BIOMECHATRONIC SMART WHEELCHAIR

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Introduction:

Individuals with limited mobility face significant challenges in autonomy due to the limitations of traditional wheelchairs, which primarily focus on basic movement. Prolonged inactivity leads to muscle stiffness, pressure sores, and impaired circulation. The Biomechatronic Smart Wheelchair addresses these gaps by integrating robotics, embedded systems, and medical technology into a single multifunctional unit. It combines motorized navigation, real-time health tracking and an automated exercise module to improve the general well-being of users.

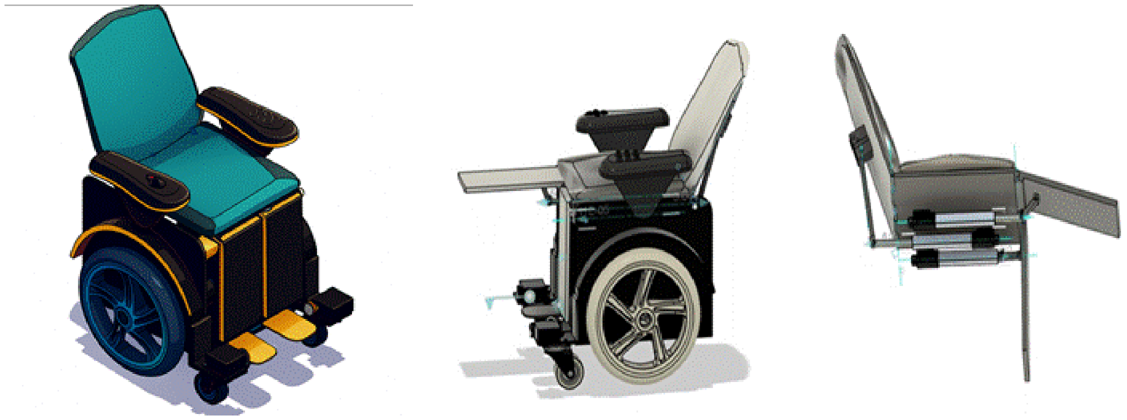

Figure 1: Finalized 3D CAD Design of the Biomechatronic Smart Wheelchair Created in Autodesk Fusion 360

Objectives:

1. Physiotherapy Modules: To design controlled exercise modules for the knee, hip, and ankle using linear and servo actuation.
2. Safe and Intelligent Mobility: To enable motorized movement integrated with ultrasonic obstacle detection for collision-free navigation.
3. Unified App Interface: To develop a mobile application (Saath Safar) for movement control, exercise activation, and real-time vital monitoring.
4. Accessible Control: To provide manual button-based inputs for users who may not rely solely on the mobile application.

Methodology:

The methodology for the **Biomechatronic Smart Wheelchair** followed a structured, multi-phase engineering approach. It began with identifying user needs through consultations with experts, such as physiotherapist Dr. Jim Daniel Johnson, to understand the musculoskeletal risks of long-term immobility. These clinical insights defined the motion requirements for safe joint exercises and postural transitions.

The mechanical structure was modeled using **Autodesk Fusion 360** to visualize the frame, actuator mounts, and exercise mechanisms. The prototype was brought to life through **3D printing** for precision components and the use of acrylic sheets and aluminum supports for structural stability. The design features an automated **bed-to-chair transformation** system, allowing users to move smoothly between sitting and resting positions.

The system is built around an **ESP32 microcontroller**, which serves as the central processing unit for sensor data and motor control.

Sensing: The system integrates ultrasonic sensors for real-time obstacle detection and a temperature sensor for health monitoring.
Actuation: High-torque DC motors handle navigation, while linear actuators and servo motors drive the physiotherapy modules for the knee, hip, and ankle.
Programming: Firmware was developed to manage motor synchronization and wireless communication protocols.

A dedicated mobile application, **Saath Safar**, was developed using **MIT App Inventor**. The app communicates with the ESP32 via **Wi-Fi**, providing an intuitive interface for both users and caregivers. This digital platform allows for remote wheelchair control, the activation of guided exercise routines, and real-time visualization of health parameters. The final prototype was refined through iterative testing to ensure safe, responsive, and ergonomic operation.

Result and Conclusion:

In conclusion, the final prototype successfully demonstrates a fusion of robotic assistance and medical monitoring. Key results include a smooth bed-to-chair transformation, successful real-time transmission of body temperature to the mobile app, and synchronized movement of exercise actuators. This innovation reduces caregiver dependency and provides a cost-effective platform for automated physiotherapy.

References:

- Eric, S., et al. (2023). "Multi-Modal Mobility Morphobot (M4)." Nature Communications, 14, 3323.
- Johnson, D., et al. (2022). "Integration of health monitoring systems in assistive devices." Journal of Medical Engineering, 15(4), 253-267.

- Zhao, Q., & Wang, H. (2019). "Integration of exercise systems into mobility aids." JRRD, 56(4), 389-403.

Future Scope:

The future scope of this project includes:

1. The future scope includes integrating AI-based navigation with LiDAR for better path planning in crowded areas.
2. We also plan to expand health monitoring to include SpO_2, ECG, and blood pressure tracking, alongside voice and gesture-based control systems for enhanced accessibility.
3. By installing various exercise routines directed by a mobile app or AI companion, the wheelchair can be transformed into a comprehensive physiotherapy platform. In this setup, motion sensors and encoders would evaluate the user's movement accuracy and provide real-time correction instructions, creating a specialized rehabilitation environment.