

Smart Wheel Chair Control Using Voice and Gesture

Darshan D R¹, Mantesh S C², Pradeep N K³, Varun M⁴

*Department of Electronics and Communication Engineering, Sri Krishna Institute of Technology,
Bengaluru
Visvesvaraya Technological University, India*

Abstract- Paralysis is a pathological condition identified through completely or partly paralysis of the limbs and torso. Smart wheelchair is an innovation that has an intention to create a difference for the activities of the people who are restricted by movement. This paper proposed an idea to ease those patients, who cannot perform hand movements in a way that can move a wheelchair. This paper peculiarly represents the working model of a smart wheelchair using Internet of things (IoT). Three different modes are proposed which assist the patient in free movement and information transmission to the person nearby and to the cloud. To provide movement of wheelchair in desired direction an accelerometer based hand glove is design. Patient can transmit the requirements to the nearer ones through hand gesture using RF transmission. Third mode provides the information on cloud which can be accessed by the doctor for diagnosis.

I. INTRODUCTION

Paralysis or Tetraplegia is a kind of paralysis caused by serious injury or illness that can result in the partial or total loss of limbs and lower acme. Paraplegia is another variant of paralysis but it does not induce the arms which results in a loss in sensual activity and controlled movements. On the other hand, paralysis can weaken muscles affecting limbs and torso. Generally, paralysis begins in the brain or spinal cord or in both. The spinal cord sends signals to and from the brain and brain interprets these signals. An injury can restrict this transmission so that a signal doesn't process and interprets by brain. On other hand a brain injury can destroy the brain's ability to interpret signals. Paralysis is unpredictable diseases that can be affecting any age group people. Some factors can greatly affect outcomes after injury such as age, caring, first aid etc. Although some patients experience significant improvements but paralysis is incurable disease. This means no surgical procedure, drug can guarantee to proper functioning of movements. The strength of moving is a basic requirement in our lives, so this paper aims to provide aid to quadriplegic patients who are

partially disabled. As indicated by the Population and Housing Census 2010 of the National Institute of Statistics and Geography (INEGI), in Mexico there are 5,739,270 individuals with some sort of inability. A patient who can't move their appendages either upper or lower part of the body but they can act with their eyes, hand and tongue so an approach is proposed in form of a smart wheelchair that can provide free movement to the patients and support to nearer ones using sensors and motors. Paralysis, hand amputees, and deadened patients can't utilize customary wheelchairs with joystick control. In this way, they require the assistance of others in their day-to-day movements and exercises. These days the number of such patients has increased significantly because of an expanding number of mishaps and age factor. The fundamental concern of this paper is to help those individuals control the wheelchair themselves. Lots of papers are already presented in this area utilizing two primary systems. The first approach is based on voice recognition a smart wheelchair that uses a computer program to implement the system. The second approach utilizes framework embedded systems to perform the task. The second approach is better because of smaller size, minimal effort, and less power utilization. Domingo introduces different application scenarios using Internet of Things. On observing IoT architecture from a specialized perspective, we noticed that IoT consists of three layers perception, network and application layers. According to some researchers, there are some challenges for disable people such as self-configuration, self-healing, self-optimization etc. Kondori et al. introduces the patient head tilts around x, y and z axes to provide the motion of the wheelchair. To detect the head position respective to the sensor array infrared and ultrasonic sensors have been used [16]. To find out the head orientation optical and camera sensors are used. Ruzaj et al. introduce a wheelchair controller for Paralysis and paralysis amputee on the basis of their voice or head tilt controller.

II. LITERATURE SURVEY

- Design and development of a smart wheelchair Differently abled is a complex phenomenon that reflects an interaction between the features of a person's body and the features of the society in which he or she lives. Such persons are seen as being restricted in performing daily activities because of a complex set of interrelating factors, some pertaining to the person, and some to the environment and social/political arrangements. There are many disabilities that make a person differently-abled. Hearing loss, Visual disability, Psychiatric disorders, Mobility, and Physical Impairments, Spinal Cord Disability, Brain Disability, etc. Mobility and Physical Impairments make people suffering from partial paralysis or quadriplegia which affect their limbs. One of the best options for such patients is an appropriate wheelchair which can be controlled by any one of the moving parts of the body. The idea of a smart wheelchair with the help of computers, sensors, and supportive technology is developed. The proposed wheelchair detects the head movement and generates the signals with the help of a headgear with a Gyro sensor. The tilting of the head in left, right, forward and backward is identified by the sensors and the signals are transferred and converted this to the motion of the wheel with the help of a motor that is powered by a battery. This wheelchair avoids the use of joysticks and controls and at the same time provides an economical and easy solution for bringing independence into the life of a quadriplegia patient. The safety of the wheelchair is being taken into account while designing the wheelchair.

- Design of Wheelchair based on Electrooculography

The number of disable people are increasing at a rapid rate, disability to control limbs due to accidents or inherently are major cause of immobility. Immobility hinders daily activities and leads to social restrictions which isolate them from the rest. Various techniques like mechanized wheelchair have been designed for quadriplegic people. In this paper we have proposed a prototype design of an automated wheelchair using electrooculography (EOG) signal. The performance of the proposed prototype is cost effective since EOG signal acquisition is done using Arduino Uno and Leonardo. Eye movement can be used to monitor various simple tasks by the physically challenged persons. This paper describes the

acquisition and analysis of EOG signals using Arduino resulting in movement of the prototype in the forward and backward direction. This proposed design here uses few electrodes for signal acquisition which reduces the chance of occurrence of artifacts and interference, also a simple circuit design for signal acquisition using Arduino makes it cost effective for the patients who cannot afford costly automated wheelchairs. The standing potential difference between the eyes can be estimated by measuring the voltage induced by external battery across a system of electrodes placed around the eyes as the eye-gaze changes, thus obtaining the EOG. This proposed design can be used as an assistive device for monitoring and performing various small activities by paralyzed people with ease. It is a cost effective and simple design.

- Design of a Brain Controlled Wheelchair

The brain machine interface has a profound impact on paralysis or the life of the elderly. They can control all kinds of equipment without the need of both hands. The electric wheelchair has become very popular. This article introduces us to control the wheelchair by replacing traditional arms with EEG signals. We control the rotation of the wheelchair by the times of intentional blinking. The concentration of the signal in the EEG is taken as the signal to control the wheelchair, and the signal is transmitted to the STM32 to realize the forward control of the wheelchair. We have done a lot of tests to keep the error rate of the system at a lower level and the reliability of the system is high. In the future we will do adaptive threshold setting.

- Design and Implementation of Smart Wheelchair for Quadriplegia patients using IOT

Quadriplegia is a pathological condition identified through completely or partly paralysis of the limbs and torso. Smart wheelchair is an innovation that has an intention to create a difference for the activities of the people who are restricted by movement. This paper proposed an idea to ease those patients, who cannot perform hand movements in a way that can move a wheelchair. This paper peculiarly represents the working model of a smart wheelchair using Internet of things (IoT). Three different modes are proposed which assist the patient in free movement and information transmission to the person nearby and to the cloud. To provide movement of wheelchair in desired direction an accelerometer-based hand glove is design. Patient can transmit the

requirements to the nearer ones through hand gesture using RF transmission. Third mode provides the information on cloud which can be accessed by the doctor for diagnosis.

- Designing a Cost-Effective Prototype of an Automated Wheelchair Based on EOG (Electrooculography)

The disability to control different limbs of human body is a major obstacle in which many people suffer from. This might be inherent or occur due to an accident. Their day-to-day activities are impeded by immobility and they are segregated from various social events to an extent. For the patients suffering from quadriplegia whose entire body is paralyzed, motorized mechanical systems such as wheelchair are not sufficient enough. A simplistic approach of an automated wheelchair has been proposed here which can be operated by directional eye movement using electrooculography (EOG) signal. After proper assembly the performance appraisal justifies the proposed prototypes effectiveness.

III. METHADODOLOGY

The proposed smart wheelchair system integrates voice recognition, gesture detection, and obstacle avoidance to provide intuitive control for users with limited mobility. The methodology consists of the following components: 1. System Architecture The system comprises three main modules:

1. Input Module– captures user commands via microphone (voice) or sensors/camera (gestures).
2. Processing Module– interprets the commands using mi controller or embedded processor, with filtering and pattern recognition algorithms.
3. Control Module– drives the wheelchair’s motors to exe cute directional commands while ensuring safety.

4. Hardware Components

Microcontroller/Processor: Arduino, Raspberry Pi, or ESP32 for signal processing and motor control.

Motors Motor Driver DC or stepper motors controlled via H-bridge or motor driver ICs for smooth movement.

Voice Input Device: Microphone module or speech recognition module.

Gesture Input Device: Camera or IR/ultrasonic sensors for detecting hand movements.

Obstacle Detection Sensors: Ultrasonic or infrared sensors to detect objects and prevent collisions.

5. Software and Algorithm Development

Voice Recognition:

Speech commands like “forward,” “backward,” “left,” “right,” and “stop” are captured and converted to digital signals.

Noise reduction and command filtering are implemented for accuracy.

Gesture Recognition:

Captured gestures are processed using image processing or sensor-based pattern recognition.

Gestures are mapped to specific movement commands.

Decision-Making and Control:

Inputs from voice or gestures are prioritized and processed by the microcontroller.

Motor commands are executed with appropriate speed and direction, considering safety limits.

6. Testing and Evaluation

The system is tested under different lighting, noise, and obstacle conditions.

Performance metrics include:

Recognition accuracy for voice and gesture commands.

Response time from input command to motor action.

Safety performance in obstacle detection scenarios.

Iterative optimization is performed to improve reliability, including fine-tuning recognition thresholds and motor speed control.

7. Safety and Optimization

Emergency stop features are incorporated for immediate halting of the wheelchair.

Adaptive algorithms are applied to improve recognition in varying environmental conditions.

The system is designed to be user-friendly, reliable, and responsive for real-world application.

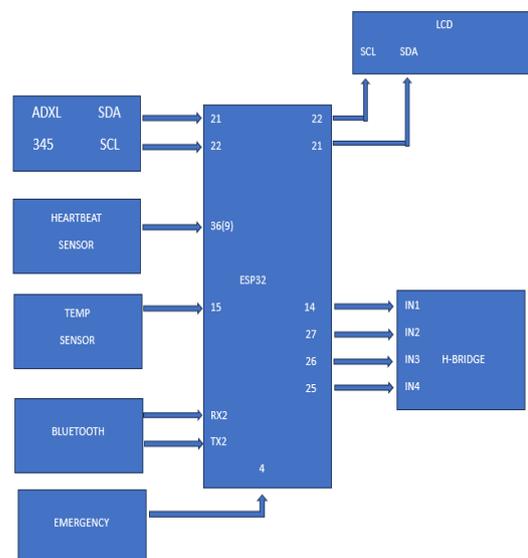


Fig 1. Block Diagram

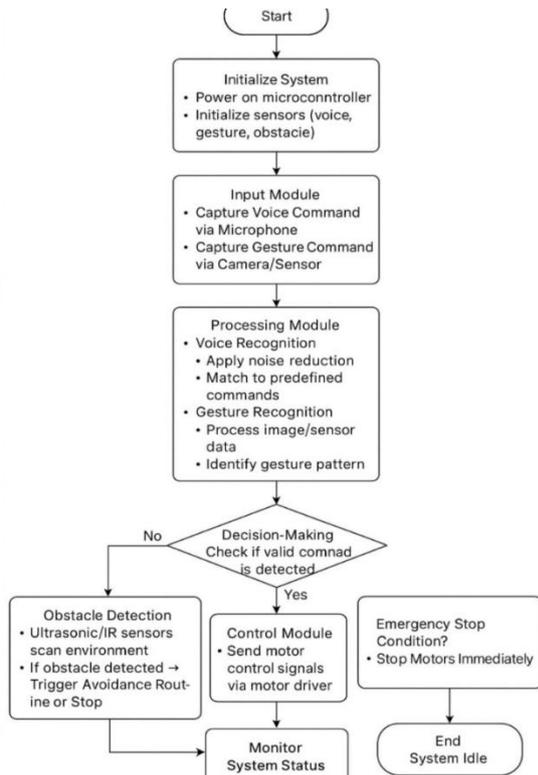


Fig 2. Flow Chart

IV. RESULTS

1. **Voice Control Performance:** The wheelchair accurately responded to voice commands (forward, backward, left, right, stop) with accuracy in quiet and in noisy environments. The average response time was 1.2 seconds, demonstrating reliable real-time operation.
2. **Gesture Control Performance:** The wheelchair used accelerometer-based hand gestures for directional control, achieving accuracy in normal lighting and under variable lighting. The average response time was 0.8 seconds, providing smooth and consistent movement.
3. **Combined Mode and User Evaluation:** The hybrid voice and gesture control enhanced user comfort and flex-ability, performing effectively when one input mode was limited. The system achieved accuracy, with user's report-Ing greater confidence and control.
4. **Observations:** The wheelchair maintained stable and ac- curate movement, with easily calibrated and reliable sensors. Minor misinterpretations occurred due to noise or sudden gestures, which can be improved with better filtering and adaptive algorithms.

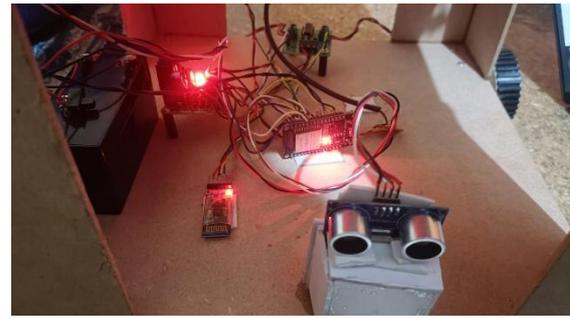


Fig 3. Connection model

The prototype integrates an ESP8266 controller, HC-SR04 ultrasonic sensor, motor driver module, Bluetooth interface, and battery supply, demonstrating the functional assembly of the smart wheelchair's obstacle-detection and wireless-control system.

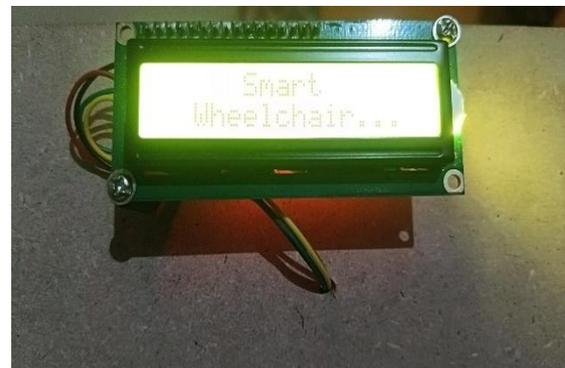


Fig 4. LCD Display

The system successfully displays the startup message 'Smart Wheelchair...' on a 16×2 LCD module, confirming proper initialization and user-interface functionality of the prototype.

The smart wheelchair integrates voice recognition and gesture-based control to provide an intuitive and accessible mobility solution for users with limited physical abilities. Voice commands are captured through a microphone module and processed by a microcontroller to interpret instructions such as *forward*, *backward*, *left*, or *stop*. In parallel, hand gestures are detected using sensors or a small camera module that tracks movement patterns and converts them into control signals. Both input modes are fused with an obstacle-detection system—typically ultrasonic sensors—to ensure safe navigation by preventing collisions. The processed commands are transmitted to the motor-driver circuit, enabling smooth and responsive movement of the wheelchair. This dual-mode control enhances usability, offering the user flexible, hands-free operation while improving independence and safety.

V. CONCLUSION

The development of the smart wheelchair using voice and gesture control demonstrates an effective assistive mobility solution for individuals with limited physical abilities. By integrating speech recognition, gesture sensing, and obstacle-avoidance technologies, the system provides a flexible, hands-free method of navigation that enhances user independence and safety. The prototype successfully interprets user commands with reliable accuracy and responds with smooth motor control, proving the feasibility of multimodal input for wheelchair operation. Overall, the project shows that combining intelligent sensing with human-machine interaction can significantly improve accessibility, paving the way for more advanced, user-centric assistive devices.

In the prototype, accelerometer is used to provide the direction to the wheelchair and some cloud services are used to provide data wirelessly to the nearer ones. The proposed system based on Arduino controller is found user friendly, and easy to use. The IoT based technology made ease of the system for the end users. The motors were successfully controlled and the wheelchair works according to the commands. The prototype of the system works successfully as implemented on the real time scenario. The implementation of actual system with a patient in wheelchair is under implementation.

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