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REVIEW PAPER ON MULTIFUNCTIONAL ELECTRIC WHEELCHAIR CUM STRETCHER

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ABSTRACT

This paper presents the design and development of a multipurpose electric wheelchair that transforms seamlessly into a stretcher, aiming to enhance mobility, comfort, and independence for individuals with limited physical capabilities. Traditional mobility devices such as wheelchairs and stretchers each fulfill specific roles, but they often lack versatility and can be inconvenient in situations requiring frequent transfers between devices. Our proposed design integrates both functionalities, allowing for easy transitions between a wheelchair and stretcher form, powered by a battery-operated electric mechanism.

Key features of the device include an adjustable seat and backrest, a motorized frame for smooth transformation, and ergonomic support for various postures. The electric wheelchair-stretcher hybrid is controlled via a joystick, enabling users or caregivers to adjust the device's configuration effortlessly. Safety features, including a braking system and stability controls, ensure secure operation, while compact and foldable elements promote ease of storage and transport.

I. INTRODUCTION

In recent years, advancements in assistive technology have focused on enhancing the independence, comfort, and convenience of individuals with limited mobility. Now days mobility devices like wheelchair, stretchers serve vital roles in enabling movement and support, but they often function independently and require time-consuming and physically demanding transfers between devices. this limitation can lead to inconvenience for both users and caregivers, particularly in environments where mobility and adaptability are critical, such as hospitals, nursing homes, and personal residences. The multipurpose electric wheelchair-stretcher hybrid addresses these challenges by combining the functionality of both devices into a single, adaptable solution. This hybrid device allows users to transition smoothly between wheelchair and stretcher configurations with minimal effort, thanks to an electric mechanism controlled by a joystick. Incorporating features such as a stable electric frame, safety locks, and an intuitive control system, the electric wheelchair-stretcher offers a safe and reliable experience. Furthermore, this device minimizes the physical strain on caregivers, reduces the risk of injury during transfers, and provides users with enhanced autonomy.

Key Points : Independence, Physical disability ,Electric wheelchair (EWC),Mobility ,Efficiency ,Variable speed control, Lightweight design, Custom dimensions , Affordability ,Improved control.

II. LITERATURE REVIEW

In 2023 Ahmed Ali, 2Dr. M. Sohail Pervez. They discuss about a wheelchair is designed to help people who have difficulty walking or are unable to walk. It is used by people with physical disabilities, elderly individuals, and children who need assistance with movement. There are different types of wheelchairs, including ones that can be moved by the user (self-propelled), powered by a motor, or pushed by someone else. Wheelchairs are often used to move patients within hospitals or help people get around at home. Over the years, there have been significant improvements in mobility devices, and wheelchairs remain one of the most commonly used aids for people with mobility issues."(1)

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In 2024 Rishi Shyam Vishwakarma . They studied the goal of our project is to create an automatic wheelchair that can also be used as a bed.

This device can switch between being a wheelchair and a bed by moving up and down, making it easier for people with physical disabilities to live more comfortably and independently."(2)

In 2023 T. Kumar Raju . In this paper they discusses various methods, such as FL, DARE analysis, and the Pugh concept selection method, to turn customer needs into a product concept. Feedback from the wheelchair users was crucial in the development process, ensuring the final product met their needs.

The developed wheelchair allows people with leg disabilities to transfer themselves to a bed without needing help."(3)

In 2023 Yane Kim . " They studied Smart wheelchairs (SW) are an important innovation that greatly improve mobility and independence for people with physical limitations. They use advanced technology, like sensors, artificial intelligence (AI), and easy-to-use controls, to help users move safely and easily through complex environments. This combination of technology makes daily tasks easier and allows for more freedom and accessibility."(4)

In 2021 Siddhant Pawar. The paper discusses the need for a wheelchair that can also function as a stretcher. It explains how this conversion can be done using a lead screw mechanism. However, the main drawbacks of this system are its high cost and the added weight of the wheelchair."(5)

In 2015 Ranjit P. Katkar. They studied first powered wheelchair was developed in the 1950s, using a motor for movement. Around that time, wheelchair sports also began. In 1964, the first Paralympic Games were held in Tokyo, Japan.

Today's wheelchairs are made from lightweight materials and use advanced systems, like microprocessors. There is a wide variety of modern wheelchairs designed to meet different needs and preferences. In the future, even more advanced wheelchairs are expected, catering to various needs and imaginations."(6)

In 2019 S.Ganapathy ." In 1962, Ernesto Blanco, while at the Massachusetts Institute of Technology (MIT), designed a self-propelled wheelchair that could climb stairs. Although a full-sized version was never built, a small model was created to show how the wheelchair would work on flat ground and while climbing or descending stairs.

An image of the model can be found on MIT's website, even though no detailed research papers were published about Blanco's design."(7)

In 2018 AnupKumar Vishwakarma ."They studied the needs of people who are physically disabled, ill, or hospitalised and rely on wheelchairs for mobility. Based on their findings, they made improvements to the traditional wheelchair by adding new features.

One of the main issues they found was the difficulty in using the bathroom, so they added a commode to the wheelchair. The seat is also flexible, allowing users to lie down if needed. Additionally, they included a working table that can be used for various tasks.

They combined these features to create an electric wheelchair that is self-propelled."(8)

In 2019 A.V.S. Sanjeeva Reddy ." They Developed a voice-controlled wheelchair, allowing users to control movement through voice commands. It mainly helps those with limb disabilities, but has limited control features.

Created a semi-automated wheelchair using computer vision and EEG signals for navigation, with a joystick for manual control. However, the system requires many steps, which can be exhausting."(9)

III. OBJECTIVES

- Optimize for Compactness and Portability
- Adapt to Various Environments
- Ensure Safe Operation
- Simplify Caregiver Assistance
- Increase Comfort and Support
- Enhance User Independence
- Increase Versatility in Multiple Environments

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Promote Compact and Efficient Design Material Selection

When selecting materials for an electric wheelchair that can also function as a stretcher, several factors must be considered to ensure safety, comfort, durability, and functionality. Here's a breakdown of material options based on different components:

Frame

- Aluminum Alloys: Lightweight and strong, resistant to corrosion. Ideal for reducing overall weight while maintaining durability.
- Steel: Provides excellent strength and stability but is heavier than aluminum. Suitable for high-stress areas but may need coating to prevent rust.
- Carbon Fiber: Lightweight and high strength, but more expensive. Suitable for premium models where weight savings are critical.

Seat and Backrest

- High-Density Foam: Provides comfort and support, available in various densities to accommodate different user needs.
- Memory Foam: Offers excellent pressure relief, ideal for users who may be in the chair for extended periods.
- Vinyl or Waterproof Fabric: Durable, easy to clean, and resistant to moisture. Important for hygiene and maintenance.

Wheels and Tires

- Polyurethane Wheels: Offer a good balance of durability and shock absorption, suitable for various terrains.
- Air-filled Tires: Provide better shock absorption and comfort but require maintenance to prevent punctures.
- Solid Rubber Tires: Puncture-proof and low maintenance, ideal for indoor and outdoor use.

Electronics and Components

- Water-Resistant Casings: Protect electronics from moisture and dirt. Ensure durability and reliability in various environments.
- Lithium-Ion Batteries: Lightweight and high energy density, offering longer operational times with less weight compared to lead-acid batteries.

Upholstery

- Antimicrobial Fabrics: Helps reduce the risk of infections, especially important in medical applications.
- Easy-Clean Materials: For hygiene, materials that can be easily wiped down or are machine washable are beneficial.

Safety Features

- Reflective Materials: For visibility in low-light conditions, especially if the wheelchair is used outdoors.
- Safety Harnesses and Straps: Made from durable, adjustable materials to secure users safely during transit.

Additional Considerations

- Weight Capacity: Ensure all materials can support the maximum expected weight.
- Modularity: Consider materials that allow for easy assembly and disassembly for repairs or upgrades.
- Cost vs. Benefit: Balance between high-performance materials and budget constraints.

Concept Design and Development

The design and development of a multifunctional electric wheelchair cum stretcher begins with a focus on user needs, prioritizing both mobility and emergency transport capabilities. The frame should be constructed from lightweight materials like aluminum or carbon fiber to enhance portability while ensuring durability. Key features include a reclining backrest for stretcher use, adjustable components for user comfort, and all-terrain tires equipped with a reliable electric drive system for ease of movement. Safety is paramount, with features such as a wide wheelbase for stability, anti-tip mechanisms, and adjustable safety straps to secure users during transit. The design should also consider ergonomic aspects, incorporating intuitive controls, adjustable armrests, and

integrated storage for caregiver convenience. Prototyping is essential, involving material selection, 3D printing for initial components, and user testing to gather feedback on comfort and usability. Iterative design allows for refinements based on test results, leading to finalized specifications for manufacturing. A strategic marketing plan targets healthcare facilities and individual users, while post-launch evaluations focus on gathering feedback for future improvements.

Brief Mechanical Design

The mechanical design of the multipurpose electric wheelchair-stretcher is centered on combining stability, durability, and flexibility, allowing seamless transition between wheelchair and stretcher configurations. Key design components include a foldable and adjustable frame, ergonomic supports for user comfort. The device is structured to be lightweight yet durable, suitable for use in home, clinical, and transport settings. The frame is crafted from lightweight, high-strength materials such as aluminum alloy, chosen for its durability, corrosion resistance, and weight advantage. The frame includes folding joints and pivot points to allow a transition between the wheelchair and stretcher modes. The design is composed of several key sections:

- ➔ Base Frame: A sturdy, broad base equipped with anti-tilt wheels that ensure stability during movement and transformation. The base includes a foldable mechanism to save space when not in use or during transport.
- ➔ Seat and Backrest Frame: Adjustable for height and recline, the seat frame is connected to the main base with a pivoting joint that allows smooth transitions between upright (seated) and horizontal (lying) positions.
- ➔ Leg Rest Frame: Attached to the seat, this section supports the user's legs and is also adjustable to enhance comfort and accommodate various postures.

Construction

1. **Frame:** Lightweight yet durable materials like high-grade aluminum or stainless steel are commonly used for the frame.
2. **Cushioning:** The seat and backrest are padded with high-density foam and covered in easy-to-clean, water-resistant materials such as synthetic leather or medical-grade fabrics.
3. **Wheels:** Designed for both indoor and outdoor use, the wheels are typically made from durable rubber or polyurethane for smooth operation on different surfaces. The rear wheels may be powered by electric motors, while the front wheels are smaller for better steering control.

Mechanism

- ➔ The wheelchair cum stretcher uses an electric mechanism powered by rechargeable batteries, which allow the device to operate for extended periods. Some key mechanisms
- ➔ **Motorized adjustment:** The backrest and footrest can be reclined or adjusted electronically, allowing for a smooth transition between the wheelchair and stretcher modes.
- ➔ **Battery-powered movement:** Electric motors are attached to the wheels, facilitating movement without manual pushing. The speed and direction are controlled via a joystick or remote.
- ➔ **Manual Override:** In case of power failure, the device can be switched to manual mode for pushing or operating mechanically.

Component

1. **Arduino-** The Arduino Uno is a small computer board that uses the ATmega328 microcontroller. It has 14 digital pins for input and output (6 of these can produce special signals called PWM), and 6 pins for reading analog signals. It runs on a 16 MHz crystal, connects to computers via USB, and can be powered by an adapter or battery. The name "Uno" means "one" in Italian, marking the release of Arduino version 1.0. The Uno and version 1.0 serve as standard examples for Arduino boards.
2. **Joystick-** The Joystick Shield kit contains all the parts you need to enable your microcontroller with a joystick as you, the shield sits on top of your microcontroller and turns it inte a simple controller, Five momentary push buttons (4+ joystick select button) and a twe- axis thumb joystick gives your microcontroller functionality on the level of old Nintendo controllers.
3. **Motor-** In electric wheelchairs, gear motors are essential for providing controlled, reliable movement. These motors offer high torque, which is necessary to support the weight of the user and the wheelchair, especially

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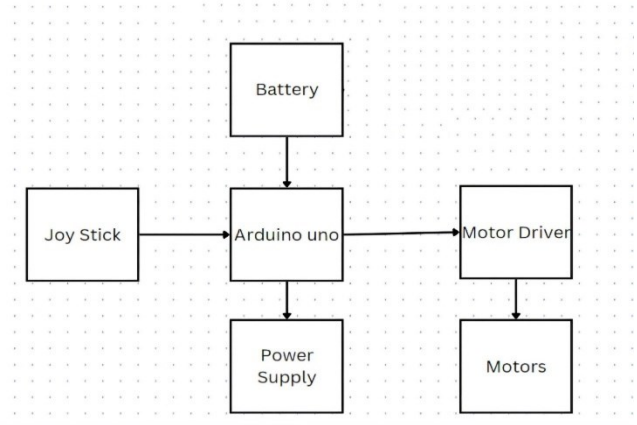
when navigating inclines. They operate at low speeds to ensure smooth, precise movements, crucial for safe and comfortable navigation. Typically, DC gear motors are used because they provide efficient speed control and can be powered by batteries.

4. **Drive circuit-** When using a low-voltage microcontroller with a high-voltage motor, a special circuit is needed to keep the two systems separate. This circuit, called a driver circuit, controls the direction and speed of the motor. one common way to do this is with an H-bridge, which is an electronic circuit made up of four switches. The H-bridge allows you to apply voltage to the motor in either direction, making it possible for the motor to spin clockwise or counterclockwise.
5. **Battery-** A 12V battery is a common power source used in various applications, including electric wheelchairs, automotive systems, and portable devices. It provides a steady 12-volt output, which is suitable for powering motors, control circuits, and other electronic components. These batteries come in different types, including lead-acid, lithium-ion, and nickel-metal hydride (NiMH). Lead-acid batteries are widely used for their reliability and cost-effectiveness, although they tend to be heavier and require regular maintenance.

Electrical System

The electrical system includes a rechargeable battery, joystick controls, and a motors. A backup battery ensures reliability during extended use. The joystick provides smooth, responsive control, allowing for effortless transitions and directional movement.

Block Diagram



Working

The system operates by taking user input from a joystick, which allows the user to control the movement of the electric wheelchair. When the joystick is moved, it generates analog signals that indicate the desired direction and speed (such as forward, backward, left, or right). These signals are sent to the Arduino Uno, which acts as the central processing unit. The Arduino reads and processes these inputs, converting them into digital commands to control the wheelchair's movement. The system is powered by a battery, which provides electrical energy to the Arduino, motor driver, and motors. A power supply module ensures that each component receives the appropriate voltage, maintaining smooth and reliable operation. Once the Arduino has processed the joystick inputs, it sends the corresponding control signals to the motor driver. The motor driver acts as an interface, converting the low-power signals from the Arduino into high-power outputs needed to drive the motors.

The motors, connected to the wheelchair's wheels, receive these signals and rotate in the specified direction and speed. This allows the wheelchair to move smoothly and respond accurately to the user's commands. In essence, the system provides an intuitive and efficient way for users to maneuver the wheelchair by simply moving the joystick, while the Arduino processes the inputs and the motor driver ensures the motors operate accordingly, all powered by a reliable battery setup.

Challenges and Limitations

Design Complexity

- Dual Functionality: Creating a device that seamlessly transitions between wheelchair and stretcher modes can complicate the design process, making it difficult to achieve optimal performance in both functions.

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- Mechanical Reliability: Ensuring that mechanisms for adjustments and transformations are reliable and easy to operate can be challenging.

Weight Constraints

- Portability vs. Durability: Balancing lightweight construction with the need for strength and durability is a significant challenge. Materials that are strong enough to support weight may add unnecessary bulk.

Safety Concerns

- Stability Issues: Maintaining stability in both configurations is critical, particularly when the device is used as a stretcher. A wider base can improve stability but may also limit maneuverability.
- Secure Restraint Systems: Developing effective and comfortable restraint systems that can be quickly and easily adjusted is vital for user safety during transport.

User Accessibility

- Adjustability for Diverse Needs: Ensuring that the wheelchair cum stretcher accommodates a wide range of users, including those with varying physical capabilities, can complicate design.
- Ease of Use for Caregivers: Designing controls and adjustments that are intuitive for caregivers while still being user-friendly for those using the device is a challenge.

Cost Considerations

- Manufacturing Costs: Advanced materials and complex designs can drive up production costs, potentially making the product less accessible for some users or healthcare facilities.
- Market Pricing: Finding a price point that reflects quality and functionality without alienating potential buyers is crucial.

Regulatory Compliance

- Medical Device Regulations: Navigating the regulatory landscape for medical devices can be complex, requiring adherence to strict safety and performance standards.
- Testing and Certification: Extensive testing for safety, durability, and usability is often necessary, which can be time-consuming and costly.

Maintenance and Longevity

- Durability of Components: The moving parts and electronic components must withstand regular use without frequent maintenance or replacement, which can be a concern in high-demand environments.
- Battery Life: Ensuring that the electric system has adequate battery life for both wheelchair and stretcher functions is essential, especially in emergency situations.

User Acceptance

- Cultural Perceptions: Some users may have reservations about using a multifunctional device due to perceptions of stigma or usability concerns.
- Training Requirements: Caregivers may require training to effectively use the device, adding an additional layer of complexity to adoption.

Applications

- Hospitals and Clinics: Ideal for patient transfer in emergency rooms, wards, and between departments.
- Home Care: Suitable for individuals who require assistance with mobility and frequent movement between lying down and sitting positions.
- Ambulances: Can be used in ambulances for efficient patient transfer and mobility during emergency transportation.

Market Demand- The demand for multifunctional electric wheelchair cum stretchers is driven by:

- Aging Population: The growing elderly population worldwide increases the need for versatile mobility aids.
- Healthcare Advancements: Hospitals and clinics are increasingly adopting advanced devices that streamline patient care and enhance comfort.

- Home Care Solutions: There is a growing demand for home-based care devices due to the rising preference for treating patients in their homes.
- User AcceptanceStigma: Some users may have reservations about using mobility devices, impacting overall demand.
- Cost Considerations Affordability: The initial cost of multifunctional electric wheelchairs cum stretchers may deter some potential buyers, especially in low-income settings.
- Compliance: Manufacturers must navigate complex regulatory environments to ensure safety and efficacy, which can slow down product development and market entry.
- Rehabilitation Centers: Facilities focused on recovery often require versatile mobility solutions that can adapt to various patient needs.
- Demographic Trends: The global population is aging, leading to an increased prevalence of mobility-related issues among elderly individuals. This demographic shift creates a higher demand for assistive devices that can enhance mobility and ensure safety.

IV. CONCLUSION

The electric wheelchair cum stretcher represents a significant innovation, merging the functionality of a wheelchair and stretcher into a single device designed for individuals with complex mobility needs. While current models offer enhanced mobility, convenience, and versatility, challenges such as weight, battery limitations, and cost still limit accessibility and practicality in some settings. Future advancements focusing on lightweight materials, improved battery life, AI-powered navigation, and enhanced comfort are likely to overcome these barriers, making these devices even more adaptable and user-friendly. As technology continues to evolve, electric wheelchair-stretchers hold great promise for providing greater independence and quality of life for users, as well as improving caregiving efficiency across medical and personal care environments.

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