DESIGN AND DEVELOPMENT OF AN APP-CONTROLLED SMART WHEELCHAIR-CUM-BED FOR PARALYZED PATIENTS

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Introduction:

Paralyzed and mobility-impaired patients face many difficulties in daily life as they cannot move or change their position on their own. They depend on caretakers for basic activities like sitting, lying down, or moving, which can cause discomfort and physical strain for both the patient and the caretaker.
To overcome these challenges, this project focuses on developing a Smart Wheelchair cum Bed that helps patients move independently and also allows them to convert the wheelchair into a flatbed without physical assistance. The system is designed for easy use by both patients and caretakers, making it suitable for home and hospital environments.
The design was first developed using Autodesk Fusion 360 to ensure proper dimensions, strength, and load distribution. The structure is made using mild steel for durability and stability. A lead screw mechanism is used to smoothly convert the wheelchair into a bed, providing controlled and safe movement.
The wheelchair is powered by a 12V battery and controlled through an Arduino-based system with a Bluetooth mobile application. This allows easy control of movement and reclining functions. Testing of the system confirmed smooth operation, safe bed conversion, and reliable performance.
Overall, this project provides a practical and efficient solution that improves patient comfort, independence, and safety while reducing caretaker effort.

Objectives:

1. **To Develop a Smart Mobility System:** Create a wheelchair capable of smooth directional movement (forward, backward, left, right) controlled through a mobile app for enhanced accessibility.
2. **To Integrate a Motorized Bed Conversion Mechanism:** Design and implement a lead screw-driven reclining system that allows smooth and controlled transformation between chair and bed modes.

3. **To Implement an Obstacle Detection and Alert System:** Use ultrasonic sensors to detect nearby obstacles and activate a buzzer alarm until the obstacle is cleared to ensure safe navigation.
4. **To Enhance User Safety with Emergency Stop:** Provide an emergency stop function within the app to instantly halt all wheelchair and reclining operations during unsafe conditions.
5. **To Improve Usability Through Smart App Interfac**e: Develop a user-friendly mobile interface that supports movement control, reclining, battery indication, and safety notifications.
6. **To Evaluate Performance, Safety, and Reliability:** Test the system under real-life conditions to assess motor load capacity, battery performance, structural stability, and overall user comfort.
7. **To Validate Design Using ANSYS Simulation:** Perform static structural analysis of the wheelchair-cum-bed frame and rack-and-pinion mechanism in ANSYS (for a design load of about 110 kg human weight) to verify stresses, deformation and FOS, and to optimize material selection and dimensions.

Methodology:

1. **Problem Identification & Concept Selection:** The study began by identifying issues faced by paralyzed and elderly users, such as discomfort and limited posture adjustment. A wheelchair-cum-bed was designed to support up to 110 kg with smooth conversion using a motorized lead screw mechanism for safe and controlled operation.
2. **Material Selection:** Mild steel (MS) was selected for the frame due to its strength, weldability, and cost-effectiveness. MS square tubes (20 × 20 × 1.6 mm) and standard components were used for reliability and ease of Manufacturing.
3. **Load Analysis & Design Considerations:** Load analysis was performed considering a 110 kg user and self-weight under static conditions. Factors like bending stress, load distribution, stability, and safety were considered to ensure safe design.
4. **CAD Modelling & Design Finalization:** A 3D CAD model was developed to finalize the structure, layout, and alignment. It helped in checking clearances and served as a reference for manufacturing.
5. **Mechanism Design & Integration:** A lead screw mechanism driven by an electric motor was used for smooth conversion between sitting and lying positions, ensuring stability and uniform load distribution.
6. **Manufacturing of Frame:** The frame was fabricated using MS tubes through cutting and welding. Proper alignment and finishing processes like grinding were carried out.
7. **Assembly of Components:** All components including wheels, motor, and mechanism were assembled and aligned properly. Electrical connections were provided using simple control switches.
8. **Testing & Validation:** Testing was conducted for load capacity, stability, and smooth operation. The system was validated for safe and reliable performance.

Result and Conclusion:

The wheelchair-cum-bed developed in this project successfully integrates mobility, comfort, and automation into a single assistive device. By combining a sturdy mild steel frame, a reliable lead screw–based bed conversion mechanism, Bluetooth-based mobile control, and essential safety features such as limit switches and obstacle detection, the system provides an efficient and user-friendly solution for individuals with limited mobility. Testing with a 70 kg human load confirmed that the structure is safe, mechanically stable, and electronically reliable under practical operating conditions. The smooth conversion between sitting and bed positions improves user comfort, while app-based control reduces physical effort and enhances accessibility. Overall, the project demonstrates a successful application of Engineering design principles, resulting in a cost-effective and functional mobility aid suitable for daily use.

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Project Outcome & Industry Relevance

The Smart Wheelchair cum Bed developed in this project successfully combines mobility and comfort into a single system. The wheelchair is capable of smooth movement and can be easily converted into a bed using the lead screw mechanism, providing convenience for both patients and caregivers. The integration of Bluetooth control, obstacle detection, and emergency stop features ensures safe and user-friendly operation.

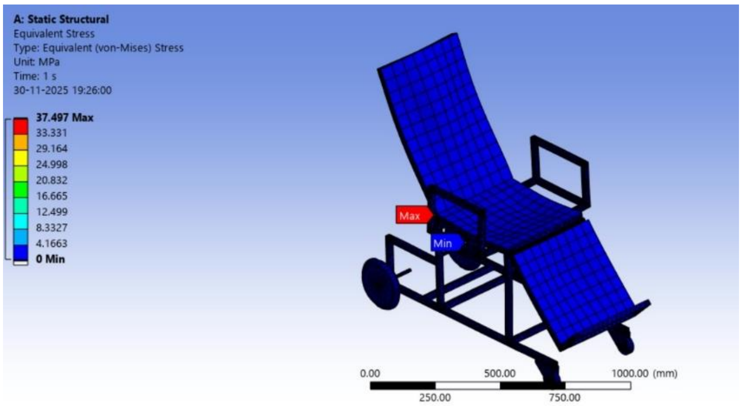
This project has strong relevance in the healthcare and assistive technology industry. It can be used in hospitals, rehabilitation centers, and home care environments to improve

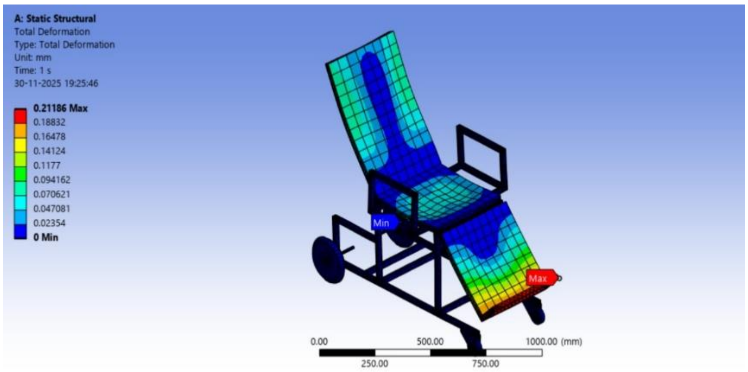
patient mobility and reduce the physical effort required by caregivers. The system supports patient independence and enhances overall comfort during long-duration use.
With further improvements, this design can be developed into a commercial product. It also aligns with the growing demand for smart healthcare devices and IoT-based solutions in the medical field. Overall, the project demonstrates a practical approach to solving real-world problems faced by mobility-impaired individuals.

Working Model vs. Simulation / Study

Working Model: The working model is the actual manufactured wheelchair-cum-bed developed using mild steel frame, wheels, motor, and lead screw mechanism. The system was tested under real conditions by applying human load (up to 70 kg) to check its strength, stability, and smooth conversion between sitting and lying positions. This helped in understanding the real performance, safety, and comfort of the design.

Simulation/Study: The simulation was carried out using ANSYS Workbench to evaluate the structural performance of the wheelchair. A load of 110 kg was assumed to represent the weight of the user. Based on this load condition, equivalent stress (von Mises) and total deformation were analyzed to study the strength and displacement of the structure. A suitable factor of safety was also considered to ensure safe and reliable operation. The results confirmed that the design is safe and can withstand the expected load without failure.





Project Outcomes and Learnings

Project Outcomes:

1. Designed and manufactured a smart wheelchair-cum-bed with smooth conversion using a rack-and-pinion mechanism.
2. Developed a Bluetooth-based mobile app for movement control, bed adjustment, and emergency stop.
3. Integrated safety features like obstacle detection and buzzer alert
4. Ensured the system can safely support up to 110 kg.
5. Validated design using testing and ANSYS Workbench analysis.

Learnings:

1. Gained practical knowledge in designing and developing assistive healthcare devices.
2. Learned CAD modeling, fabrication processes, and assembly techniques.
3. Understood the application of CAE tools like ANSYS Workbench for stress and deformation analysis.
4. Developed skills in integrating mechanical systems with electronics, sensors, and mobile app control.
5. Improved problem-solving, teamwork, and project management skills during the complete development cycle.

Future Scope

1. Add automatic posture adjustment using sensors to reduce pressure sores.
2. Use load and tilt sensors to improve safety during movement and bed conversion.
3. Use lightweight materials like aluminum or composites to reduce weight and improve portability.
4. Improve battery life using efficient motors and solar-assisted charging.
5. Add IoT-based health monitoring (heart rate, body temperature) for remote tracking.
6. Implement voice control for easy operation.
7. Introduce AI-based navigation for better mobility and user convenience.