Indonesian Journal of Electrical Engineering and Informatics (IJEEI)
Vol. 12, No. 3, September 2024, pp. 558∼574
ISSN: 2089-3272, DOI: 10.52549/ijeei.v12i3.5593

Wireless Need Sharing and Home Appliance Control for Quadriplegic Patients Using Head Motion Detection Via 3-Axis Accelerometer

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Article Info

Article history:

Received May 18, 2024
Revised Jul 31, 2024
Accepted Aug 30, 2024

Keywords:

Quadriplegic patient
Assistive Technology
Head Motion
Accelerometer
BPM Monitor

ABSTRACT

Patients who are quadriplegic are immobile in all four limbs. Quadriplegic patients with low voices struggle to communicate their needs to family members or caregivers, requiring assistance to use household items like fans and lights. This paper presents an electronic system designed to enhance the quality of life of quadriplegic patients by enabling them to share needs, manage household items, and monitor their health. The quadriplegic patient can move their head. In the proposed system, an accelerometer sensor placed on the patient's forehead to record head movement, which is processed to detect and share needs or operate home appliances. The system consists of two units: one in the patient's bed and another in a common place at home. Both communicate through Bluetooth. By moving head in the right direction, patients can share needs like water, rice, snacks, sickness or washroom. The common unit notifies caregivers through a matrix display and makes sounds with a buzzer. Patients can also control specific household appliances through left-head movements. The system also features a pulse oximeter sensor for monitoring heart rate and oxygen saturation. A prototype of the system has been developed and tested, and it is functioning smoothly. This system will free the quadriplegic patients from dependence on others and make their lives easier.

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1. INTRODUCTION

A quadriplegic is a person who cannot move any of their limbs. There are several other conditions that may lead to such limited range of motion, including arthritis, high blood pressure, stroke, degenerative disorders of the bones and joints, paralysis, and birth defects. Paralysis affecting both arms and legs was formerly referred to as quadriplegia. According to a report from the WHO, an estimated 250,000 to 500,000 new cases of spinal cord injuries are documented globally each year. Statistical data reveal that approximately 43 million individuals worldwide live with disabilities. Notably, among individuals afflicted with spinal cord injuries, 52% are classified as paraplegic, while 47% are identified as quadriplegic [1]. In Bangladesh, its rate is increasing day by day. Through increasing their quality of life, our research seeks to improve the lives of quadriplegics who are often socially isolated. Research in assistive technology for quadriplegia is advancing rapidly. Moving beyond manual systems, innovations now focus on advanced computer controls and other assistive tools, transforming daily life for those with limited mobility. Some of the previous works on assistive technology for people with quadriplegia have been categorized based on aspects such as head movement, eye tracking, voice control, camera controlled systems, and Electroencephalogram (EEG) based system.

Most previous research on head motion in wheelchair users across three axes has relied on sensor-based measurements. A semi-autonomous wheelchair is developed for physically challenged people in [2], which has features to navigate and control the speed of the wheelchair by joystick, voice command, or gesture command. This wheelchair can detect the obstacles on the front and back sides and notify the caregivers with the GPS location if an accident occurs. The proposal in [3] suggests a head gesture-controlled wheelchair to assist individuals with tetraplegia in their daily activities. Here, a set of predefined head gestures are translated into commands to move the wheelchairs. In [4], the authors developed a wheelchair based system for physically challenged people that uses a camera to detect obstacles in the environment, and an IMU sensor to detect the desired head movement patterns by measuring the user's head inclination and vector fields. The proposal in [5] introduces a system for tetraplegic individuals that uses a six-degree-of-freedom IMU sensor, which is placed on top of a pair of headphones to capture, analyze, and extract features from head movements for recognition. In [6], authors developed a wheelchair based system for quadriplegic individuals uses a helmet-based transmitter as the master device, equipped with an accelerometer to detect head tilts. It sends signals wirelessly to the wheelchair, acting as the slave device, for movement control. The proposal in [7] introduces a wheelchair-based system for quadriplegic individuals that uses tilt sensors and diode logic to record the patient's head gestures for control. The gesture-based monitoring system for partially paralyzed patients in [8] suggests that an MPU6050 accelerometer sensor tracks the patient's hand movements, stores data in Firebase Realtime Database, and sends emergency alerts to caretakers. An electric wheelchair is developed for physically challenged individuals in [9], which features navigation and speed control based on a combination of acceleration sensor data from head rotation and image processing data from the user's face recognition. The proposal in [10] suggests a semi-autonomous wheelchair that uses an accelerometer to detect head movements for navigation, controlling two DC motors to maneuver the wheelchair. It also features sonar sensors to detect obstacles and prevent collisions, and sends SMS alerts with location information via a GSM modem. The authors developed a system for sick individuals in [11], where head gestures are detected as sixteen different movements using an accelerometer positioned on the user's forehead. A head movement-based touchless typing keyboard is developed for people with limited ability in [12], utilizing a front-facing smartphone camera to detect head gestures. The keyboard is organized into nine color-coded clusters, and a bidirectional GRU-based model analyzes these movements to determine which letters the user intends to type. The proposal in [13] introduces a Tongue Drive System (TDS) that uses magnetic sensors and a small tongue-mounted tracer to detect intentional movements. Integrated into a lightweight headset, it combines tongue commands, head tracking, and speech recognition for intuitive and reliable computer access and daily task assistance. In [14], the authors developed a system for physically impaired individuals that features eye movement tracking, tongue interfaces, and brain-computer interfaces. A head movement-based wheelchair is developed for people with disabilities in [15], which uses an overhead accelerometer and a Kalman filter to minimize noise and accurately classify movements such as forward, backward, right turn, and left turn, enabling precise wheelchair control. The proposal in [16] introduces a wheelchair-based system where patient head movements are detected by a gyro sensor, and ultrasonic sensors detect obstacles. Family members can steer and track the wheelchair in real-time through an app with GPS, and a crash alert triggers a buzzer. In [17], the authors developed a wheelchair-based system for physically challenged people, where head motions are detected by an accelerometer sensor, data are processed by the Blynk IoT platform, and alerts are sent via the Blynk mobile app to the caretaker.

Eye movement monitoring systems use high resolution cameras and sensors to precisely measure the direction, speed, and focus of eye movements. The proposal in [18] introduces an eye blink system designed to help individuals with tetraplegia manage their home devices. The system uses Bluetooth and an Android app to transmit data, enabling patients to send emergency SMS alerts for immediate assistance. In [19], the authors developed a system for physically impaired individuals that tracks eye and hand movements to control a cursor on a computer monitor. By comparing eye fixations with target locations, the system functions similarly to an assistive robot arm. A computer vision-based eye gaze-controlled virtual keyboard for people with quadriplegia is developed in [20], which features 40 keys, including delete, letters, numbers, and symbols. The keys light up sequentially in forward or backward direction, and eye gaze selects the active key, while eye blinking confirms typing. The proposal in [21] introduces a system that utilizes EEG features of eye-blinking for paralyzed patients. Eye blink brain signals are captured using head front electrodes fp1 and fp2, focusing on the beta band (15-30 Hz). EEG and blink data are collected with a memory headset and transmitted via Bluetooth, with integration managed through a MATLAB interface.

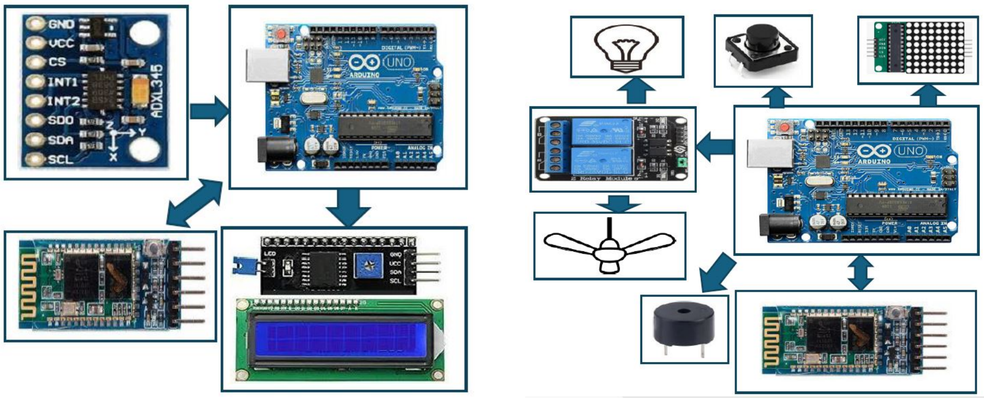
Voice tracking systems analyze vocal patterns, capturing pitch, tone, volume, and speech rate to enable emotion detection. A head movement-controlled wheelchair for paralyzed people in [22] combines voice control with a mobile app, utilizing Bluetooth, Arduino, and an accelerometer for seamless control and personalized mobility. In [23], the authors developed a wheelchair-based system where head movements and eye blinks are detected by the IoT-based EyeCom and an IR sensor. A microcontroller connected to a computer moves the cursor on the screen based on the received signals, enabling actions such as opening documents and operating speech-to-text. A voice-controlled appliance system for quadriplegia patients in [24], which manages all electrical loads. User voice input is captured via a USB microphone, converted to text through Google API, and processed to control relays, toggling devices on or off.

Camera monitoring systems use high-resolution cameras to capture and analyze visual data for security, movement tracking, and AI-driven insights like facial recognition and anomaly detection. A head movement-controlled wheelchair for physically challenged individuals in [25] uses an RGB camera to capture facial orientation. Based on computer vision and deep learning, it accurately estimates head position, enabling personalized calibration and continuous navigation, unlike the discrete commands of traditional head switches. Controlling a personal computer through head movements and voice commands in [26] uses camera-monitored head movements and the AdaBoost algorithm to translate actions into mouse cursor movements on the screen. Vocal commands handle clicks, enabling seamless navigation without additional hardware. In [27], the authors developed a head mouse control system for people with disabilities using CNN and Haar cascade classifiers. A camera tracks head movements and eye blinks, with CNN1 detecting head movements to control the cursor and CNN2 identifying eye blinks to trigger mouse clicks based on right or left eye blinks. A hands-free head mouse control system in [28] tracks head movements by analyzing facial expressions and mouth position using the YUV color model algorithm. It adjusts the computer screen pointer based on the mouth's location and the face's boundary relative to the camera.

Research on using electromyography (EMG) to track patient face and neck muscles. A wheelchair for tetraplegic patients is developed in [29], where electric wheelchairs are controlled by electromyography (EMG) signals from neck and face muscles. The increase in EMG signal amplitude during muscle contraction is used as a trigger for the wheelchair's electric motor to move forward, backward, turn right, and turn left. An electromyography monitoring system for patients in [30] uses muscle disorder EMG signals to control the computer pointer, with a microcontroller triggering clicks based on muscle activity. An inertial sensor with MEMS technology detects mouse movement and monitors EMG signals from the biceps, providing real-time support for patients with muscle disorders

Electroencephalogram (EEG) research tracks brain impulses to diagnose neurological conditions and monitor brain activity. The proposal in [31] introduces an EEG system that tracks brain impulses to diagnose neurological conditions and control a wheelchair. Using a NeuroSky headset with an electrode on the left forehead, the system captures EEG signals to manage wheelchair movement through Brain-Computer Interfaces (BCIs). In [32], a Brain-Computer Interface learning system for quadriplegics uses the Emotiv EPOC headset to received EEG data. This data is processed to communicate predefined commands, monitor emotional behavior, and provide feedback. Vital signs such as heartbeat, blood pressure, ECG, and temperature are also tracked and uploaded to the Intel Edison SoC, with patient metrics displayed through Intel IoT Analytics cloud service.

Previous research has primarily focused on improving mobility for quadriplegic patients with partial paralysis. Most studies have explored wheelchair-based approaches, focusing on head and hand movements, while others have examined voice-controlled systems for managing room lights and fans. Our research primarily focuses on individuals who are unable to move except for head movements. Quadriplegic patients can share daily needs such as eating rice, using the washroom, expressing feelings of sickness, and operating household appliances like lights and fans with simple head movements. This research has additional features for monitoring the BPM (beats per minute) of quadriplegic individuals. Caregivers can monitor a patient's health data in real-time via a display. This feature can significantly benefit quadriplegic individuals by enhancing their independence and facilitating easier communication with caregivers.



(a) (b)

Figure 1. Block Diagram of the (a) Transmitter and (b) Receiver Section

2. RESEARCH METHOD

2.1. System Block Diagram

The Transmitter Section of the quadriplegic system, as demonstrated in Figure 1a, integrates an Arduino, an I2C-connected 16x2 LCD, a 3-axis accelerometer for detecting head movements, and Bluetooth.The Arduino detects head movement analysis sensor data, displays messages for interaction with quadriplegic patients, and transmits data to the receiver section via Bluetooth. The receiver, as demonstrated in Figure 1b, integrates the Arduino, relay, dot matrix, push button, and Bluetooth. The Arduino harnesses Bluetooth connectivity to actively manage real-time data received from the transmitter. Quadriplegic patients, detecting head movements, are demonstrated by indication arrow signs on DOT Matrix Displays, while a buzzer sounds an alarm upon the corresponding output being displayed. Household appliances are controlled through relay switching. It ensures effective data processing and simple operation in a device that is suitable for quadriplegics.

Quadriplegic patients' BPM (beats per minute) monitoring, as an additional feature, is depicted in Figure 2, incorporating a pulse oximeter and heart rate sensor for health monitoring, alongside an Arduino. The microcontroller processes health sensor data and transfers it to the OLED display for real-time monitoring.

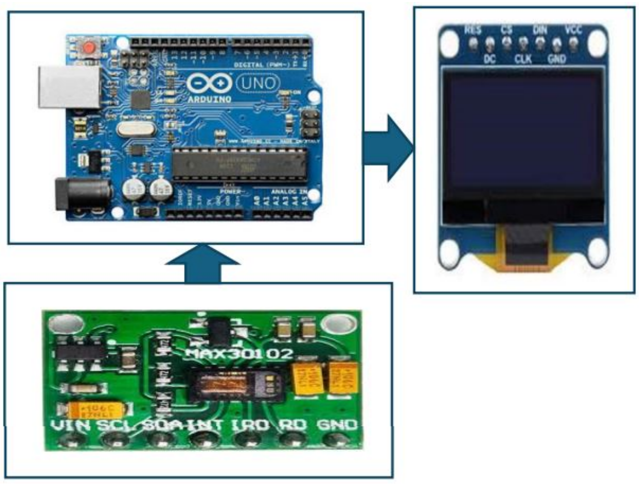


Figure 2. Block Diagram of the BPM Monitoring System

2.2. Circuit Diagram of the System

The system is monitoring the BPM (blood pressure measurement) of quadriplegic individuals using a pulse oximeter with the assistance of an OLED display. In Figure 3, BPM monitoring system, connect

MAX30102's GND to Arduino's GND, SDA and SCL to A4 and A5, and Vin to Arduino's 5V. For the OLED display, link GND to Arduino's GND, Vcc to 3V3, and SDA/SCL to A4/A5, respectively.

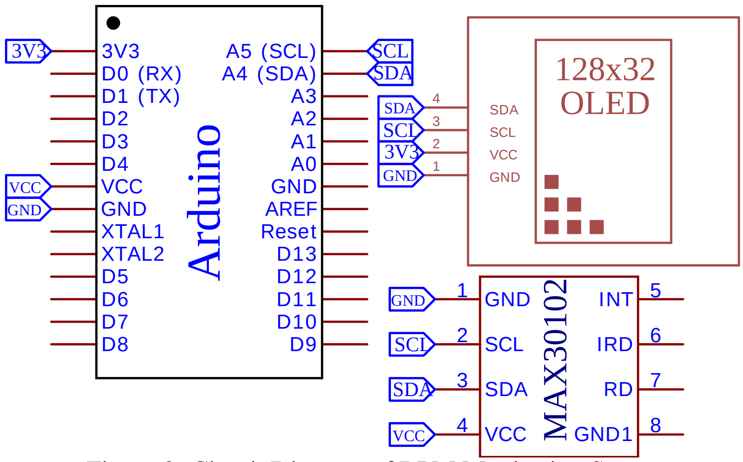


Figure 3. Circuit Diagram of BPM Monitoring System

The Arduino and Bluetooth are connected in the Figure 4, transmitter Section circuit and the Bluetooth's RX pin facilitates efficient connection with Arduino's D7. The 3V3 pin on the Arduino is used to power the Bluetooth module. Common ground and Vcc from Arduino are connected to an I2C-capable LCD display via A5 and A4 for SCL and SDA, respectively. Furthermore, a 3-axis accelerometer integrates easily, using the Arduino's 5V to power it. Its SDA and SCL pins are connected to A4 and A5.

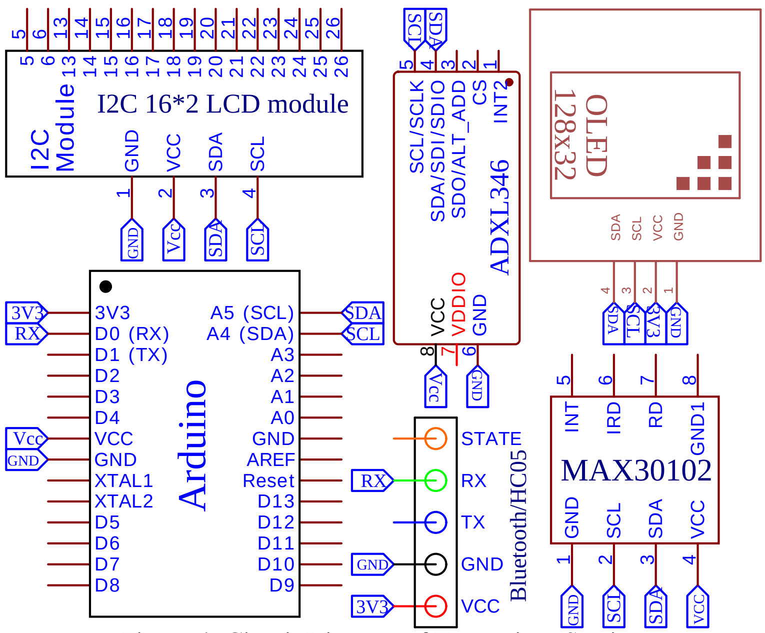


Figure 4. Circuit Diagram of Transmitter Section

In Figure 5, the Bluetooth I/O connections to the Arduino at the receiver end, where GND is connected to GND and Vcc is connected to the Arduino's 5V. Vcc is connected to Arduino via the DOT Matrix Display. The positive pin of the buzzer is connected to D7, while its GND is connected to GND. The GND of the push button is connected to GND, while its positive side is connected to D6. The Arduino's Vcc and GND are connected to the Relay's Vcc and GND. Connected to D8 is the bulb, and to D9 is the fan. Using Arduino and Bluetooth technology, this setup produces a simplified and effective control system.

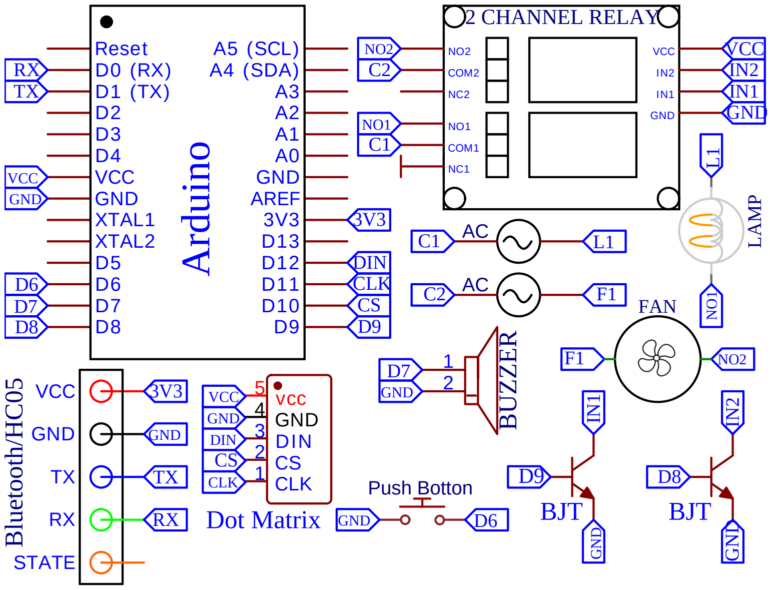


Figure 5. Circuit Diagram of Receiver

2.3. Headmovement detection

A three-axis accelerometer is used to record head movement. The sensor is positioned on the patient's forehead. When a patient turns their head, the orientation of the sensor is also continuously changed in the x, y, and z dimensions. The change results in the fluctuation of the acceleration in the x, y, and z- directions. The microcontroller reads the data from the sensor at a 200 Hz sampling rate via its I2C interface.

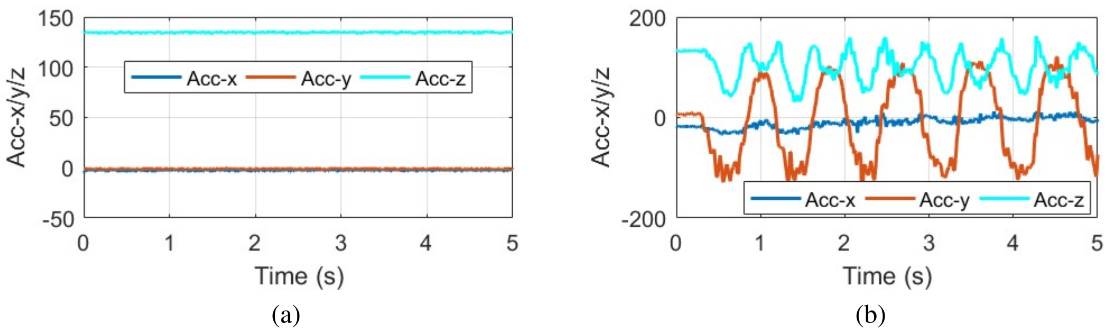


Figure 6. The change in acceleration in the x, y, and z-direction when (a) there is no head movement and (b) the head moves left and right

When there is no movement, Figure 6a displays the change in acceleration in the x, y, and z dimensions; when the patient turns their head left or right while laying in bed, Figure 6b displays the movement. It is observed that in normal situations (no movement), the acceleration in the x and y directions fluctuates near zero, while the z value remains almost constant at 140. On the other hand, when the head moves in the right or left direction, the change in acceleration in the x direction is not significant. However, there are large variations in acceleration in the y and z directions. The acceleration pattern in the y direction is more predictable with head movement than in the z direction. Acceleration in y-direction becomes negative (0 to -150) for right movement and positive (0 to 150) for left movement. Therefore, acceleration in the y direction is considered to detect the movement of the head.

The system's operational procedure is illustrated by the algorithm that appears in Figure 7. In the beginning the device reads data from the accelerometer, then conditions are evaluated using the information it has obtained. The y-axis value is considered for further processing. To remove the high-frequency noise, a moving average filter is used. Then a thresholding operation is performed to convert the left or right movement into pulses. A left head movement appears if the y-axis value rises beyond +70 or a predetermined threshold (thP). A right head movement, on the other hand, is indicated if the y-axis value declines below -70 or below another threshold (thN). The device detects two sequential head motions as confirmation of the patient's desire. When a head movement is verified during the need-sharing procedure, the 7-segment display is instructed by the Transmitter microcontroller to display the message "Move head twice." subsequently, utilizing Slave Bluetooth and Point-to-Point Protocol (PPP), the Master Bluetooth transmits the data to the receiver microcontroller. The receiver microcontroller analyzes the head motion count upon receiving the sent data. According to the patient's needs, the dot matrix display demonstrates an arrow pointing in the direction of the expressed "need," and the Buzzer beeps to notify the recipient. Likewise, in the event of a left head movement, the receiver microcontroller counts the head motions and autonomously governs the light and fan's on and off times based on the demands of both patients. Additionally, the bell is silent in this scenario because no outside help is needed. The flowchart that goes with it shows the several outputs that correlate to motions of the head to the left or right, giving a thorough insight of the response mechanism of the system.

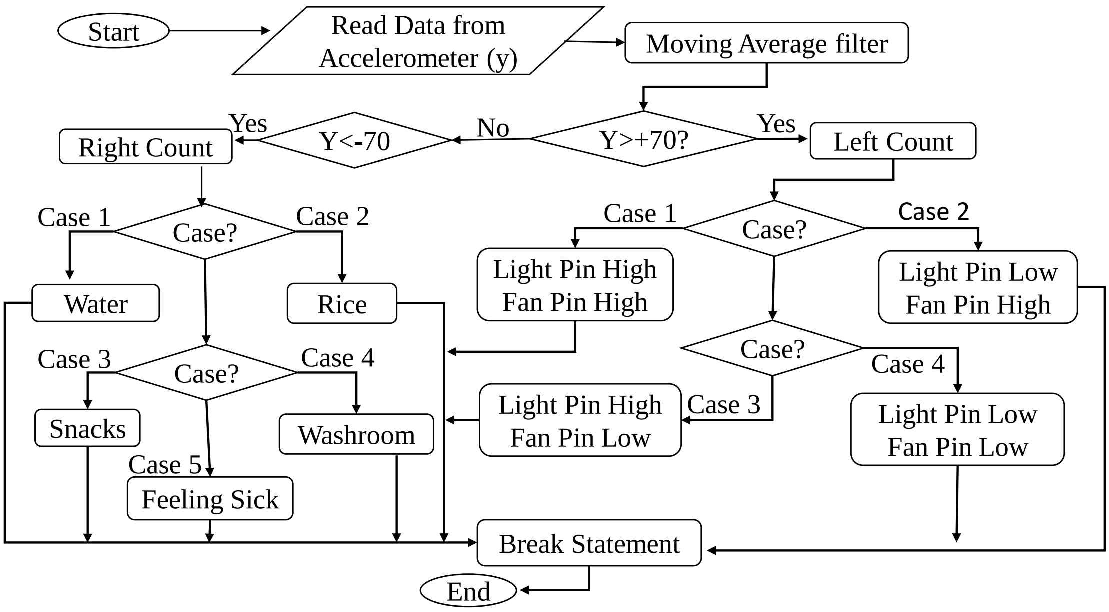


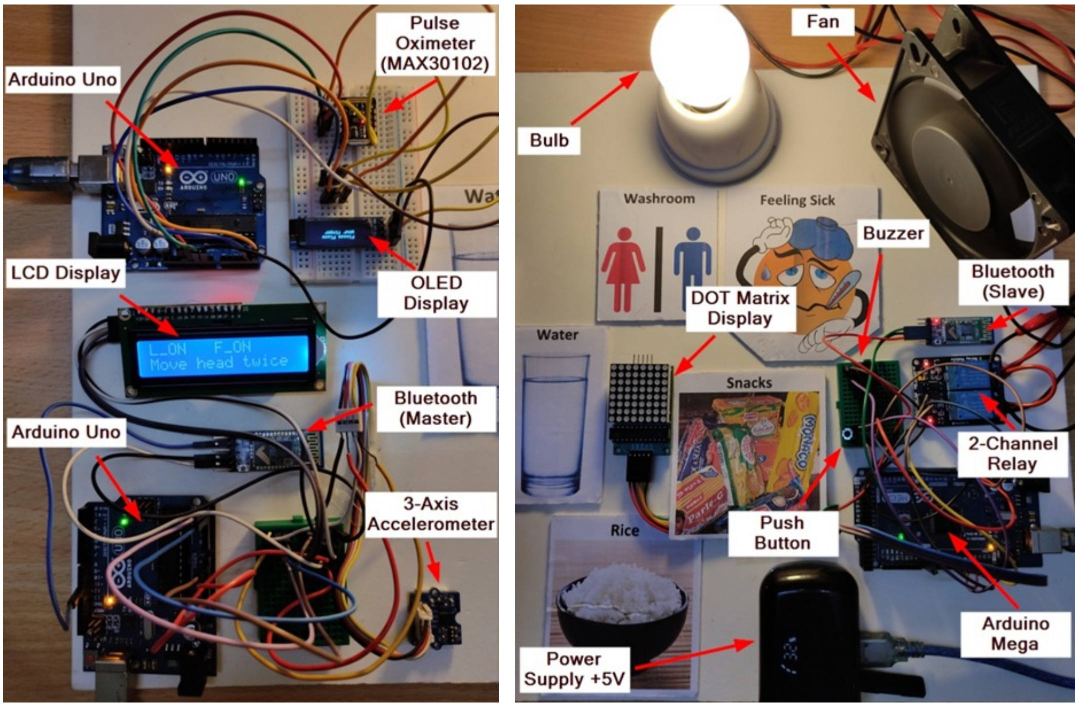
Figure 7. System Algorithm Flowchart

3. IMPLEMENTATION, RESULTS AND DISCUSSION

The development of a wireless device that combines a 3-Axis Accelerometer for personalized need communication (such as hunger, thirst, or discomfort) and gives patients the ability to independently control home appliances to enhance their autonomy has led to in an innovation in the assistance of quadriplegic patients. This section describes the development of the prototype, testing of the system, and analysis of the results.

3.1. Prototype

Quadriplegic patients use a head-mounted sensor, such as a 3-axis accelerometer, to detect directional head movements. This sophisticated sensing device measures acceleration across three perpendicular axes (X, Y, Z), enabling precise detection of motion, orientation, and vibration in three-dimensional space. The core of the device is a MEMS (Micro-Electro-Mechanical System) sensor that converts physical movement into electrical signals. These signals are processed by a microcontroller, which filters noise and interprets the data. The prototype typically includes a power management system and communication interfaces like I2C or SPI. The accelerometer's transmitted head movement data triggers a microcontroller to display intuitive arrows on a Dot Matrix. These arrows denote specific needs, such as rice, snacks, water, bathroom, and feeling sick, while also offering control over lights and fans. The prototyping process involves designing the circuit, assembling components, programming firmware, and rigorous calibration to ensure precise measurements, making it a key innovation in motion sensing and inertial navigation. The prototype is customizable, allowing for sensitivity adjustments and tailored interfaces, and is rigorously tested to ensure it meets the specific needs of users. This technology offers a practical solution to enhance autonomy and communication for those with severe mobility impairments. An overview of the transmitter and receiver sections of the prototype are shown in Figures 8a and 8b.



(a) (b)

Figure 8. Wireless Need Sharing and Home Appliance Control for Quadriplegic Patients: Transmitter (a) and Receiver Section (b)

3.2. Results

The prototype has gone through testing to ensure that it can achieve all of the objectives. First, all cases of need sharing are tested, followed by the testing of home appliance control cases. The measurement of heart rate and oxygen saturation is then checked and compared with readings from standard devices. Finally, the robustness of the system is evaluated by analyzing its performance in multiple distinct circumstances.

3.2.1. Sharing Needs

The graph shown in the Figure depicts a case in which the patient wants to inform the caregiver that he or she needs water. The patient must move head in the right direction once to convey this; one right movement indicates the need for water. Two further right-to-left (full head movement) motions are needed to prove that the preceding movement was intended in order to prevent the system from picking up on routine or inadvertent head movements. In Figure 9, the first graph is the raw sensor data for the signal to inform the caregiver about the need for water. The signal is corrupted by random noise. The noise is eliminated by a moving average filter, and the second graph presents the noise-free signal. After the thresholding operation, the signal is converted into pulses. It is observed in the third graph. The first negative pulse of this graph indicates one right movement; the next two pairs of negative-positive pulses indicate two complete head movements. The microcontroller decodes the need by counting the pulses before the two complete movements. Then transfer the need to the notifying unit. In this case, the notifying unit produces beep sounds and creates an arrow in the matrix display towards the picture of "water glass" which is observed in Figure 10. There is a LCD display in the transmitter section. This display informs the patient if the command was correctly understood and transmitted to the notification device.

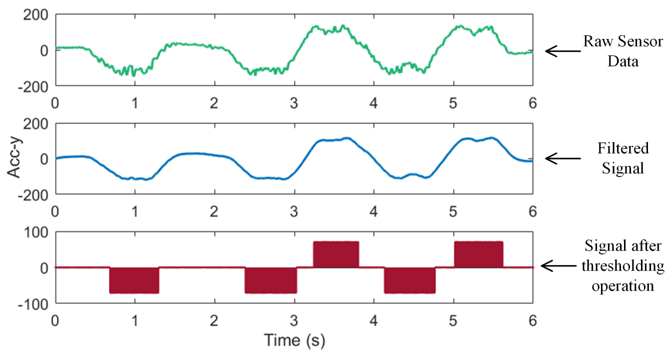


Figure 9. Right Movement Case 1 (Raw Sensor Data, Filtered signal and signal after thresholding operation)

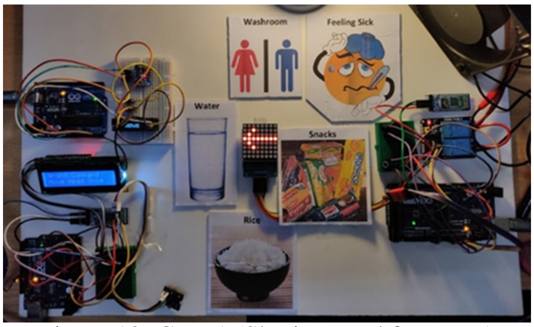
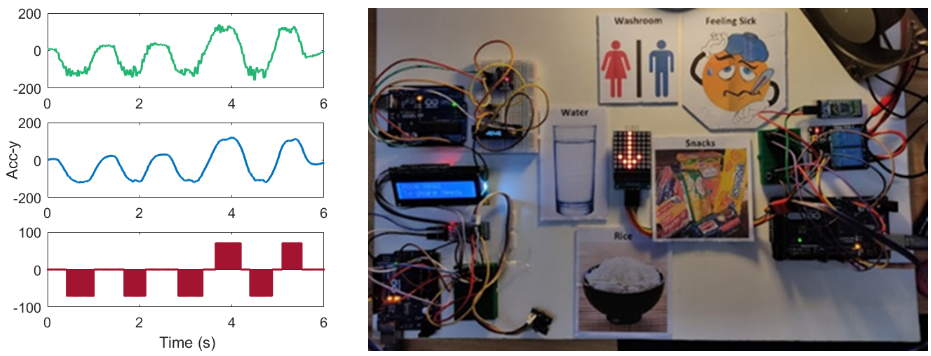


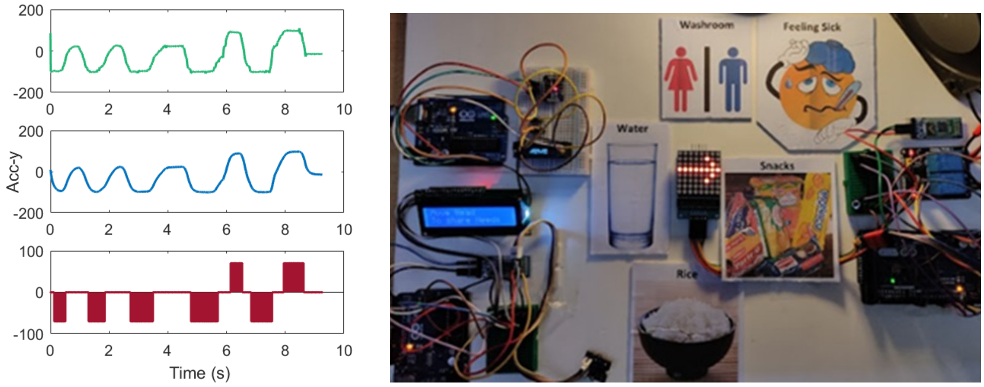
Figure 10. Case 1 (Sharing need for water)

In a similar way, patients can share other needs such as rice, snacks, a washroom, and feeling sick by moving their heads two, three, four, and five times in the right direction, respectively. If the patient turns his head twice in the right direction, the notifying unit will create an arrow in the matrix display pointing to the image of rice. This result is shown in Figure. The left side graph of the figure represents the signal of head movement received from the accelerometer, the signal after removing noise and pulses obtained for decision making. The left part of Figure represents the execution of the decision in the notifying unit. In the same way, three, four, and five instances of movement in the right direction imply that the patient needs a snack, needs assistance to go to the washroom, or needs care due to sickness. Figure 11, 12, 13, 14 displays these situations, in that order.



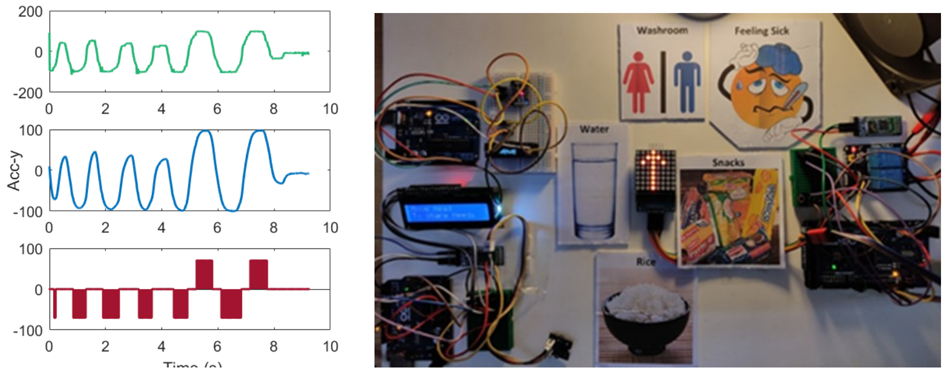
(a) (b)

Figure 11. Case 2 (Rice), head movement in the right direction two times (a) Raw sensor data, filtered signal and generated pulses after thresholding operation and (b) Execution of command in the hardware.



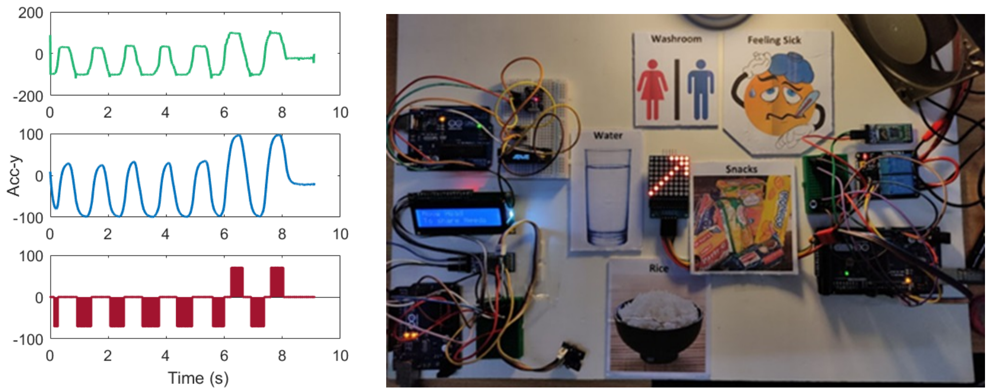
(a) (b)

Figure 12. Case 3 (Snacks), head movement in the right direction two times (a) Raw sensor data, filtered signal and generated pulses after thresholding operation and (b) Execution of command in the hardware.



(a) (b)

Figure 13. Case 4 (Washroom), head movement in the right direction two times (a) Raw sensor data, filtered signal and generated pulses after thresholding operation and (b) Execution of command in the hardware.

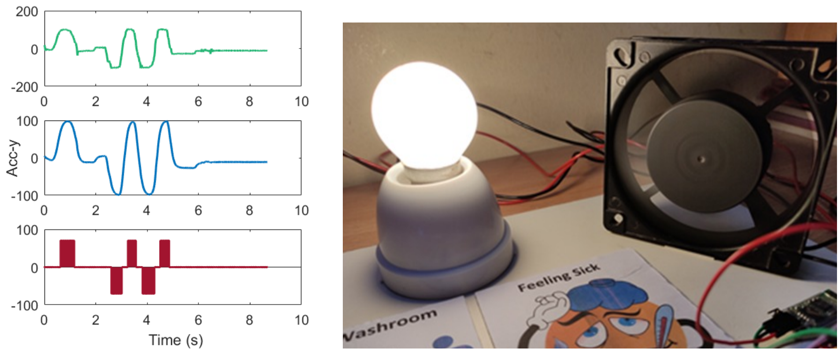


(a) (b)

Figure 14. Case 5 (Feeling Sick), head movement in the right direction two times (a) Raw sensor data, filtered signal and generated pulses after thresholding operation and (b) Execution of command in the hardware.

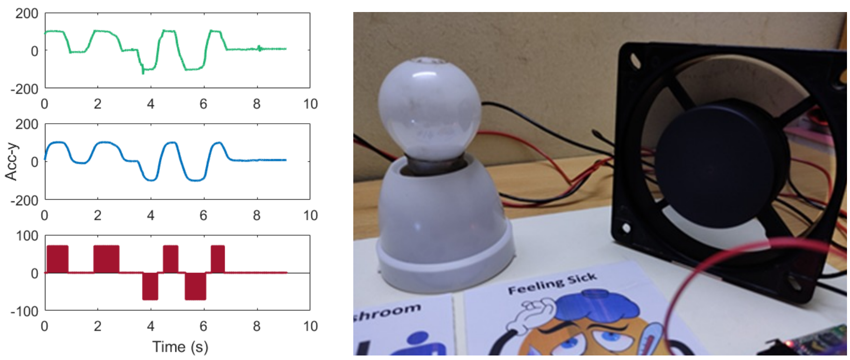
3.2.2. Home Appliance Control

Head movements enable quadriplegic patients to control lights and fans. A left head movement triggers a y-axis acceleration of up to 150, generating a positive pulse. One left movement turns on both the light and fan. Two left movements turn off the light, keeping the fan on. Three right movements turn on the light and turn off the fan, while four right movements turn off both. Figures 15, 16, 17, and 18 display these situations in that order.



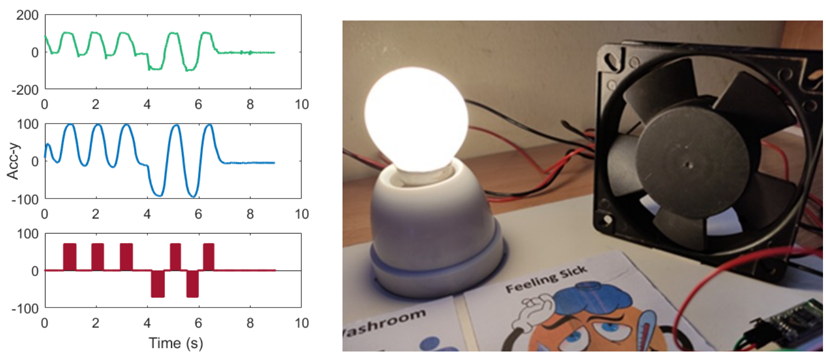
(a) (b)

Figure 15. Case 1 for head movement once in left direction (Light ON, Fan ON): (a) Raw sensor data, filtered signal and generated pulses after thresholding operation and (b) Execution of command in the hardware.



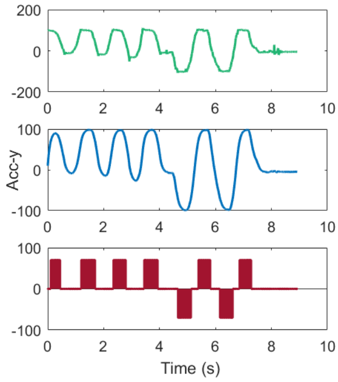
(a) (b)

Figure 16. Case 2 for head movement twice in left direction (Light OFF, Fan ON): (a) Raw sensor data, filtered signal and generated pulses after thresholding operation and (b) Execution of command in the hardware.



(a) (b)

Figure 17. Case 3 for head movement 3 times in left direction (Light ON, Fan OFF): (a) Raw sensor data, filtered signal and generated pulses after thresholding operation (b) Run command on hardware.



(a)

(b)

Figure 18. Case 4 for head movement four times in left direction (Light OFF Fan OFF): (a) Raw sensor data, filtered signal and generated pulses after thresholding operation and (b) Execution of command in the hardware.

3.2.3. BPM Outcomes

The MAX30102 sensor in the Pulse Oximeter can measure a patient's oxygen saturation (SpO2) and heart rate (HR). Table 1, displays the pulse rate of patients in Beats Per Minute (BPM), tracked continuously. Caregivers can continuously monitor a patient's health, as real-time heart rate measurement data is displayed on the OLED Display.

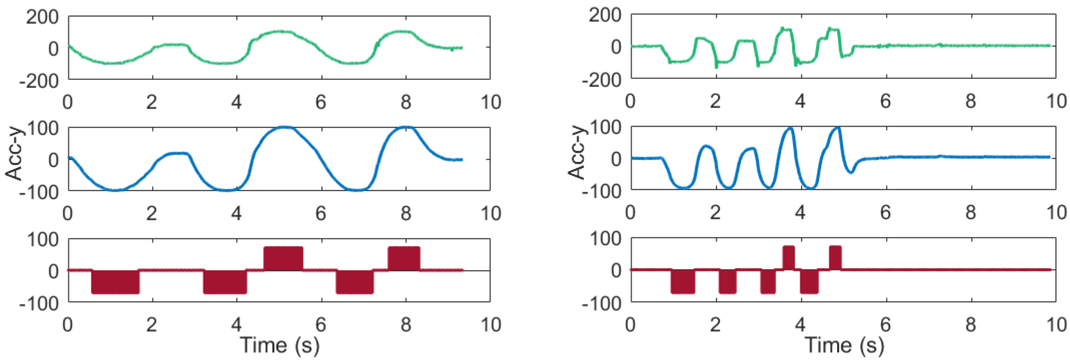
Table 1. BPM Detected Heart Rate (HR) and Blood Oxygenation (SpO2)

Person (Age)	Measured by Our System		Standard System	
	BPM	(SpO2)(%)	BPM	(SpO2)(%)
12	56	97	60	98
14	68	97	70	99
22	71	96	68	97
25	67	95	70	98
55	72	96	75	99
59	69	98	72	95

3.2.4. Robustness of the System

The system caters to quadriplegic patients who spend a significant amount of time in bed. They can control the home appliances and share needs by head movement through this system while lying on the pillow in bed. The effectiveness of the system may depend on two factors: the speed of the head movement and the angle of the head on the pillow. The influence of the head movement speed is investigated by subjecting the prototype to a range of head movement speeds. The system is reported to be able to detect head motions at different speeds and respond appropriately. Actually, the algorithm has no concern how long the signal is or how long it takes the head to move left or right. Rather, it is based on the number of pulse counts. For slow head motions, the resulting pulse width will be large; for fast head motions, it will be small. The system counts the pulses, detecting the rising edge and falling edge, not the width of the pulses. The system's effectiveness for both slow and quick head movement is depicted in the Figure 19. As illustrated in Figure 19a, one right movement of head followed by two complete movements is performed slowly. The system generated a negative pulse as well as two pairs of negative-positive pulses after analyzing the signal. Consequently, the command is accurately interpreted by the system. In Figure 19b, two fast right moves of head are followed by two complete movements. In this case, the system also recognizes the signal accurately.

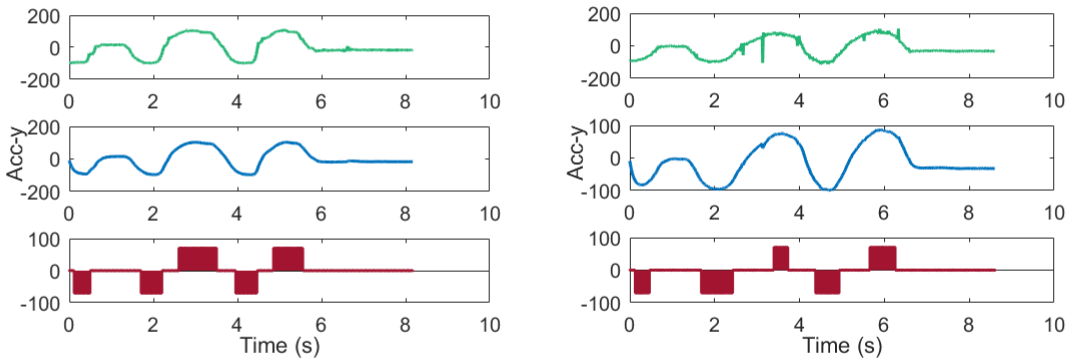
The height of the pillow can be varied, allowing the patient's head to rest at different angles depending on the height of the pillow. Since the accelerometer sensor is positioned on the patient's forehead, its angular location can also be changed. The performance of the system is assessed using the sensor at different angles. It has been observed that the system operates perfectly up to a deviation of 60-degree angle from the plane of



(a) (b)

Figure 19. Recognition of command from head movement signal (a) Slow head movement signal (b) Fast head movement signal

the bed. Figures 20a and 20b show two cases of accurate recognition of head motion signals at sensor angles of 30 and 60 degrees with respect to the plane of the bed.



(a) (b)

Figure 20. Recognition of command from head movement signal (a) head angle at pillow (30 degree) (b) head angle at pillow (60 degree)

3.2.5. Discussion

Many assistive devices are developed for the quadriplegic patient by the researcher, such as wheelchairs for their movement, mouse for using computers, electronic systems for controlling home appliances, etc. Many different technologies, such as voice control, head motion control, eye movement control, electromyography (EMG) signal control, and electroencephalogram (EEG) control, are used to develop these assistive systems. The application of our system differs from that of other assistive technologies that have been developed for quadriplegic patients. The proposed system has made it easier for patients who are quadriplegic to express their needs to family members and caregivers. In addition, patients are self-sufficient in using household appliances. Head motion was chosen as the method for giving commands because it is the most suitable option, considering comfort, cost, and complexity. Voice control is ineffective for quadriplegic individuals whose voices are very weak and who are in noisy environments. To use EMG and EEG signals, electrodes must be positioned in the body, which could cause discomfort for the patient. Eye movement detection is expensive since it involves sophisticated technology. In contrast, the head motion-controlled assistive device just needs an accelerometer sensor, which is quite inexpensive and doesn't require any unique placement arrangements. The performance of the sensor is unaffected by radiation, body resistance, light intensity, or body temperature. Many of the proposed systems use machine learning techniques to analyze head motion data, increasing the computational load and requiring expensive hardware setups. Our findings indicate that the proposed system does not require complex computations to accurately deduce the user's purpose from head motion inputs in normal and special conditions.

4. CONCLUSION

The study presents a wireless needs-sharing and home appliance control system for quadriplegic patients that are based on head movement. The transmitter end and the reception end are the two main parts of the system. They communicate with each other through Bluetooth Point-to-Point Protocol (PPP). Whenever the transmitter signal is received, a buzzer and an arrow that correspond to various circumstances are activated via a Dot Matrix display. The system also has the ability to manage household appliances on demand. A pulse oximeter is integrated to measure the pulse beat per minute in order to monitor the patient's health. In order to identify head motions, the accelerometer is essential since it sends signals to the microcontroller for processing. Based on the patient's requirements, the microcontroller executes the aforementioned situations by processing the head movement and count data. This method could develop into a highly effective model with more research and improvements, helping quadriplegic people and provide crucial support to their primary careers. On the other hand, there are certain drawbacks, like limitations on battery life. The existing design enables room-specific data transfer over a specified distance. IoT integration can transform the workflow and enhance this. By developing a mobile app, caregivers are able to obtain updates in real time via Wi-Fi, enabling seamless wireless data transfer from the device and getting around geographical restrictions.

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