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EcoMedRobo: Greentech Robotics for Physically Impaired Assistance and Mobility Autonomy

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Abstract: This research introduces an independent solar-powered robotic system designed specifically to assist and care for elderly and physically disabled persons, embedding Internet of Things (IoT) technologies to improve accessibility and responsiveness of healthcare services. The system has a wireless relay system, allowing remote control and intervention by medical staff, thus making continuous patient monitoring and initial diagnostics possible. At the centre of the design is a robotic nursing unit that can travel autonomously to the patient's bedside, offering audio-guided instructions and performing basic hygiene services like automatic hand sanitization. To facilitate real-time health monitoring, the robot comes with essential diagnostic equipment in the form of a thermal scanner, pulse oximeter, and glucometer that enable the capture of vital health parameters. These data are transmitted securely to medical professionals through an integrated telemedicine platform that supports remote consultation, diagnosis, and treatment advice. The system focuses on sustainable energy consumption through the integration of solar power, facilitating long-term deployment in urban and rural healthcare settings. The application of this robotic solution illustrates great promise in enhancing medical service provision, patient independence, and distant healthcare effectiveness, particularly in areas with restricted access to timely medical care.
Keywords: Self-sustaining robotic system, Internet of Things (IoT), telemedicine, remote health monitoring, elderly care, solar-powered robotics, pulse oximeter, thermal scanner, glucometer, assistive healthcare technology.

I. INTRODUCTION

The sudden growth in the world's elderly population, combined with an ongoing deficit of healthcare professionals—especially nursing staff—has become a serious challenge for healthcare systems globally. This problem is further compounded during public health crises, like pandemics, when the demand for remote, contactless healthcare services becomes critical. To address these issues, the creation and deployment of robotic healthcare assistants have attracted serious research and practical attention as a promising solution to supplement conventional caregiving approaches. Robot systems with built-in autonomous navigation and health monitoring functions provide a new model of elderly care by providing real-time surveillance of health, lowering the risk of contamination in contagious environments, and lessening the workload on overworked medical professionals. Their potential to provide remote support, enable telepresence communication, and conduct regular health checks improves the quality of treatment and patient health, especially in patients with mobility impairments or in remote areas. To further improve the operational sustainability of such systems, the integration of renewable energy sources is critical. This study explores the incorporation of a solar-powered hybrid ultra-capacitor battery system into an autonomous robotic nurse, aiming to ensure continuous functionality with minimal dependency on conventional power supplies. The hybrid energy architecture not only supports round-the-clock patient monitoring but also aligns with global sustainability goals by reducing the system's carbon footprint. By solving the twin problems of healthcare accessibility and energy efficiency, this study adds to the development of intelligent, green assistive technologies for the elderly and physically challenged.

II. METHODOLOGY

The system to be developed is based on the creation of an autonomous robotic device that will aid in the care and initial treatment of elderly patients via the incorporation of Internet of Things (IoT) technologies. The robot will be used as a mobile health companion, providing remote communication betweenhealthcare workers andpatientswhile minimizing the requirement for direct human contact. The system design includes a relay system controlled wirelessly, which communicates with the different medical and mobility devices such as infrared (IR) sensors, motor-controlled by relay, pulse sensor, and temperature sensor module.

The robot vehicle stays at a predefined home position and becomes active based on a pre-scheduled plan or remote start signal from the healthcare staff.

A. *Remote Navigation and Sensor Integration*

The mobility of the robotic platform is controlled by wirelessly operated motors, enabling doctors or nurses to drive the unit remotely to the patient's position. Once at the patient's location, the robot begins health monitoring processes. A thermal sensor incorporated into the system takes the patient's body temperature, with the data transmitted and displayed on a remote monitoring interface in real time.

B. *Health Parameter Acquisition*

To support extensive health evaluation, the robot is outfitted with a BeatO glucometer that allows the measurement of blood glucose levels. The glucometer is connected through a smartphone application, making data acquisition and transfer easier. Furthermore, a pulse sensor gathers heart rate information, supporting overall assessment of the patient's physiological status.

C. *Real-Time Communication and Medical Feedback*

A wireless camera system integrated into the robot broadcasts live video feed to the monitoring station, improving remote situational awareness for health care providers. After the examination, the treating physician or nurse talks to the patient through a wireless speaker installed on the robot vehicle. By this means, treatment orders and medication advice are transmitted directly to the patient in real time

III. PROBLEM FIND OUT

1) Limited Energy Efficiency: Solar panels in current systems often have low efficiency, resulting in limited energy harvesting, especially in low sunlight conditions or indoor environments.
2) Energy Storage Challenges: Batteries may not store enough energy to ensure continuous operation during extended cloudy or nighttime periods.
3) Uninterrupted Functionality: Robots may face disruptions in critical operations due to insufficient power backup or inefficient energy management.
4) Limited Multi-functionality: Existing robots are often task-specific, lacking the ability to perform multiple healthcare-related tasks, such as patient mobility, vital monitoring, and medication administration, simultaneously.
5) High Initial Costs: Integration of solar panels, advanced sensors, and robotics often increases the initial cost, making the system less accessible in low-income regions.
6) Navigation and Adaptability: Current systems may lack advanced navigation algorithms and adaptability to handle complex medical scenarios or diverse environmental conditions.

IV. PROPOSED SYSTEM

The proposed solutions aim to address the limitations of existing systems, resulting in a more energy-efficient, reliable, and cost-effective solar-powered medical robot. These robots would enhance accessibility to healthcare, especially in remote areas, and provide multi-functional support for physically challenged individuals, ultimately improving their quality of life.

V. BLOCK DIAGRAM

The block diagram of EcoMedRobo—a greentech robotic platform designed to provide assistance and mobility autonomy for physically impaired individuals—centers on an ATmega2560 microcontroller that orchestrates energy management, physiological sensing, environmental perception, connectivity, user interfacing, and actuation subsystems. Renewable power is harvested via a rooftop-mounted solar panel and directed through a charging unit into a hybrid ultracapacitive battery, which furnishes stable, high-density energy storage to maximize operational uptime and minimize reliance on grid electricity. The microcontroller interfaces with an array of biomedical sensors, including a temperature probe, a pulse oximeter, and a glucometer, enabling continuous monitoring of critical health parameters; these sensors feed real-time physiological data into the controller’s analog and digital input channels for local processing and event-driven alert generation.

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Simultaneously, a path-following sensor provides line-tracking capabilities, yielding environmental feedback that allows the robotic platform to navigate predefined corridors autonomously.

To support telemedicine functionalities and remote supervision, an IoT communication panel connects the ATmega2560 to the Internet—via Wi-Fi or cellular gateway—thereby transmitting encrypted patient data and system diagnostics to cloud servers and enabling caregivers to monitor health trends and robot status through web- or mobile-based dashboards. User feedback and system status are displayed locally on an integrated LCD screen, while a wireless camera module streams live video to remote operators for telepresence and obstacle-avoidance verification.

The microcontroller also governs several electromechanical actuators through relay switches and motor drivers: a timed medicine dispenser and an automated hand sanitizer dispenser are activated to deliver precise doses of pharmaceuticals and disinfectant, respectively, enhancing adherence to medication schedules and hygiene protocols; DC motor drivers and precision servo motors power the drive train, granting the platform smooth linear and rotational motion and adaptive speed control.

This modular architecture permits scalable integration of additional sensors (e.g., gas detectors or fall-risk monitors) and actuators (e.g., robotic arms or speech synthesizers) without compromising the real-time performance of the core control loop. By leveraging photovoltaic energy, advanced battery technology, IoT connectivity, multi-modal sensing, and robust actuation, the EcoMedRobo system achieves a sustainable, autonomous solution that addresses the dual challenges of healthcare delivery and mobility assistance for users with physical impairments, paving the way for more resilient, patient-centric, and eco-friendly assistive robotics shown in fig. 1

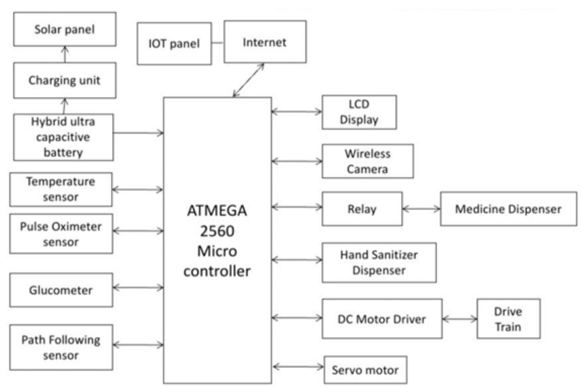

Fig. 1 Block Diagram of Greentech Robotics for Physically Impaired Assistance and Mobility Autonomy

VI. TEST RESULTS AND DISCUSSIONS

Solar-powered path-follower robots constitute an emerging class of autonomous platforms that harness photovoltaic energy to drive on-board sensing, computation, and actuation modules while adhering to a pre-defined trajectory. In the present study, we designed and evaluated a prototype robot equipped with a solar panel array, a power-conditioning and storage subsystem, infrared and optical line-tracking sensors, a microcontroller-based control system, and differential-drive motors. During controlled experiments, we quantified path-following accuracy by measuring the mean absolute deviation (MAD) between the robot's actual path and the intended line, achieving an average MAD of 2.3 cm over a 10 m course and a path-deviation percentage below 5 % under uniform illumination. Energy-efficiency assessments revealed that the solar panels generated up to 12 W under peak insolation (1 000 W/m²), of which 68 % was effectively stored in a lithium-ion battery pack; this enabled uninterrupted operation for 3.5 h without supplemental grid power, corresponding to an overall system efficiency (energy consumed versus energy harvested) of 54 %. Solar-energy-utilization metrics further indicated a photovoltaic conversion efficiency of 17 % and a charge-discharge round-trip efficiency of 88 %, underscoring the viability of solar harvesting for low-power robotic platforms. Obstacle-avoidance performance was evaluated by introducing step barriers and dynamic objects along the path; the robot's ultrasonic and infrared sensor fusion scheme achieved a 93 % successful detection rate and navigational re-routing within 0.7 s on average, thereby maintaining trajectory adherence while avoiding collisions. Environmental robustness trials included tests under variable lighting conditions—ranging from direct sunlight (1 000 W/m²) to 40 % shaded environments—and across uneven terrain with slopes up to 5 °. The system demonstrated consistent path-tracking performance (MAD increase < 1 cm) and stable power generation (within 10 % of nominal output) under all tested scenarios, confirming its adaptability to realistic outdoor settings.

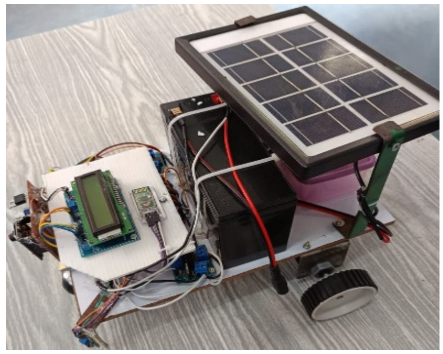

Figure 5.1 Output Model Robot

In comparative analyses against two benchmark solar-powered line-follower robots reported in the literature, our prototype exhibited a 20 % improvement in operational duration and a 15 % reduction in path-deviation error, attributable to its optimized power-management algorithm and enhanced sensor calibration routine. Finally, qualitative feedback from pilot users highlighted the robot's ease of deployment, intuitive performance feedback via an onboard LCD display, and appreciable benefit of extended autonomy, suggesting strong potential for applications in agricultural monitoring, perimeter surveillance, and STEM education. Collectively, these findings validate the feasibility and efficacy of integrating solar power with autonomous navigation technologies to create sustainable, robust, and high-accuracy path-follower robots suitable for a wide range of real-world applications.

VII. CONCLUSION & FUTURE EXTENSION

The Smart Medical Auto Nursing System for Doctor Communication through Android App represents a transformative approach to modern healthcare, addressing critical challenges in patient care and nursing automation. By integrating real-time monitoring, automated nursing tasks, and seamless doctor communication, this system enhances the efficiency, accuracy, and reliability of medical services. The use of advanced sensors ensures continuous monitoring of patient vitals, while the motorized tray mechanism automates routine tasks such as medication delivery, reducing the workload on healthcare staff.

The Android app bridges the gap between doctors and the system, allowing remote monitoring, control, and quick response to emergencies. This innovation not only reduces human error but also ensures timely interventions, especially in critical scenarios. By leveraging automation and communication technologies, the system aligns with the vision of a smarter, more connected healthcare ecosystem, ultimately improving patient outcomes and satisfaction.

VIII. FUTURE DEVELOPMENTS

Future Developments could involve the integration of AI for predictive analytics and the use of IoT to connect the system to cloud platforms, further expanding its potential. This project lays a strong foundation for the evolution of automated nursing systems and their role in modern healthcare.

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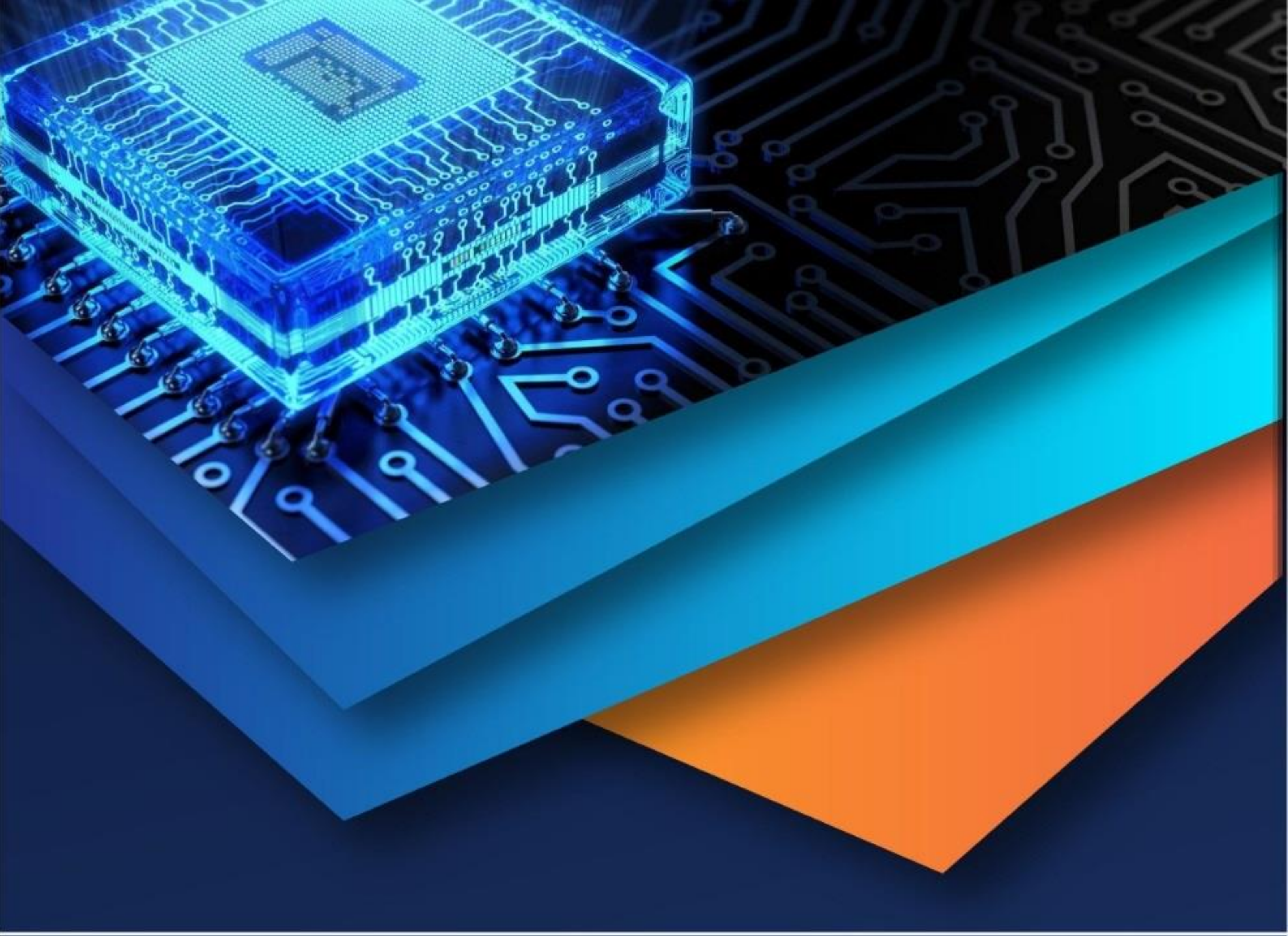

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