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Bridging the Gap Between Intent and Movement: A Review of Accelerometer-Based Wheelchair Control Systems

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Abstract: *There are currently 15% of people on the planet who are disabled in one way or another. Mobility incompetence is the most common type of impairment among the others. Frequent complication that has a major impact on the patient's day-to-day life. Attaching the patient to a standard wheelchair is the standard method. Unfortunately, because the user will always need help from others, it doesn't give them a taste of independence. This device can be manually operated, but it will require a significant amount of physical exertion on the part of the user. Significantly less work can be done with a smart wheelchair that has multiple driving modes. Using two different driving systems—a thumb and a gesture control system—we designed a smart wheelchair for this study. The user can quickly traverse the menu and select their chosen control system thanks to the User Interface (UI) design. It includes a heart rate sensor to calculate. The patient's medical status. A notification will be sent to the concerned party using the built-in response mechanism in the event of an emergency.*

Keywords: Accelerometer sensor, Heart rate sensor, Arduino Uno, Gesture

I. INTRODUCTION

In order to improve the mobility and autonomy of people with limited mobility, there has been an increasing focus on creating novel assistive technology in recent years. For these people, wheelchairs are essential equipment that let them move about and take part in more activities. Wholeheartedly in daily pursuits. However, the safety, control, and maneuverability of conventional wheelchair designs are frequently compromised.

In order to overcome these restrictions and enhance overall usefulness, this project presents a revolutionary approach to wheelchair design by utilizing cutting-edge technologies. An Arduino Uno microprocessor controls a single DC motor, a differential drive mechanism, an ultrasonic collision avoidance system, and a gesture-based control interface in the proposed wheelchair system. With the use of a differential drive mechanism and a single DC motor, users may easily negotiate a variety of situations thanks to the vehicle's responsive steering and efficient propulsion. Moreover, adding an ultrasonic collision avoidance system improves security by identifying obstructions in the wheelchair's route andautomatically changing course to avoid collisions. The gesture-based control interface is a keycomponent of the wheelchair system's usability, offering both the user and their carer an easy way to navigate. Users are given more autonomy and control over their mobility with the Arduino Uno microcontroller, which interprets human movements recorded byonboard sensors andperforms movement and steering orders. The goal of this project is to improve the safety and quality of life of people who have limited mobility in addition to their mobility and autonomy. This wheelchair system marks a substantial improvement in assistive technology by fusing cutting-edge technologies with user-centric design concepts, providing a complete solution that takes into account the various demands of consumers in practical situations.

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II. LITERATURE REVIEW

1) Hand Gesture Recognition Using Accelerometer Sensor for Traffic Light Control System

Shirke Swapnali et al. [1] discusses the implementation of hand gesture recognition using an accelerometer sensor for a traffic light control system. The system uses a thresholding algorithm and an ARM-based control unit to sense the gestures of the hand. LED lights are used to indicate the traffic lights, and XBee, SD card, and a speaker are used for communication, storage, and announcements. The paper also discusses the challenges with conventional traffic light systems and the advantages of using accelerometer sensors for gesture recognition. It also compares different microcontrollers and explains the use of the IEEE 802.15.4 (ZigBee) wireless standard. The paper concludes by presenting the results and discussions of the implemented system.

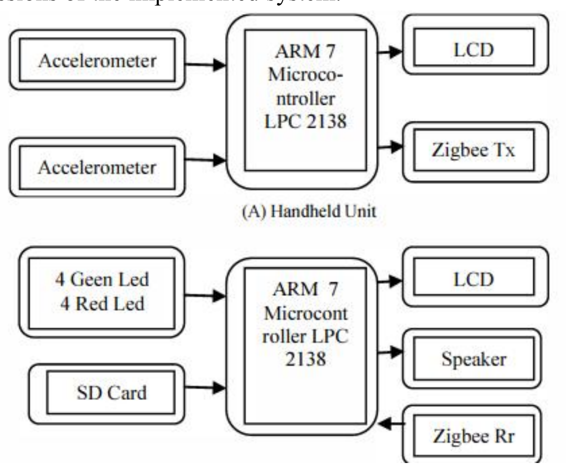

Figure1: Diagram of Hand Gesture Recognition System for TLC [1]

2) Gesture Control Robot Using Accelerometer

Rashmi Vashisth1 etal.[2] explores a robot with a gesture-controlled 3-axis accelerometer using an ATmega16 microcontroller. Gesture recognition is used to interpret humangestures through mathematical algorithms. The accelerometer detects hand movements, which are then transmitted to a comparator IC and encoded using an RF433 MHz transmitter. The receiver section decodes the data and controls the robot's movement using two DC motors. The paper also discusses the components used for the transmitter and receiver modules, as well as the testing of the accelerometer and ultrasonic sensor. The results show that the robot can be controlled using hand gestures and can detect obstacles. The paper concludes that gesture-controlled robots have promising applications in fields such as medicine and entertainment.

3) Accelerometer Based Static Gesture Recognition and Mobile Monitoring System Using Neural Networks

M.Kalyan Chakravarthi et al.[3] discusses the use of static hand gestures for controlling the locomotion of a robot using a low power wearable wristband. The wristband uses an accelerometer and an artificial neural network (ANN) trained with a Learning Vector Quantization (LVQ) algorithm to recognize and classify arm gestures. The system allows for intuitive control of the robot, but there is room for improvement in the recognition rate of postures. The paper also mentions the potential application of the wristband in controlling other devices such as unmanned vehicles and wheelchair movements.

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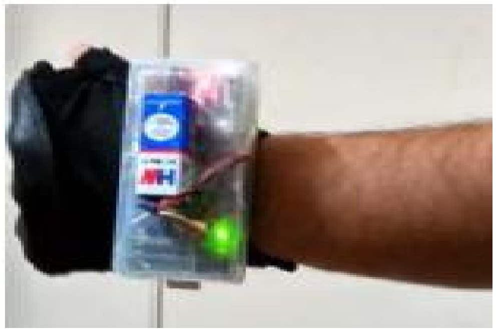

Figure2: Forward control [3]

Figure3: Left control [3]

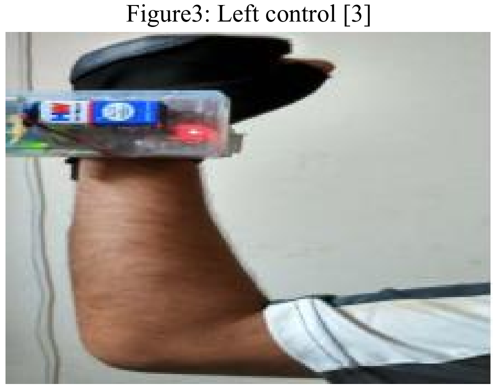

Figure 4: Stop control [3]

4) ANN for Gesture Recognition using Accelerometer Data

M. Mathew et al. [4] explore the accelerometer data which is used to identify gesture trajectory patterns in a Euclidean space through the use of Artificial Neural Networks (ANN). The k-means approach is used to parametrize the data as input for the artificial neural network (ANN) after the data has been filtered and normalized using the Fast Fourier Transform. The recognized gesture is the outcome of the ANN's training and testing, which is conducted using the FANN program. The study delves into several methods and uses of gesture recognition, including fuzzy automata and Hidden Markov Models.

5) Review on Hand Gesture Based Mobile Control Application

Swapnil M. Mankar et al. [5] discusses a review of hand gesture-based mobile control applications. The proposed system aims to recognize and identify gestures using a combination of an accelerometer sensor and Surface Electromyographical (SEMG) signals. The system includes a wearable gesture sensing device and an application program for real-time interaction with a mobile phone. The wearable device is worn on the forearm and allows users to manipulate a mobile phone using predefined or personalized gestures. The combination of accelerometer and SEMG

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sensors improves the performance and accuracy of hand gesture recognition. The paper also reviews different techniques for hand gesture recognition, including trajectory recognition algorithms and gesture recognition models. The proposed system offers a user-friendly and practical solution for controlling mobile devices through hand gestures.

6) Development of Speech and Gesture Enabled Wheelchair System for People with Cerebral Palsy

Evangelin Glory N et al. [6] explores the development of a speech and gesture enabled wheelchair system for people with cerebral palsy is discussed in this paper. The conventional joystick-operated wheelchair may not be suitable for individuals with disabilities along the arm, so the use of speech or gesture commands is proposed as an alternative. The system includes a speech recognition system trained using hidden Markov models (HMMs) and a deep learning-based robust speech recognition system using DNN-HMMs for English and Tamil. A user-defined hand gesture recognition system is alsoimplemented using an accelerometer-gyroscope-based device. The wheelchair control is enabled by a robotic arm that controls the joystick through speech or gesture commands. The system achieves high recognition accuracy for both speech and gesture commands. The entire software is mounted on a Raspberry Pi 4 module, which is connected to the robotic arm and controls the wheelchair's movement.

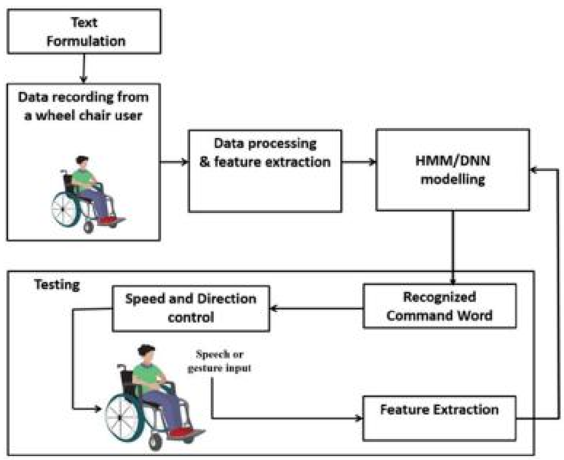

Figure 5: Block diagram of Speech Controlled Wheelchair [6]

7) A New Design Approach for Gesture Controlled Smart Wheelchair Utilizing Microcontroller

Abu Tayab Nomanet al. [7] presents a new design approach for a gesture-controlled smart wheelchair. The aim is to create a cost-effective electronic wheelchair that is easy to operate for individuals who have difficulty using traditional joystick-controlled or voice-controlled wheelchairs. The wheelchair utilizes a microcontroller, along with various components such as a motor driver, ultrasonic sensor, capacitive touch sensor, Bluetooth module, and IP camera. Special features include obstacle detection to avoid collisions and an IP camera that provides visual and acoustic information to the guardian of the rider. The paper also discusses the methodology, circuit development, operating principle, algorithm development, and hardware prototype of the wheelchair.

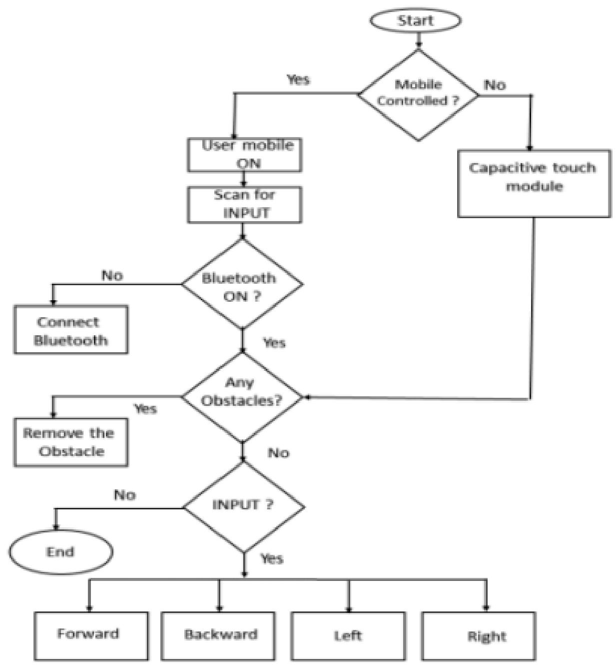

Figure 6: The flowchart of the proposed system [7]

8) Gesture-based Smart Wheelchair for Assisting Physically Challenged People

Sarnali Basak et al. [8] discusses the development of a gesture-based smart wheelchair to assist physically challenged individuals. The researchers aim to provide a solution to the mobility impairments faced by many people in Bangladesh. They propose an algorithm called the Gesture-based Smart Wheelchair (GBSWC) control algorithm, which allows the wheelchair to be controlled by hand movements using IoT technology. The wheelchair can move forward, right, left, and stop based on the user's hand motion. It also includes an emergency text feature and a double tap function to stop the wheelchair's movement. The prototype device has been tested and achieved a 98% accuracy in executing its functionalities.

9) Smart Voice and Gesture Controlled Wheel Chair

Dr. Rajeshree Khande et al. [9] proposes a smart voice and gesture-controlled wheelchair to assist physically impaired individuals. The existing devices in the market are expensive and not easily accessible to the general public. The proposed wheelchair can be operated using hand/finger/elbow/leg/head gestures or voice commands. It utilizes a voice recognition module and Arduino UNO microcontroller. The wheelchair can be controlled in different directions based on the gestures or voice commands. The research study aims to provide a cost-effective solution that allows physically impaired individuals to operate the wheelchair independently.

10) Swheel: Low-Cost Smart Wheelchair with Wireless Control

Tushar Agarwal et al. [10] theaim of the project is to create a low-cost, multi-modal control, and easy-to-operate smart wheelchair. The prototype includes an Android-basedapplication with touch-enabled buttons, gesture recognition,and voice recognition, as well as a remote operating system installation feature. The wheelchair is equipped with an ultrasonic sensor for obstacle detection and a three-axis accelerometer for slope detection. The system achieves an accuracy of 91.58% for slope detection and 85.85% for obstacle detection. It also has a feature to send an SOS message. The wheelchair is controlled wirelessly using Bluetooth on the Android application.

III. SUMMARY

The wheelchair facilitates intuitive control by converting user gestures into movement commands. An additional degree of security is provided for users who have health concerns by the addition of health monitoring. System design, software development, hardware integration, and thorough testing are all part of the development process. Optimizing the gesture detection system, guaranteeing safety, and designing an intuitive user interface are given special attention. This research, which aims to improve mobility, independence, and quality of life for those with partial paralysis, represents a significant advancement in assistive technology. One example of how technology can be used to meet certain needs in the realm of mobility aid is the wheelchair system that incorporates gesture control and health monitoring.

IV. FUTURE SCOPE

This gesture-controlled wheelchair technology has a lot of potential for innovation and improvement in the future. By combining machine learning and artificial intelligence, the system may be able to adjust to the unique habits of each user, increasing the precision of gesture identification and customizing the user interface. By adding extra sensors, such as gyroscopes or vision systems, advanced sensor fusion techniques may improve obstacle detection and navigational performance. For people with significant motor limitations, the adoption of brain-computer interfaces (BCIs) may offer an alternate mode of control. User safety could be considerably increased by investigating more advanced health monitoring capabilities, such as emergency alert systems and real-time vital sign analysis.Next-generation technology may be easily integrated with ease if a modular, upgradeable design was developed. Users may benefit from enhanced environmental awareness and navigation support if augmented reality displays are used. Further investigation into lightweight, durable materials and more effective, long-lasting power sources may improve the wheelchair's mobility and range. The incorporation of IoT capabilities may also make it possible to integrate smart home technologies seamlessly, do predictive maintenance, and monitor remotely, all of which would improve user autonomy and quality of life. These developments would serve a larger spectrum of people with mobility problems by enhancing the wheelchair's usefulness and furthering the field of assistive technology.

V. CONCLUSION

In conclusion, this small-scale study showcases a novel gesture-activated wheelchair that is tailored for those with partial paralysis. The system provides a unique and user-friendly way to manage a wheelchair by using an accelerometer as a gesture sensor and an Arduino as the central control unit. For individuals with restricted motor function, a comprehensive solution that improves mobility and freedom is created through the combination of motor drivers, pulse sensors, and a battery-powered traction motor. With little physical effort, users may manage their surroundings with the gesture control interface, potentially improving their independence and quality of life. A layer of health monitoring is added with the addition of pulse sensors, which may be vital for individuals with certain medical problems. When a traction motor is used, it guarantees effective power transmission and enhanced agility on different types of surfaces. This project shows how accessible technology and user-centred design may be used together to meet the unique needs of people who are partially paralyzed. This gesture-controlled wheelchair is a major advancement in assistive technology for those with mobility impairments since it prioritizes functionality, safety, and convenience of use.

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