributed power generation is most popular. And that sort of energy if get utilized can solve more number of problems in dense populated countries like India.

In this project solar power is utilized for the robot working under military, medicine, heavy industries etc which utilizes the solar energy to power up. As robots are usually electro-mechanical machines, they consume more energy for the movement of mechanical parts by means of electrical controllers. The replacement of utilizing renewable energy would make more convenient utilizations under remote areas. First, the background information necessary to understand photovoltaic cell is presented and followed by the description about making of robot utilizing solar energy.

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.

II. LITERATURE REVIEW

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.

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.

III. BACKGROUND OF PROJECT

The background and key concepts relevant to a solar-powered mobile robot whose motion is commanded by tilt/gesture measured with an accelerometer (typical module: MPU6050). It covers accelerometer/IMU-based gesture and tilt control, signal processing and control strategies, solar-powered mobile robots and energy management, combined systems and applications, and gaps / design considerations for this project.

Accelerometer / IMU-based gesture and tilt control

Accelerometers and IMUs (inertial measurement units) like the MPU6050 are widely used to capture hand or controller orientation and motion for robot control. Many student and research projects convert measured acceleration/tilt (or derived roll/pitch angles) into directional commands for wheeled robots or manipulators. Typical implementations place the IMU in a hand-held glove/controller or on the operator's palm and send tilt-derived commands wirelessly to the robot, or mount the IMU on the robot for self-balancing and orientation tasks. Examples include gesture-controlled cars, hand-glove systems and hand-gesture robot controllers that use MPU6050 or similar 6-axis modules.

Signal processing and control algorithms

Raw accelerometer data is noisy and includes gravity and dynamic acceleration components. To convert acceleration readings into stable tilt/angle estimates, researchers use filtering and sensor fusion techniques such as complementary filters, Kalman filters, or simple low-pass smoothing. For responsive yet stable robot motion, systems often apply deadzones, smoothing (moving average / exponential smoothing), and scaling/mapping of angle to motor PWM. In robotics applications that require balance or precise orientation (e.g., self-balancing robots), the IMU outputs are fused with gyroscope data and a feedback controller (PID) to compute corrective motor commands. Papers and project reports on angle-detection with the MPU6050 and on self-balancing robots document these techniques and practical parameter choices.

Solar-powered mobile robots and power management

Using solar panels to supplement or fully power mobile robots is an active area, especially for outdoor field robots (agriculture, beach cleaning, lawn mowing, transport). Literature emphasizes careful sizing of solar panels and batteries (matching expected duty cycle and insolation), charge controllers (MPPT preferred), and power-management strategies (e.g., duty cycling, low-power electronics, automatic return-to-charge behaviors). Several prototype systems show that small solar panels plus a battery can meaningfully extend autonomous operation if the robot's power budget (motors dominate) and charging opportunities are aligned with mission profile. Design papers typically include energy budgets, panel/battery sizing examples, and discussion of trade-offs.



Integration: gesture control + solar power - examples and applications

Several survey and project reports combine gesture control with mobile robots and separately combine solar power with mobile platforms. Applications include agricultural robots (solar-assisted), beach-cleaning robots, teleoperated transport robots, and assistive devices. While many gesture-control projects focus on wireless transmission (RF/Bluetooth) from a glove/controller to an Arduino receiver, solar-powered robot papers focus on autonomous operation and power-autonomy strategies. Direct literature combining both topics (gesture-controlled robots that are explicitly solar-powered) is limited in peer-reviewed journals, though conference papers and project reports demonstrate feasibility by integrating off-the-shelf IMUs and small solar charging systems. This indicates a practical research niche: robust remote control (tilt-based) that also operates sustainably outdoors.

Common challenges reported

Sensor noise and drift: raw accelerometer output can cause jittery commands unless filtered. Complementary/Kalman filters and deadzones are standard remedies.

Power mismatch: motors consume most energy; panels must be sized with realistic sunlight assumptions. Several studies stress that panels often supplement rather than fully replace battery power for mobile robots.

Mechanical mounting & ergonomic mapping: IMU orientation (which axis maps to which motion) and the physical mounting (on controller vs robot) affect user experience and require calibration.

Communication latency and reliability: wireless links (Bluetooth/RF) used by many gesture-control projects must be robust; missed packets or high latency degrade control quality.

Design implications for this project

Based on the reviewed literature, a successful implementation should include: An MPU6050 (or similar IMU) with complementary or Kalman filtering to produce stable pitch/roll estimates. Dead zone and smoothing in the command mapping, plus an adjustable sensitivity parameter. A realistic energy budget: estimate motor current under typical load, choose battery capacity to meet desired runtime, and size the solar panel + charge controller (MPPT preferred) to meaningfully recharge during typical sunlight hours.

IV. EXISTING SYSTEM

In the existing system, most robots are powered by conventional batteries or external power supplies, which limits their operational time and increases maintenance costs due to frequent recharging. The control mechanism in traditional robots is often based on wired connections or manual switches, making them less flexible and less intuitive for users. While some wireless-controlled robots exist, they generally rely on joystick or remote-based controls rather than motion-sensing devices. Moreover, these systems do not typically incorporate renewable energy sources like solar power, resulting in higher energy consumption and reduced sustainability. Additionally, the absence of smart sensing technologies such as accelerometers limits the robot's responsiveness and precision in movement control.

Limitations:

- **Limited Power Source:** Robots often rely on conventional batteries, leading to frequent charging and limited operational duration.
- **Lack of Renewable Energy Use:** Most systems do not utilize solar energy, making them less energy-efficient and environmentally sustainable.
- **Wired or Manual Control:** Traditional robots are usually controlled through wired connections or manual switches, reducing mobility and ease of use.
- **Low Flexibility:** The control system lacks adaptability and user-friendliness compared to modern gesture-based systems.
- **Absence of Smart Sensors:** Many existing robots do not incorporate accelerometers or other intelligent sensors for motion-based control.



- High Maintenance: Frequent charging and dependence on non-renewable energy increase maintenance and operational costs.
- Limited Range: Wired or basic wireless systems restrict the control distance and real-time response capability of the robot.

V. PROPOSED METHOD

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.

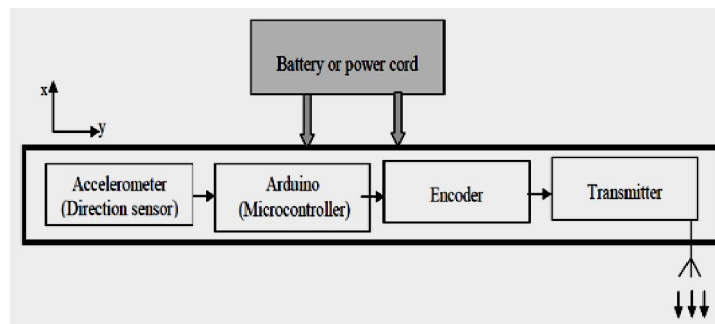


Fig.1. Transmitter Block

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.

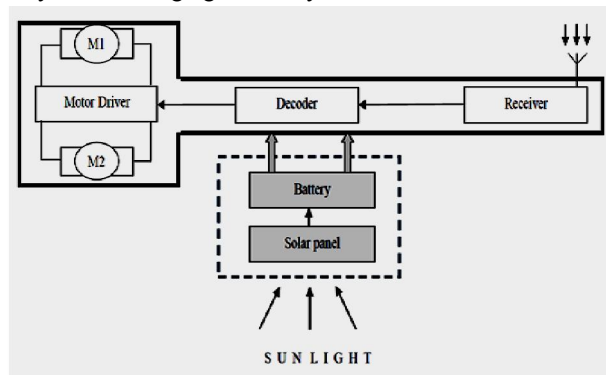


Fig.2. Receiver Block

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

- Accelerometer (adxl335)
- Arduino UNO (containing microcontroller atmega328)
- Encoder (HT12E)
- 433MHz 4 channel RF pair
- Rechargeable battery (12V, 1.3A, Pb acid)
- Motor Driver (L293D)
- DC motor (12V, 60 RPM)
- Solar Panel

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.
- Gesture control through accelerometer movements provides a simple and natural way to direct the robot's motion.

V. CONCLUSION

The purpose of the project is to utilize the renewable energy for the movement of robot and conserve the non renewable energies for future generation. As robots generally have some electronic parts and more mechanical parts for movement they consume more energy for the mechanical parts and electronics as well. This energy demand for the robots cannot be supplied always with the already recharged battery or powering up through an adapter as wiring itself is a big disadvantage.

This robot when equipped in the applications of military like detection of mines and dismantling them roves in sun light hence this gets charged effectively. This prevents the mental pressure for the controllers to notify the back up of battery and replacement under peak situations. Battery gets charged at the time of robots working time itself. Equatorial nations like India are always exposed to sun light over a wide area and seasonal changes have no recognizing impact over sun light intensity. Hence this can be used everywhere in the places of outdoor environment. This robot can be used in indoor also in the field of medicines for doing surgery etc by utilizing the stored energy from the battery in the situation of operating a spreadable diseased patients by Doctors. If this technique is improvised more non renewable energy can be saved for our future generation.

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