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Smart Wheelchair with Automated Breaking and GPS

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Abstract: *Mobility assistance devices are essential for enhancing the quality of life for senior citizens and people with disabilities. This project introduces the design and execution of a Smart Wheelchair featuring Automated Braking and GPS, aimed at improving safety, navigation, and independence. To keep track of the environment around it and to identify possible impediments, the system makes use of both infrared and ultrasonic sensors. When detected, an automatic braking system is engaged to avert crashes and guarantee user safety. The wheelchair's movement is coordinated by a microcontroller that processes user commands and sensor inputs in real time. With its integration of embedded systems, sensor technology, and wireless communication, this smart wheelchair serves as a cost-effective solution that showcases its promise as a dependable assistive device for safe and independent mobility. To ensure that the system responds quickly to dynamic environments and minimizes human reliance in critical situations, advanced control strategies are utilized. Furthermore, location-based services help maintain connections between caregivers, family members, and the user, which promotes feelings of security and assurance. By merging modern healthcare technology with embedded control systems, the proposed wheelchair highlights the role of innovation in building inclusive and accessible mobility aids for the future.*

Keywords*:* Smart Wheelchair, Automated Braking System, GPS Technology, Obstacle Detection Mechanism, Embedded Systems, Assistive Technology Solutions, Navigation System

I. INTRODUCTION

The advancement of technology in healthcare and assistive devices has significantly improved the quality of life for elderly and physically challenged individuals. Among these innovations, smart wheelchairs have emerged as intelligent mobility aids that combine safety, comfort, and independence.

Traditional wheelchairs often lack advanced safety features, making users vulnerable to accidents such as collisions or falls. To address these challenges, this project introduces a Smart Wheelchair with Automated Braking and GPS, designed to ensure secure navigation and real-time location tracking.

The proposed system integrates ultrasonic and infrared sensors for obstacle detection, enabling the wheelchair to automatically stop or slow down to prevent accidents. A microcontroller processes the sensor inputs and user commands, ensuring smooth and safe operation. Additionally, the GPS module provides outdoor navigation and location tracking, By combining intelligent braking with GPS-based tracking, this project enhances both safety and autonomy, making it a practical solution for differently-abled individuals and elderly patients.

This work showcases the potential of combining embedded systems, sensor technology, and wireless communication to develop assistive mobility devices that are affordable, user-friendly, and reliable. Mobility is a basic human necessity, and lacking the ability to move independently can have a significant impact on a person's confidence, productivity, and overall quality of life. For individuals with mobility impairments, wheelchairs have been a crucial support for a long time; most traditional designs, however, are limited to basic movement and lack the advanced intelligence necessary for safety in dynamic environments. The emergence of embedded systems, smart sensors, and wireless communication has created the possibility of converting traditional wheelchairs into intelligent mobility platforms.

A smart wheelchair equipped with automated braking and GPS is a significant advancement in this regard. Such systems differ from standard assistive devices in that they aim to provide physical support while also improving situational awareness, decision-making, and connectivity.

II. LITERATURE SURVEY

M. EhatMahdin et.al [1] have introduced a smart wheelchair controlled by hand gestures, which includes GPS tracking and a deep learning object detection module to prevent collisions. This research centers on offering an intuitive way for users with restricted fine motor control to operate, by converting hand gestures into movement instructions. Convolutional neural networks are employed for object detection to identify obstacles and initiate automatic avoidance actions. To assist with caregiver monitoring and route logging, GPS tracking is integrated. The authors constructed a prototype and evaluated it under controlled indoor conditions, reporting encouraging results for gesture recognition accuracy and real-time obstacle detection. They talk about latency considerations and the balance between detection sensitivity and false positives.Limitations include constrained testing environments and the need for more robust evaluation outdoors and in cluttered real-world scenarios.

S. A. V. Kuppa et.al[2] depict the design and creation of a smart wheelchair, focusing on accessibility, cost-effectiveness, and modularity. Their system combines a control unit based on a microcontroller with standard sensors and motor drivers to ensure dependable motion control. They investigate various user input methods to cater to different disabilities and underscore ergonomic design selections for user comfort. The prototype undergoes testing in indoor settings and is assessed for its responsiveness and safety attributes, including obstacle detection. A cost analysis demonstrates how the choice of components maintains a low overall price to facilitate broader adoption. The authors address battery longevity and propose enhancements in power management as future tasks. They acknowledge that including advanced autonomy would raise both complexity and cost. This article presents a pragmatic blueprint for smart solutions that are low-cost and can be manufactured locally manufacturable smart wheelchair systems.

L. Hou et.al[3] propose a smart wheelchair based on IoT that combines mobility support with health monitoring for the elderly through built-in sensors and cloud integration. The system gathers physiological and environmental data on an ongoing basis and sends it to a remote monitoring platform for caregivers. The wheelchair preserves essential mobility functions while serving as a health-monitoring hub, facilitating the early identification of health anomalies. The implementation details cover sensor fusion, protocols for data transmission, and a lightweight server-side dashboard for alerts. The authors confirm the reliability of data collection in experimental trials, mentioning occasional transmission delays when the network is heavily loaded. The privacy and security of transmitted medical data are emphasized as concerns that necessitate encryption and access control. Their proposal includes future endeavors focused on sophisticated analytics and anomaly detection based on historical data. This work demonstrates the value of integrating healthcare monitoring into assistive mobility devices to support independent living for older adults.

F. Ahmed et.al[4] report on a practical and affordable smart wheelchair designed for individuals with disabilities, featuring joystick control and ultrasonic obstacle detection. The aim is to provide a safe mobility aid that is affordable and can be made using readily available components. In the hardware design, simplicity, ergonomics, and ease of maintenance are prioritized. The authors provide documentation of the motor control circuitry and sensor placements. Practical testing demonstrates successful obstacle evasion and seamless user control in common indoor situations. The article addresses battery runtime and power management choices as significant design constraints. The authors additionally provide user feedback centered on comfort and usability, highlighting aspects of seat design and control sensitivity that could be enhanced. Limitations include restricted outdoor capability and the absence of higher-level autonomy. Overall, the work contributes a cost-sensitive design suitable for resource-limited settings.

S. Basak et.al[5] investigate a gesture-based control system for wheelchairs designed to empower users with significant motor impairments. Their method utilizes low-cost sensors to capture hand gestures, which are then transformed into directional commands via a microcontroller. The research highlights the importance of a simple system, gesture-to-motion translation with low latency, and the incorporation of obstacle sensors to ensure safety. Trials of the prototype demonstrated intuitive control for basic directional commands, with testing indicating a satisfactory level of system responsiveness. The authors consider the difficulties involved in reliably detecting gestures under different lighting conditions and when users are positioned in various ways. They propose possible enhancements involving gesture recognition based on machine learning to boost robustness and accommodate a wider range of gestures. The battery life and the requirements for sensor calibration are mentioned as practical factors to take into account. This manuscript illustrates a user-centered, economical approach to hands-free wheelchair control.

A. Bumulleret.al[6] have present a modular smart wheelchair platform aimed at making upgrades and customization easier to meet various user needs. Thanks to their modular design, drive, sensing, and user-interface modules are separated from one another, allowing for independent swapping or upgrading of components. The paper describes the mechanical and electrical interfaces, as well as software abstractions that facilitate module interoperability. They carried out the implementation of various modules—motor control, ultrasonic sensing, and a basic user interface—and evaluated the system for stability and ease of maintenance. The authors emphasize the advantages of modularity for long-term serviceability and customizing the platform to meet clinical or research requirements. Limitations consist of the initial intricacy involved in establishing standard module interfaces and the increased weight due to modular connectors. They promote the use of community-driven module libraries and future standardization as a means to speed up development.

S. N. Nijhumet.al[7] suggest an Android-operated smart wheelchair that can be controlled by joystick, gestures, and voice, with the goal of creating a low-cost and adaptable user interface. The smartphone functions as both the controller and telemetry gateway, utilizing its integrated sensors and communication stacks to minimize the need for dedicated hardware. Through the mobile app, the system incorporates voice recognition and gesture interpretation via a Bluetooth or Wi-Fi connection to the wheelchair controller. Under quiet conditions, tests indicated a reasonable accuracy for voice commands and effective joystick/gesture control for navigation. The authors highlight the benefit of the widespread presence of smartphones for reducing costs and expediting feature updates. Identified challenges include robustness against background noise for voice, smartphone battery longevity, and the necessity of a dependable wireless connection. They propose enhancements such as edge-based ML for better gesture recognition and offline voice models. The paper demonstrates an accessible architecture leveraging smartphones to broaden smart wheelchair functionality.

S. R. K. S. Giri et.al[8] depict a smart wheelchair that utilizes IoT technology for mobility aid and patient observation, integrating sensor networks with cloud services. The architecture they use includes environmental, physiological, and obstacle-detection sensors that transmit data to a cloud dashboard for caregivers and clinicians. The system enables remote alerts and logging, allowing caregivers to react to emergencies or deviations in user health patterns. The authors describe the integration of hardware and software, assess system reliability in standard usage scenarios, and note that data transmission rates are within acceptable limits. Challenges related to security and data integrity are highlighted, along with suggestions for encrypted channels and authentication. Additionally, they look into latency issues regarding crucial alerts and suggest local fallback actions on the wheelchair controller. Constraints comprise reliance on network availability and the necessity for a user-focused UI improvement. The study highlights IoT's potential to make wheelchairs both mobility devices and remote health-monitoring platforms.

S. S. Sheth et.al[9] introduce a smart wheelchair solution that utilizes IoT technology to aid individuals with physical challenges via remote monitoring and automated safety features. The article describes a hardware-software stack that comprises obstacle sensors, motor controllers, and a cloud-based telemetry backend. During testing of the prototype, the writers show features for real-time monitoring and mechanisms for alerting caregivers. They emphasize that dependable obstacle detection is necessary for autonomous or semi-autonomous behaviors. The study incorporates a usability discussion that draws on caregiver feedback and simulated patient scenarios. The pointed out limitations are the scalability of cloud storage and the need for strong offline operation. They suggest prospective avenues like predictive analytics based on usage patterns and the incorporation of supplementary assistive sensors. The contribution is a unified IoT-centered strategy highlighting caregiver support and remote oversight.

R. and S. S. Tippannavaret.al[10] explore the use of Raspberry Pi in an EEG-based smart wheelchair aimed at elderly and paralyzed individuals who are unable to use conventional controls. After processing and classifying the signals, the system translates user-intent signals captured through EEG into directional commands. The authors address preprocessing measures, feature extraction, and the classifier selected for mapping EEG patterns to control intents. The onboard controller, which connects to motors and other sensors, is a Raspberry Pi. It offers a compact and cost-effective solution. While tests demonstrate potential under controlled circumstances, they underscore the challenges of dependable EEG interpretation for intricate commands and emphasize the necessity for training and calibration.

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A. G. S. et.al[11] put forward a high-tech wheelchair for paralyzed individuals, highlighting sophisticated IoT integration for remote monitoring and enhanced assistive services. The system architecture connects on-board sensors (physiological, environmental, and obstacle detectors) with cloud services for logging, alerts, and caregiver interfaces. The communication stack, power management, and data flow from device to cloud are detailed in the paper, which highlights use cases such as fall detection and route history. While prototype testing shows trustworthy telemetry and caregiver alerts in uncomplicated situations, latency is noted during network congestion. The authors recommend encryption and access controls for medical data while discussing privacy-preserving techniques conceptually. They pinpoint difficulties in guaranteeing strong operation in areas with inadequate network coverage and propose localized fail-safe actions. Future work proposed includes model personalization and incorporation of edge AI for latency-sensitive tasks. Overall, the paper contributes a comprehensive IoT-forward design targeted at intensive-care user groups.

S. M. Shifa et.al[12] showcase an intelligent wheelchair featuring state-of-the-art control systems, investigating multi-modal inputs and tiered safety measures. Their implementation combines joystick, gesture, and voice control with obstacle detection and an arbitration layer that prioritizes safety over direct commands when necessary. It contains accounts of the signal processing pipelines, sensor fusion logic, and control arbitration strategies employed to merge user intent with autonomous safety actions. Usability is enhanced and collision incidents are reduced in shared-control modes as opposed to pure manual control, according to experimental validation conducted in indoor settings. The authors emphasize the difficulties of combining noisy or contradictory inputs, particularly in the context of voice recognition amidst fluctuating noise levels. To reduce these problems, they suggest adapting the weight of inputs and calibrating to the individual user.

C. R. Teenetiet.al[13] adopt a system-level engineering perspective on wireless charging for power wheelchairs, emphasizing free-positioning wireless power transfer. This study explores coil designs, resonant coupling techniques, and the control electronics necessary for optimizing efficiency in cases of misalignment. We present detailed experiments and simulations that assess transfer efficiency, misalignment tolerance, and thermal profiles during charging sessions. Safety is a key focus: they talk about detecting foreign objects, ensuring electromagnetic compatibility, and managing thermal issues. The results indicate that although the convenience of WPT is high, efficiency and cost are still trade-offs in comparison to wired charging. The authors present practical design recommendations and suggest methods for integrating charging docks in residential and clinical settings. Current hardware costs and lower peak efficiencies compared to wired solutions are among the limitations. The paper is a thorough technical treatment enabling practical WPT adoption in wheelchair systems.

S. Naresh et.al[14]describe the design of a powered wheelchair focusing on mechanical robustness, ergonomics, and cost-effective component choices. Tests conducted with different loads and on typical indoor surfaces demonstrate stable handling and sufficient traction. The authors also report that battery sizing decisions are in line with anticipated daily usage. They stress the importance of adjustable seating and control settings to cater to various user body types and impairments. Limitations comprise the lack of advanced autonomy features and restricted outdoor performance on uneven terrain. The authors propose modular upgrades for sensors and path-planning algorithms as potential future

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work. The contribution serves as a practical engineering blueprint for dependable powered wheelchairs in resource-limited settings.

R. A. Ramlee et.al[15] research a Bluetooth-based smart-home integration system for disabled individuals that allows wheelchairs to connect with home appliances. The project concentrates on user interfaces and pairing strategies for lighting, doors, and various other smart devices, with the goal of improving home independence. This paper describes implementation specifics, latency assessments, and user-focused UI design factors for simplified control. The writers emphasize concerns about reliability regarding Bluetooth range and interference, and they address backup strategies in the event that connectivity is lost. Security issues particularly the risk of unauthorized entry to domestic devices are scrutinized, accompanied by suggestions for combining security measures with authentication. Due to Bluetooth's limited range and bandwidth, the study has its constraints. The authors recommend looking into other protocols for larger homes or multi-room setups. Overall, it shows how integrating mobility aids with home automation can substantially boost user autonomy.

S. Soma et.al[16] propose a method to construct a smart, intelligent wheelchair that integrates sensing, control, and lightweight autonomy for navigation indoors. Methods for obstacle detection, straightforward path-planning heuristics for doorways and corridors, and factors regarding embedded-processing constraints are detailed in the paper. The writers emphasize how crucial it is for hardware with limited resources to be computationally efficient and responsive in real time. The simplicity of the user interface and ergonomic factors are considered crucial for actual use, they discuss. Limitations encompass simplified testing scenarios and limited participation of target end-users in the evaluation process. The writers propose future actions: enhanced perception (such as vision-based SLAM) and adaptation based on user behavior through learning. The study contributes an implementation-minded view balancing intelligence with embedded-system practicality.

O. Horn et.al [17] The review synthesizes trends in smart wheelchairs up to 2012, including control methods, sensing modalities, human-machine interaction, and clinical deployment issues. Historically arranging the domain, the article demonstrates how it advanced from mechanical power-assist features to nascent biosignal interfaces and semi-autonomous behaviors. Horn addresses obstacles to clinical adoption, including safety certification, user acceptance, and the difficulty of designing for a diverse user population. The review emphasizes the need for standardized benchmarks and collaboration across disciplines among engineers, clinicians, and patients. Additionally, it emphasizes the research gaps of that period, such as robust perception in cluttered environments and studies on long-term usability. The review's limitations include its temporal cutoff and the swift developments in AI and sensing technologies post-2012. Nonetheless, it remains a useful foundational reference for understanding early research trajectories.

N. Aziz et.al[18] provide a concentrated evaluation of control techniques for smart wheelchairs, contrasting manual, shared and fully autonomous approaches. This paper surveys algorithmic approaches like potential fields, behavior-based control, and probabilistic planners, assessing them for latency, safety, and computational complexity. It highlights human factors, contending that shared-control paradigms frequently provide the best compromise between autonomy and user agency. Practical constraints such as sensor noise, computational limitations, and the need for personalization are recognized as significant obstacles for actual deployments. The review emphasizes the lack of standardized performance metrics and urges the establishment of consistent experimental protocols. The authors

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suggest future avenues such as adaptive control that learns user-specific behaviors and online model updating. This review summarizes control-focused research and underscores evident avenues for technical enhancement.

P. G. Pinheiro et al. [19] put forward a predictive shared-control framework that forecasts user intent in the short run and modifies control commands to enhance safety and efficiency. To avoid harm while maintaining user autonomy, their method employs a predictive model to encourage or supersede direct commands when a collision or unsafe maneuver is probable. Simulated obstacles were used in experimental assessments, which demonstrated that anticipative control results in fewer collisions and smoother trajectories compared to direct manual control. The article addresses the trade-offs involving human factors, emphasizing the necessity of balancing assistance with a perceived loss of control. Limitations consist of the possibility of predictive inaccuracies in cases where user behavior shows significant fluctuation and the necessity for tailoring to individual user preferences. The authors propose adaptive thresholds for adjusting assistance levels and recommend future validation with actual users.

P. V. Baiju et al. [20] the paper is marked as retracted; the initial submission, which was retracted from the proceedings, described a smart wheelchair intended for individuals with physical disabilities. The retraction states that the findings should not be considered a dependable technical source without comprehension of the withdrawal's rationale. During a literature survey, it is crucial to highlight retracted work so that readers do not base their work on or reference results that may be invalid. This inclusion is solely for the purpose of documenting the record and reminding researchers to favor peer-validated and reproducible studies. In case a reason for the retraction is required, it should be examined through the records of the publisher or conference. This instance bolsters the custom of verifying citations against one another in the course of literature reviews and system design.

F. E. Casado and Y. Demiris et.al [21] investigate federated learning-from-demonstration to create assistive policies for smart wheelchairs, ensuring privacy preservation. This method collects demonstration models that have been trained locally and aggregates updates to the model at a central location, all without sharing raw user data. This allows for collaborative learning among users. Their experiments suggest that federated aggregation can enhance the generalization of assistance policies while reducing privacy exposure. This paper addresses issues like the variety of user demonstrations, communication overhead, and robustness against noisy or adversarial updates. They suggest merging global models with local fine-tuning for personalized assistance. Limitations include the necessity for realistic, large-scale user demonstrations and effective communication protocols for actual deployments. This contribution represents a new application of federated learning concepts in assistive robotics that prioritizes user privacy.

P. Gawli et al. [22] showcase a wheelchair that is controlled by voice and gestures, highlighting multimodal redundancy to enhance resilience and provide users with options. Their system processes inputs from speech and gestures, employing an arbitration scheme to resolve conflicts or revert to the most reliable modality in context. Testing of the prototype shows that when multiple input modes are offered, task completion improves and user satisfaction increases—this is particularly true in noisy or physically constrained environments. Latency trade-offs and advantages of local processing for commands critical to safety are examined by the authors. Limitations encompass the necessity for adaptation of accent and gesture styles for different users, as well as the energy costs associated with operating multiple sensing modalities. Future work suggested involves developing adaptive fusion algorithms and conducting clinical trials to evaluate long-term usability. This paper provides additional evidence that multimodal input increases accessibility in assistive systems.

M. Nirmala et al. [23] depict a wheelchair that incorporates gesture control, emphasizing uncomplicated and sturdy gesture sets as well as cost-effective sensor components. Microcontroller-based processing is utilized in the design to convert detected gestures into navigation commands, and it incorporates obstacle detection for safety. Their experiments demonstrate successful navigation for typical actions in indoor environments and underscore frequent failure modes, such as sensor sensitivity to environmental factors. The authors stress the importance of calibration procedures and tailoring gesture sets to individual users in order to enhance reliability. Some constraints involve the necessity of constant recalibration in certain conditions and diminished robustness in low-light situations. Their proposal includes the future integration of gesture recognition based on machine learning to achieve user generalization. This research provides a practical and inexpensive approach to gesture-based control.

R. Chauhan et al. [24] present an innovative IoT-enabled wheelchair designed specifically for quadriplegic patients, focusing on alternative input modalities and caregiver integration. The architecture includes environmental sensors, physiological monitors, and cloud connectivity for remote supervision and alerting. Prototype demonstrations emphasize safety behaviors and caregiver notification during emergencies. The authors discuss challenges in translating limited user inputs into effective navigation and about ensuring robust behavior under network variability. Limitations include the absence of extended clinical trials and the need to validate user acceptance in real-world contexts. Future directions proposed include adaptive control schemes and integration of predictive analytics to anticipate care needs. This work addresses a high-need patient group with a practical IoT-first solution.

A. Azad et al. [25] investigate a clever, self-directed, and battery-free transmission system for electric wheelchairs that enables free-positioning charging and alleviates the need for exact alignment. This paper introduces coil geometries, resonant coupling strategies, and control logic that ensure charging efficiency even in the presence of misalignments. The charging power over realistic misalignment ranges is demonstrated through experiments, which also address the thermal and safety management necessary for home deployment. In comparison to wired charging, the authors discuss enhancements to user experience and system-level integration. Limitations include increased system cost and somewhat diminished efficiency compared to wired chargers. They suggest further optimizing coil design and power electronics to bridge the performance gap. The contribution strongly advocates for a charging convenience focused on users in mobility devices.

M. D. Zbancioc et al. [26] a method for recognizing voice commands in Romanian based on CNNs, which has direct applications for voice-operated wheelchair controls in languages that lack sufficient representation. The article addresses the creation of datasets, model design, and techniques for data augmentation to enhance robustness when data is scarce. According to experimental findings, CNNs can reach competitive accuracy when customized for language-specific phonetics and trained with suitable augmentation. Practical issues including background noise, variability in accents, and limitations of on-device deployment are investigated. The authors propose using transfer learning from larger multilingual models as a solution in situations where training data are limited. Limitations comprise the relatively small sizes of datasets and the necessity for robustness testing in real-world scenarios. Inclusive voice-driven assistive systems greatly benefit from language-specific models, as the study emphasizes.

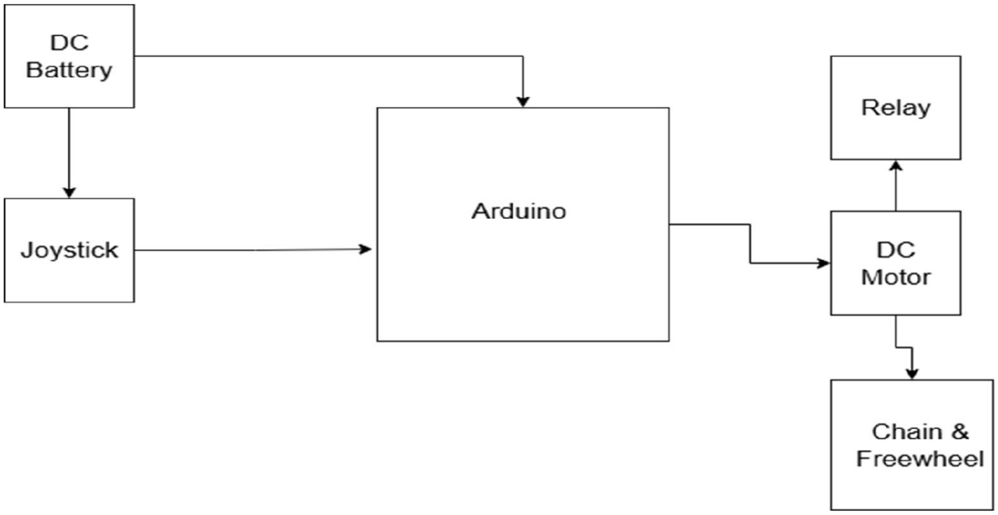
J. C. Luna et al. [27] create a virtual training system that incorporates lateral trunk motion into wheelchair mobility training, with the goal of enhancing user skill, balance, and safety. The system emulates realistic navigation situations and offers feedback on biomechanical cues, aiding users in learning safer postures and maneuvering techniques. According to pilot trials, the acquisition of skills occurs at a quicker pace and risky maneuvers are less frequent during the initial phases of training. The authors highlight possible advantages for rehabilitation and therapist-supervised training, along with instances of remote learning. Limitations include the necessity of longitudinal studies to verify retention and transfer to daily mobility tasks. Proposed enhancements comprise of adaptive difficulty scaling and more sophisticated haptic feedback to more closely mimic real-world dynamics. This study links rehabilitation science with virtual training aimed at assistive mobility.

F. Harrou et al. [28] document a pilot study utilizing AI that focuses on automatic sitting-posture recognition for wheelchair users, with the goal of diminishing pressure-sore risks and aiding in posture-aware interventions. The paper outlines sensor configurations, the extraction of features from time-series signals, and classification models that differentiate common sitting postures. The pilot study results indicate a promising level of accuracy under controlled conditions, suggesting possible applications in real-time monitoring and alerting caregivers. According to the writers, sensor wearability, comfort over extended periods, and false alarm risk are all significant practical issues. Limitations encompass small pilot cohorts and restricted assessment across diverse daily-living situations. The research recommends personalizing thresholds and incorporating automated posture-adjustment mechanisms as subsequent steps. It provides initial proof that AI posture monitoring can have clinical applications in wheelchairs care.

R. Khande and S. Rajapurkar et.al[29] introduce a wheelchair that is controlled through voice and gestures, which seeks to enhance user choice and control robustness. Their system combines a speech-recognition module with gesture sensors and employs arbitration logic to manage conflicts and fallback situations. While trials demonstrate functional navigation ability in quiet settings, voice recognition performance diminishes in high-noise environments. The authors examine the energy and processing trade-offs involved in continuous multimodal sensing. Limitations encompass the necessity for customization for various accents and gesture styles, as well as the lack of larger-scale user studies. It is suggested that future work includes the use of machine-learning-based fusion to enhance robustness, as well as offline speech models for greater reliability and privacy. This work provides another practical demonstration of multimodal control for assistive devices.

S. A. K. Kumar et al. [30] depict a voice-controlled wheelchair management system that utilizes IoT technology and highlights modular design, oversight of caregivers, and use of readily available components in order to maintain low costs. The system integrates voice-command navigation with cloud telemetry to enable remote monitoring and recording of usage patterns. Prototype testing demonstrates that command recognition and caregiver alerts are feasible in controlled settings, but their reliability in noisy, real-world conditions is still a concern. The authors suggest offline voice models and edge processing as solutions for problems related to latency, privacy, and reliability. Noted limitations include a lack of extensive clinical validation and testing on a small user sample. The paper presents a practical architecture that combines voice-driven control with caregiver-focused IoT capabilities.

III. PROPOSED METHODOLOGY



The suggested wheelchair system aims to offer safe, dependable, and easy-to-use mobility support by combining electrical and mechanical elements into one automated unit. The system starts with the DC battery, which acts as the main power source for the whole configuration. It delivers consistent electrical energy for the operation of the Arduino microcontroller, joystick, relay modules, and DC motors. The system's portability and convenience are enhanced by the use of a rechargeable battery, which removes reliance on external power sources and guarantees long-term operation.

The joystick serves as the primary input device that allows the user to engage with the wheelchair. It offers directional control for movements forward, backward, to the left, and to the right. These inputs are produced as ananalog voltage signal that change based on the direction chosen by the user. As people with limited mobility need control mechanisms that are both effective and uncomplicated, the joystick provides a solution that is both ergonomic and familiar. These signals are sent to the Arduino microcontroller, which acts as the central processing unit.

The Arduino serves as the wheelchair's "brain," interpreting signals from the analog joystick and transforming them into commands for decision-making. It processes the inputs, identifies the intended movement, and sends suitable control signals to the relay circuit. The Arduino guarantees that thewheelchair is controlled smoothly, responsively, and accurately. Moreover, due to its programmable nature, it is highly adaptable and can incorporate additional features like speed regulation, obstacle avoidance sensors, or emergency stop The relay serves an essential function as a switch operated by electricity. The relay serves as a connector betweenthe two, as the Arduino works with low-power control signals while the DC motor needs a higher current to operate. It enables the Arduino to safely turn the high-power motor ON or OFF and control its rotational direction, all without direct exposure to high currents. The main drive system that generates motion is the DC motor. Once it gets controlled power through the relay, it transforms electrical energy into mechanical rotational energy, producing the torque necessary for moving the wheelchair.

The motor’s efficiency has a direct impact on the wheelchair’s performance, speed, and load capacity. The system uses a chain and freewheel mechanism to transmit this power effectively. The chain conveys the rotational torque from the motor shaft to the wheels, guaranteeing effective energy transmission. The freewheel component enhances safety by preventing reverse jamming, enabling smooth forward movement and minimizing the risk of mechanical damage during sudden stops or changes in direction. The mechanical energy is ultimately transferred to the wheelchair's wheels, causing movement according to the user's command. Based on the joystick's input, the wheelchair can execute move linearly in either direction or rotate left and right by manipulating the motors' rotational direction.

IV. CONCLUSION

The aim of developing the smart wheelchair is to improve mobility and independence for those who are elderly or disabled. With GPS tracking, it allows for real-time observation and guarantees the user's safety by being aware of their location. By stopping accidents and crashes from occurring, the addition of an automatic braking system offers further safeguarding. The Bluetooth-based control enables remote operation, enhancing the convenience and user-friendliness of the wheelchair. This innovation lessens reliance on caregivers while providing assistance through emergency response features. The project emphasizes how modern technology can be effectively utilized in healthcare and rehabilitation systems. Although it faces challenges like greater expense, ongoing upkeep, and reliance on batteries, the benefits far surpass the disadvantages.

The wheelchair demonstrates reliability in guaranteeing user safety, comfort, and ease of navigation. Its uses range from hospitals and assisted living facilities to smart city accessibility initiatives. All in all, this project exemplifies an important advance in the integration of technology into assistive devices for a safer and more intelligent future.

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