

Name of the Ph.D. Scholar: SAJAD AHMAD WANI

Name of Supervisor: PROF. IBRAHEEM

Name of the Co-Supervisor(s): Co-Supervisor I: PROF. SHAHIDA KHATOON

Co-Supervisor II: DR. MOHAMMAD SHAHID

Name of Department: Department of Electrical Engineering, Faculty of Engineering & Technology, Jamia Millia Islamia, New Delhi, 110025

Topic of Research: Design and Development of Smart Autonomous Wheelchair System

FINDINGS

This research confirms that smart autonomous wheelchair systems significantly enhance the mobility and independence of individuals suffering from physical disabilities such as quadriplegia, cerebral palsy, paralysis, and spinal cord injury. Traditional wheelchairs, while functionally basic, lack adaptability to dynamic environments and user needs. The developed system integrates multiple control interfaces—touch, voice (mic sensor), and SMS-based security—to allow users with different impairments to operate the wheelchair with ease and reliability. The findings establish that such multi-modal control interfaces significantly improve accessibility, safety, and customizability in real-world usage scenarios.

The study offers an in-depth comparative analysis of different control techniques for optimal motion regulation. Performance evaluations of PID, Fuzzy Logic Controller (FLC), Fuzzy-PID, and nature-inspired optimization techniques (such as metaheuristic-based PID tuning) demonstrate that the FLC and hybrid FLC-PID controllers provide better handling of non-linearities and uncertainties in dynamic terrains. The nature-inspired optimized PID controllers outperformed others in achieving smooth velocity control, system stability, and efficiency, indicating their strong potential in real-time adaptive mobility systems. These findings support the use of metaheuristic optimization in tuning control parameters for autonomous systems.

The smart wheelchair system was built on a robust iron frame using a differential drive mechanism powered by brushless DC motors, ensuring both structural durability and maneuverability. A Raspberry Pi acts as the central processing unit, managing communication among modules including RF modules, touch display, voice sensor, GSM for emergency alerts, and GPS for real-time tracking. Integration of these modules resulted in a multi-functional, user-friendly interface that ensures user comfort, navigation safety, and emergency response capability. This holistic hardware-software architecture demonstrates the feasibility of integrating advanced electronics into cost-effective assistive devices.

Simulation results and real-world testing validate the system's ability to maintain stable velocity, respond effectively to user inputs, and ensure safe operation under varying conditions. The integration of intelligent controllers and adaptive user interfaces positions this system as a significant advancement in autonomous mobility solutions. The research also provides detailed kinematic and dynamic modeling, establishing a theoretical foundation for future development. These findings not only enhance the scope of smart assistive technology but also pave the way for further innovations in autonomous healthcare robotics, ensuring inclusivity and better quality of life for people with mobility impairments.

Keywords: Smart Wheelchair, Assistive Technology, Autonomous Mobility , Control Strategies (PID, FLC, Optimization), Multi-Modal Interface