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Wheelchair with Robotic Arms

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Abstract: *The proposed project presents the design and development of an Electric Wheelchair integrated with a Robotic Arm and Mini Camera, aimed at enhancing the mobility and independence of physically challenged individuals. The system combines advanced robotics and vision based control to assist users in performing daily tasks without external help. By integrating a multi degree robotic arm, the design enables users to pick, place, and manipulate objects with precision, while the mounted camera provides real time visual feedback for accurate operation and navigation. The project incorporates intelligent control mechanisms using micro controllers and sensors to interpret user inputs through a joystick, flex sensors, or voice commands. This approach ensures an intuitive and user friendly interface that can adapt to the user's comfort and accessibility requirements. The wheelchair's modular structure integrates essential components such as servo motors, an Arduino based control system, and a mini camera module, enabling efficient coordination between mechanical and electronic subsystems. Simulation and control logic were developed and tested using Tinker cad software in Phase 1, focusing primarily on design validation and functional modeling. As a socially relevant innovation, this project contributes to the growing field of Assistive technologies, promoting inclusion and self reliance among differently -a bled individuals. While the current phase emphasizes design, simulation, and system integration, the subsequent phase will involve full hardware implementation, real time testing, and performance evaluation. The final outcome is expected to offer a cost effective, ergonomic, and reliable solution that bridges the gap between robotics and rehabilitation, ultimately improving the quality of life for individuals with mobility impairments.*

Keywords: *Electric Wheelchair, Robotic Arm Integration, Assistive Technology, Mobility Aid, Arduino Micro controller, Mini Camera Module, Vision Based Control, Intelligent Control System, Human –Machine Interface, Joystick Control, Voice Command System, Flex Sensors, Servo Motors, Embedded Systems, Rehabilitation Robotics, Accessibility Technology, Differently Able Support, Cost Effective Design, Modular System Design.*

I.INTRODUCTION

In recent years, the integration of robotics and assistive technologies has revolutionized the field of mobility enhancement for physically challenged individuals. The electric wheelchair, once a simple mobility aid, has now evolved into a sophisticated platform equipped with automation, sensors, and control systems. This transformation has allowed users to regain a Significant degree of independence, enabling them to perform everyday activities with minimal external assistance.The addition of robotic arms to electric wheelchairs introduces a new dimension of functionality. These robotic arms can perform complex tasks such as picking up objects, placing items on surfaces, and even assisting users with routine activities like eating or writing. The combination of a robotic manipulator and an intelligent control system bridges the gap between human intention and machine execution, ensuring precision and adaptability in various environments.To further enhance usability, the integration of a mini camera provides real time visual feedback to the user. This allows for improved control, especially during object manipulation and navigation in confined spaces. The fusion of these technologies mobility, manipulation,and vision creates a powerful assistive system that aims to improve quality of life, safety, and accessibility for differently able users.

II.OBJECTIVES

The objectives of this project are formulated to guide the systematic design and implementation of the proposed wheelchair system. These objectives ensure that all critical aspects mechanical, electronic, and computational are addressed to achieve optimal performance. The primary goal is to design a prototype that successfully demonstrates the feasibility of integrating mobility and manipulation into a single device. Specific objectives include designing a robust control system, integrating real time visual feedback, and ensuring intuitive user interaction. The project also aims to simulate and validate the system using software tools before moving to physical implementation. Emphasis is placed on safety, adaptability, and scalability to ensure that the final design can accommodate future enhancements. These objectives form the road map for the entire development process, from conceptualization and simulation in Phase 1 to prototype testing and evaluation in Phase 2. They establish a strong foundation for achieving both functional and social relevance through technological innovation.

III. METHODOLOGY

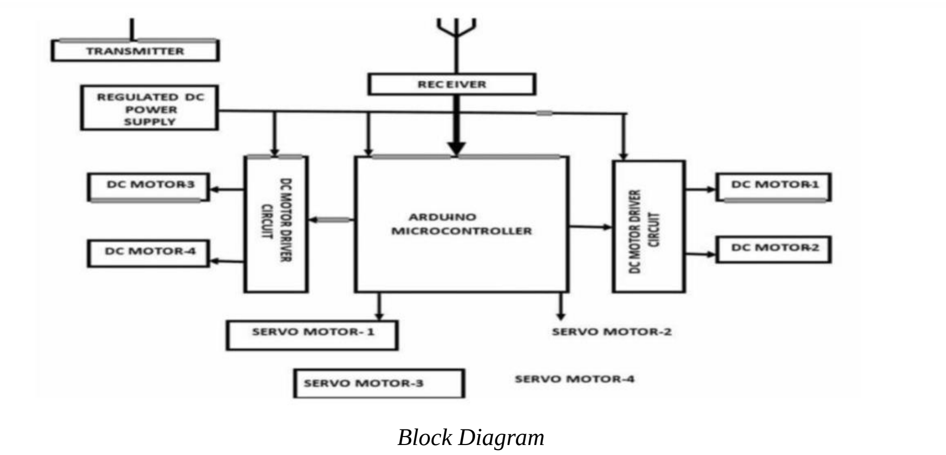
The methodology of the proposed electric wheelchair with an integrated robotic arm focuses on developing an assistive system that improves both mobility and object handling capability for physically challenged users. The system is designed by combining mechanical, electronic, and control components in a structured and systematic manner.The wheelchair base provides powered movement using DC motors, which are controlled through a joystick interface. This allows the user to move the wheelchair forward, backward, and sideways with ease. A multi degree of freedom robotic arm is mounted securely on the wheelchair frame to perform basic tasks such as picking up and placing objects. The robotic arm is driven by servo motors, which enable accurate positioning and smooth movement of each joint.A micro controller acts as the central control unit of the entire system. It receives input signals from user interfaces such as a joystick and flex sensors. These inputs are processed by the micro controller, which then generates appropriate control signals to operate the wheelchair motors and the robotic arm simultaneously. Predefined motion sequences are programmed to assist users in performing common daily activities efficiently and safely.A mini camera is integrated into the system to provide real time visual feedback. This helps the user monitor object handling and navigation, especially in situations where direct visibility is limited. The camera output enhances accuracy and improves overall user confidence during operation.The system is powered using a rechargeable battery, along with voltage regulation circuits to ensure stable and safe power supply to all electronic components. Safety features such as speed control, controlled arm movement limits, and an emergency stop mechanism are incorporated to pr event accidents and ensure reliable operation. During Phase 1, the complete control logic and system behavior are simulated using Tinker cad software. This simulation helps verify the correctness of the circuit design, motor control logic, and sensor response before moving to hardware implementation. Th e simulation based approach reduces errors, improves reliability, and ensures smooth transition to real time testing in the next phase.

IV. PROBLEM STATEMENT

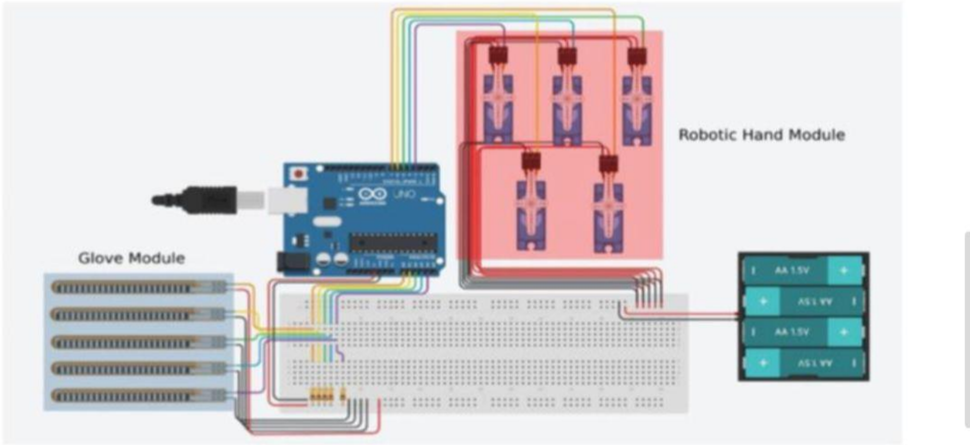
Physically challenged individuals often face significant barriers in performing daily activities that require reaching, lifting, or manipulating objects. Existing electric wheelchairs primarily focus on mobility, offering limited functionality for environmental interaction. As a result,users remain dependent on caregivers for essential tasks, leading to reduced independence and quality of life.Many available robotic wheelchair systems are either prohibitively expensive or lack The versatility needed for individualized use. Additionally, systems that do exist often fail to provide intuitive user interfaces or effective sensory feedback, which limits their adoption among the target user base. The lack of visual feedback and adaptive control mechanisms further constrains their usability.The problem, therefore, lies in designing an affordable, user friendly, and intelligent as wheelchair system that integrates motion, manipulation, and vision based control. The proposed system aims to overcome these challenges by providing a multifunctional robotic platform that empowers users to interact with their environment efficiently and safely.

V.SYSTEM DESIGN AND DEVELOPMENT

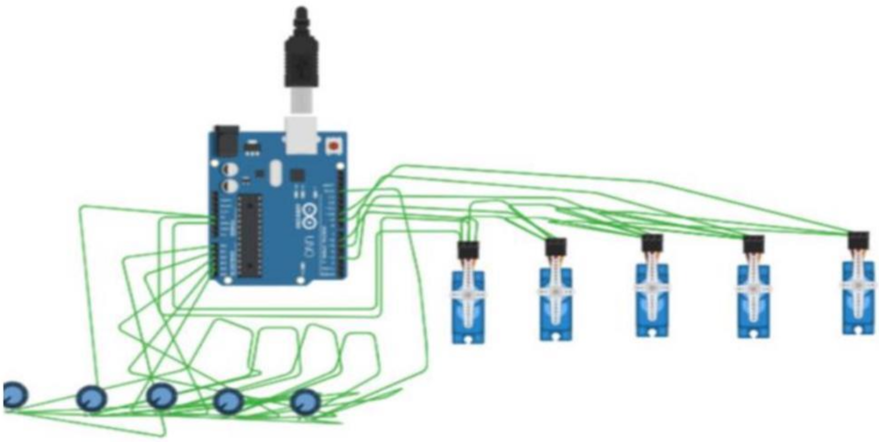
The system architecture of the proposed electric wheelchair with an integrated robotic arm and mini camera is designed to ensure seamless coordination between hardware and software components. It combines motion control, manipulation, and vision feedback into a unified framework, allowing the user to interact intuitively with the system. The architecture is modular, consisting of three primary subsystems mobility control (wheelchair base), manipulation control (robotic arm), and perception (camera feedback) .Each subsystem is connected through a micro controller unit, which acts as the central processing hub. Input signals from devices such as joysticks and flex sensors are processed by the micro controller, which generates corresponding output signals to control motors, actuators,and the camera. The use of sensors and PWM control ensures smooth, synchronized operation and real time responsiveness.The modular approach enhances flexibility and scalability, allowing future integration of additional features such a s obstacle detection, wireless communication, or AI based vision processing. This well defined system structure not only simplifies troubleshooting and maintenance but also ensures optimal performance and energy efficiency across all components.



Block Diagram



Circuit Diagram



Simulation Diagram

VI.OVERVIEW OF HARDWARE DESIGN

The hardware design of the system forms the physical foundation upon which control and feedback operations are executed. It includes key components such as the electric wheelchair frame, motors, servo driven robotic arm, sensors, battery unit, voltage regulators, and control modules. The hardware is configured to achieve stability, safety, and precision while maintaining ergonomic comfort for the user.The electric wheel chair base consists of high torque DC motors for propulsion and steering, controlled via joystick input. The robotic arm, attached to the wheelchair, features multiple servo motors for joint articulation, enabling various degrees of freedom for picking and placing objects. Flex sensors are used for detecting hand gestures, while a mini camera provides real time visual feedback. The overall wiring is designed to minimize interference and ensure efficient power distribution.Each component is carefully selected to achieve a balance between cost, reliability and performance. The hardware is design ed to accommodate modular expansions and is optimized for low power consumption. Proper mechanical integration ensures the system operates safely and comfortably under dynamic loads.

VII.CONCLUSION

The proposed project, “Electric Wheelchair with Integrated Robotic Arm and Mini Camera,” represents a significant step toward developing intelligent assistive technology for individuals with physical disabilities. Through the integration of robotics, control systems, and vision based feedback, the system aims to enhance user independence and mobility. The design combines mechanical precision with user friendly control interfaces such as joystick and flex sensors, providing an adaptable and efficient means of human machine interaction. The Phase 1 design and simulation successfully demonstrate the feasibility of integrating multiple u systems into a cohesive framework capable of responding effectively to user commands.The system’s architecture emphasizes safety, reliability, and modular, ensuring that each component operates harmoniously within the control structure. The inclusion of advanced features such as real time camera feedback, multiple control modes, and smart power management underscores the project’s innovative approach to assistive technology. The simulated results validate the system's responsiveness and stability, confirming that it can efficiently process user inputs and execute precise actuator movements. Moreover, the project demonstrates how engineering innovation can directly contribute to social inclusion and improved quality of life for differently a bled individuals.While the current phase focuses on design, simulation, and system modeling, the next phase will involve physical implementation and experimental validation of the prototype. Hardware testing, real time performance evaluation, and refinement of control algorithms will form the foundation for Phase completion, the project is expected to deliver a fully functional assistive device that integrates intelligent mobility, robotic manipulation, and vision guidance serving as a practical and impact solution in the field of biomedical and rehabilitation engineering.

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