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Design and Implementation of a Control Device for Intelligent Wheelchair by Combining Image Processing and Acceleration Sensor

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In this paper, a gadget for controlling an electric wheelchair (EWC) is designed. The device is designed based on the combination of acceleration sensor data from head rotation, and image processing data from user's face recognition, for commanding to the EWC. This gadget designed as a wearable device and is developed low cost, safe, and flexible for the patients with spinal cord injuries as well as the elderly with limited hand use. The mechanical design, sensor tuning, and 3Dprinted prototype of the gadget are presented. Finally the result of experimental test is discussed. Acceleration sensor module and camera and Raspberry Pi board are the core of the gadget. For performance evaluation, several experiments have been performed. The commands sent by the user are divided into four control commands (right, stop, move, left). Forward movement command, is performed by showing a happy expression on the face. The experiments show that the head angle controller and the image processor react to the stop in the shortest time, which indicates that it has a high level of safety.

Keyword: assistive robot, electric wheelchair (EWC), wearable gadget, image processing, acceleration sensor

1 Introduction

A significant proportion of any society face mobility problem; This range of the population includes the elderly, people with genetic motor disabilities, and people with disabilities; Proper design of mobility assistive equipment for each of these groups is one of the most important missions of engineers and the academic community.

With the development of robotic knowledge, the design approach to equipment, especially the devices with which humans interact the most, has changed. This change involves using as much technology as possible in the fields of mechanics, electronics and computers in combination, which is called *mechatronics*, which responds to the user's needs in the best way and in the simplest possible way. This effort has also been given more attention by engineers in order to improve the performance of existing movement and therapeutic systems and devices. The purpose of designing these mechatronic systems is to allow the user to perform their daily movements and activities without the need for the help of others.

A person who is unable to walk usually uses a wheelchair, and in *electrdic wheelchair* (EWC), he uses a joystick to guide the wheelchair by default. When using the joystick, one hand of the user is always involved in controlling the wheelchair; If a person has conditions such as amyotrophic lateral sclerosis and Parkinson's, user will not be able to use a joystick, [1-2].

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This article introduces a multi-input control gadget. This control interface allows the movement of a EWC by combining head rotation data as well as image processing of the user's face. This plan is designed to meet the needs of patients with spinal cord injuries as well as the elderly with limited hand use. With this interactive interface, the user will be able to adjust EWC in the desired direction and at the appropriate speed. The result is the return of independence in these people's life. In the design of this gadget, several inputs have been used to set up the control wheelchair. This gives the user more possibilities when using it and also the gadget can be made available to a wider range of users.

2 Types of user-machine interactions

Using multiple data for motion control algorithm, the inputs can be provided in different ways. This input can be implemented by combining data from different sensors, including: control based on *electroencephalogram* (EEG), control based on *electromyogram* (EMG), control based on *electrooculography* (EOG), voice recognition controller, control based on image processing, and control based on acceleration sensors.

The interface enables a direct communication pathway between the brain and the object to be controlled. By reading neuronal oscillations from an array of neurons and by using computer chips and programs to translate the signals into actions, a *brain control interface* (BCI) can enable a person suffering from paralysis to write a book or to control a EWC. Assuming that all thoughts or actions are encoded in electric signals in the brain is a gross understatement, as there are chemical processes involved as well, which electrode are unable to pick up on. Moreover, EEG measure tiny voltage potentials while the blinking eyelids of the subject can generate much stronger signals, [3]. Techniques based on BCI are currently used to develop EWC. Using human brain control in wheelchairs for people with disability has elicited widespread attention due to its flexibility. Brain-actuated smart rehabilitation wheelchair, integrates automation and artificial intelligence technology to provide users with an easy-to-use and efficient solution for applications in daily life, [4]. Electroencephalogram-based BCIs represent novel *human machine interactive* (HMI) technology that allows people to communicate and interact with the external world without relying on their peripheral muscles and nervous system. Among BCI systems, brain-actuated wheelchairs are promising systems for the rehabilitation of severely motor disabled individuals who are unable to control a wheelchair by conventional interfaces. Previous related studies realized the easy use of brain-actuated wheelchairs that enable people to navigate the wheelchair through simple command, [5-6]. The system provides a more reliable estimation of the command whereby yields a safe drive operation of the wheelchair. Those features may contribute to the user satisfaction, and consequently also motivate the adoption and engagement of this technology, [7]. Readily available commercial headset is used to record EEG signals for classification and processing. Classification based control signals were then transmitted to gadget for navigation. The gadget mimics a EWC with eye movements. The gadget is based on shared control which is safe and robust. The analysis of robot navigation for patients showed promising results, [8-9]. Each sensor caught four different brain waves[1]‡ per second and used from a wet or dry electrode. However, the main challenge of brain-controlled wheelchair is how to decode multi-degree of freedom control instruction from EEG as soon as possible, [10-11]. Among the disadvantages of this system the healthy natural person blinks every five seconds involuntarily. Therefore, incorrect signals must be filtered, [12-13]. The relationship between stress as a human factor

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[1‡] Delta: Has a frequency of 3 Hz or below occurs with sleeping, Theta: Has a frequency between 3.5 Hz and 7.5 Hz occurs during emotional condition, Alpha: Has a frequency between 7.5 Hz and 13 Hz are arisen with closing of eyes and relaxation conditions, Beta: Has a frequency of between 14 Hz and 30 Hz are captured during conditions of thinking or intending to do activities.

and cerebral and muscular signals must take into account. However, adding more moving obstacles did not show any impact. A synchronization factor was noticed between cerebral and muscular features in higher stress levels. The impact of stress on muscular and cerebral was assessed through EMG and EEG. To this end, navigation scenarios were created where, in each one, an environmental artifact was embedded to induce stress [14-15]. In [16], an EMG based hand gesture control system is developed. A wearable human machine interface device is designed for an in-home assistance service robot. An EMG-based control system utilizes *MyoWave* muscle sensor to acquire and amplify EMG signal. EMG signals are generated by muscles when activated by the nervous system, which generates electric potential. The more force applied to the muscle the larger electric potential generated from the muscle cells. Typically, EMG signal varies from 10 Hz to 500 Hz in terms of spectrum. The raw EMG signal ranges no more than 5 mV before amplification. The system has successfully acquired EMG signals and extracted from the *MyoWave* muscle sensor board. The system can calibrate and classify EMG signals from different movements performed by the system users. The communication system was successful in transmitting commands from EMG control subsystem to be received accurately by the service robot system, [17]. People with motor diseases have suffered from deprivation of both verbal and non-verbal communication abilities. Fortunately, some of them still retain coordination of brain and eye-motor. To establish a stable communication way for these disabled people, in [18], an eye gesture perception system based on EOG. The system may be applied as an alternative communication way for people with motor disabilities.

Since EEG-based and EOG-based automatic wheelchairs which use electrodes to measure neuronal activity in the brain and eye respectively, are very expensive, [19], research on controlling EWCs with other methods are widely developed. In [20] and [21], methods for commanding to a EWC that combines two controls, joystick analog and voice control are proposed. The movements resulted from the joystick analog on the x-axis axis (horizontally) are the right turn and left turn, and on the y-axis axis (vertically) are forward and backward. Meanwhile, the AMR-Voice application on Android is used to navigate wheelchairs by using sound. An eye and voice-controlled interface for a EWC to assist the mobility of physically impaired people has been designed so that they may be able to perform their daily life activities without additional support from a caregiver or healthcare professional, [22-23]. In [24], a method has been implemented to control a EWC based on eye-tracking and voice. This technique uses two types of modes to control the EWC. The first mode is using eyeball movement and the second mode is using voice control, User can give commands to move the wheelchair. In [25], EWC is controlled by several physiological variables namely; voice, head movement, finger bending, breathing pressure and EOG. The patient has the choice to use any of these variables to control the wheelchair. The voice command is recorded by a voice recognition module with its microphone, whereas, the head and finger motion operate through the gyro accelerometer and flex sensors. A pressure sensor is used to determine the force of breathing and EOG signals are used to control the wheelchair movement. All of the inputs are processed using a microcontroller. In [26-27], optimized model based on a deep learning method using *Multi-Layer Perception* (MLP) is utilized to help the disabled people by controlling the EWC using their Brain signal. Therefore, this develops an optimized model based on a deep learning approach a large community of disability people by allowing them to control the EWC.

A method is described in [28], manages steering inputs from users and mixes them with sensors to assist a disabled driver to steer safely. In [29], a technique for collecting data on wheelchair users using an intelligent system is developed.

Rabhi et al in [30], develop a new intelligent real-time emotion detection system to control equipment, such as EWC or robotic assistive vehicles. The camera mounted aligns with the eye

of the patient and captures continuous snapshots which are processed by image processing techniques in real time which, in turn, controls the direction of movement. The user needs to position his eye towards the camera mounted on the EWC to move in the desired direction for small duration. Along with the control of motion of the wheelchair, this model also designed to detect the obstacles using ultrasonic sensors, [31-32].
Paralysis is considered as a major curse in this world. The number of persons who are paralyzed and therefore dependent on others due to loss of self-mobility is growing with the population. Quadriplegia is a form of Paralysis in which you can only move your eyes. An easy but accurate algorithm is adopted in [33-34], which makes the system is easy to use.

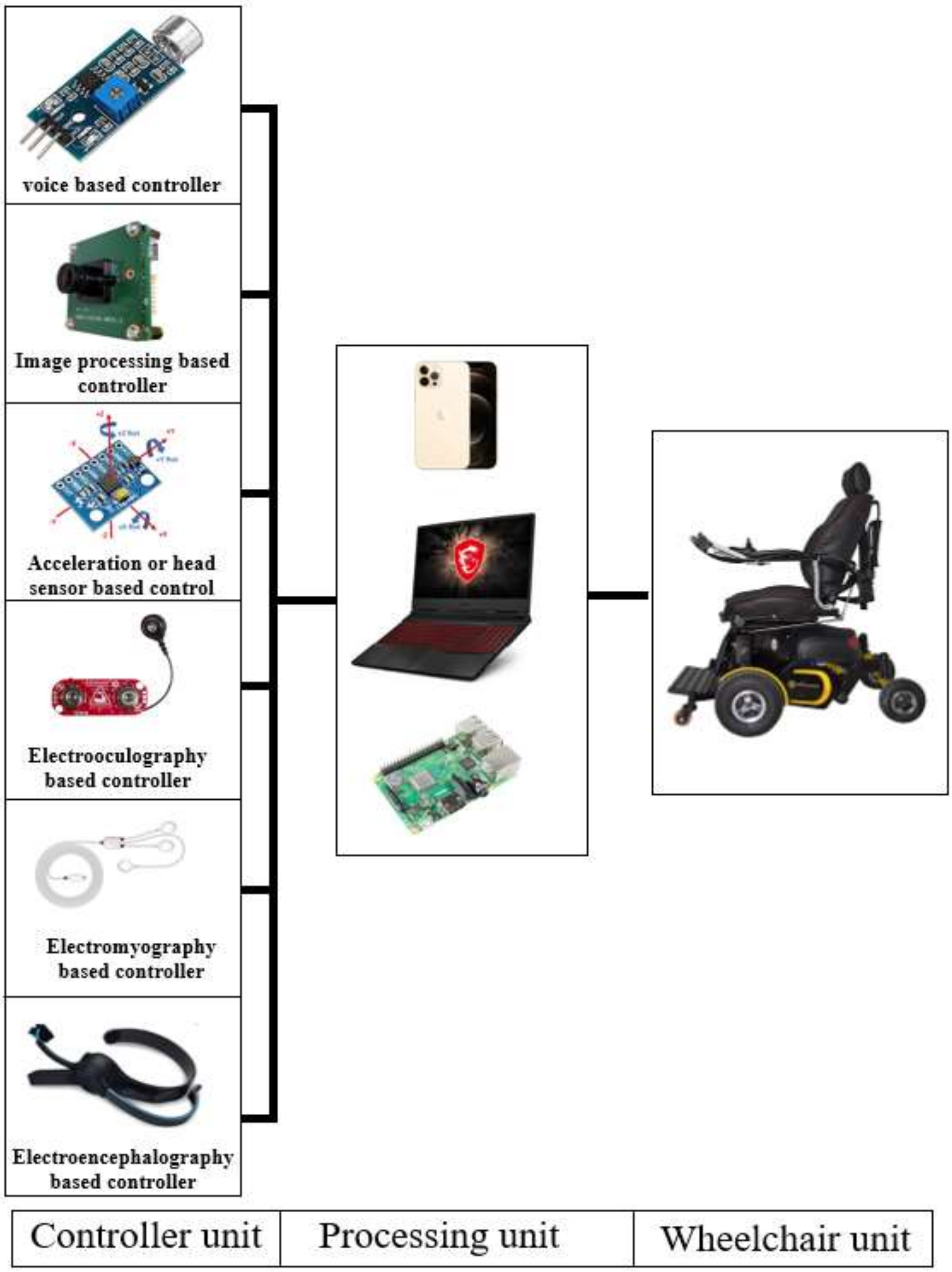


Figure 1 Types of user-machine interactions for EWC movement control

In voice primarily based methodology, that use user's voice as supply input. Whereas, voice-activated power wheelchair operates well when the patient can speak fluently and command the direction, they have to move but if there are any disturbances like heavy noise the system can't detect their voice properly even the patient. Recently, voice recognition or speech recognition has been applied in assisting just people doing work through digital devices such as mobile phone, tablets, and personal computer, [35]. The acceleration controls the implementation of an automatic or semi-automatic wheelchair for physically disabled and elderly people are quite important in order to make their life easier. These systems are useful particularly in transportation from one place to another. The system can also be used in old age homes where the aged persons who lost their self-mobility, resulting in difficulties in their movements. This device can be considered as a trustworthy medium for mobility purposes [36-37]. The combined data (filtered) of accelerometer and gyroscope ensures proper wheelchair locomotion for quadriplegic patients. The tailored made threshold for users' convenience. Moreover, the low cost of the assembly parts of this wheelchair has enhanced its affordability, [38]. In [39], for disabled people below the neck, an assistive autonomous powerchair is developed. To ease interaction with the chair, they propose embedding a head gesture recognition system using an *Inertial Measurement Unit* (IMU) sensor.
Finally, Figure (1) shows the types of user-machine interactions introduced for EWC motion control.

3 Working method and structure of the control gadget

Acceleration sensor module and camera and Raspberry Pi board are the core of the gadget. The camera is connected to the Raspberry Pi board using a cable, and the acceleration sensor is also connected to the Raspberry Pi base. Raspberry Pi first handles the raw data from the sensor and camera and then processes it using the Python algorithm. As you can see in Figure (2), it sends the verified information to the motors via Bluetooth connection, and finally the wearable control interface puts the wheelchair in the direction and speed desired by the user.
In this control gadget, with the combined method of image processing controller and acceleration sensor controller, data from face gesture and head orientation are used to control the wheelchair. Raspberry Pi is responsible for managing and controlling the system. This credit card-sized computer board that performs as well as a personal computer can process data. In this article, the Raspberry Pi board of the 3B Plus model is used. Head orientation signals are measured by the MPU6050 module. It has a three-axis gyroscope and a three-axis accelerometer sensor. This module has been selected due to the low price as well as its low

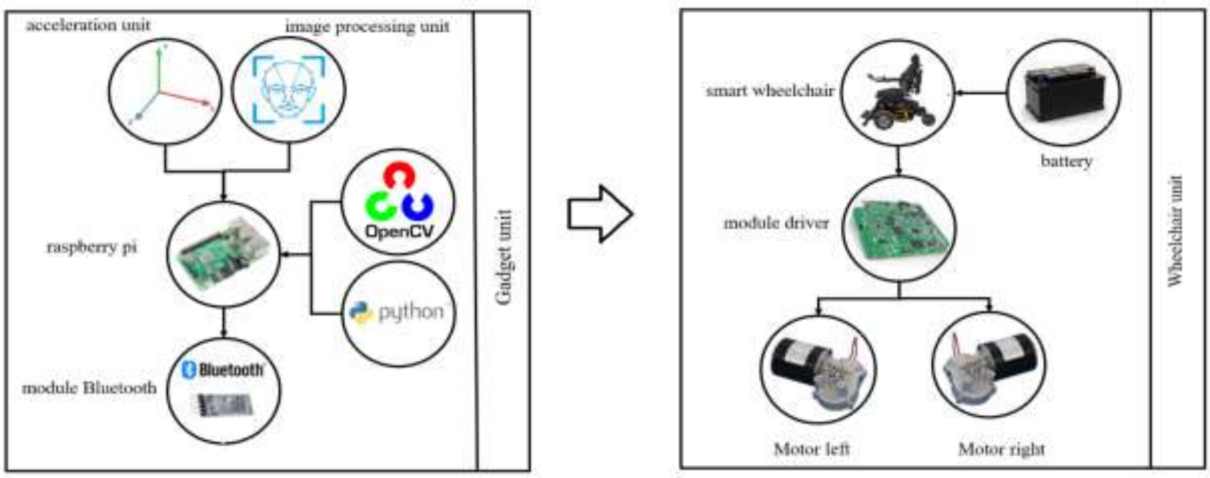
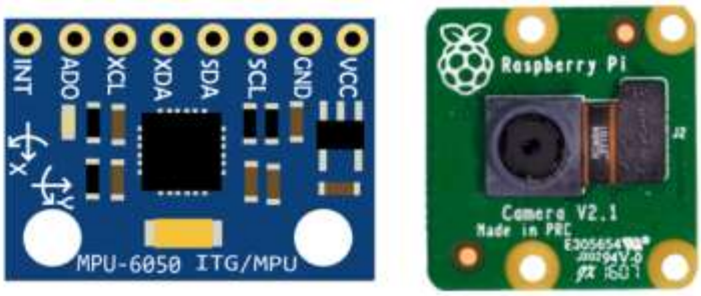


Figure 2 Gadget structure



(A) (B)

Figure 3 (A) MPU6050 module, (B) Camera module

energy consumption and good performance compared to similar modules. Figure (3-A) shows a view of this module. Another advantage of this module is that it can communicate with any microcontroller that works with the I²C protocol. The camera also receives images live. The camera is capable of capturing 5 megapixels and recording video in 1080p HD. Figure (3-B) shows a view of this module with a size of 25 × 25 mm. The small size of this module allows it to be used on gadgets. The connection between the camera and the Raspberry Pi board is made using a connector.

This module is used due to its light weight and high imaging quality. Raspberry Pi processes the resulting data using the OpenCV library and in the Python programming language. The Python programming language can be used as a tool for processing digital images, and the OpenCV library is released for free use under a FreeBSD license. OpenCV is designed for computational efficiency with a strong focus on real-time applications. Raspberry Pi sends the received commands to the EWC. The EWC used in this study is shown in Figure (4). The wheelchair has two DC motors with a voltage of 24 volts and a current of 8 amps, and a 24-volt power supply is used for the wheelchair. Its speed reaches a maximum of 60 kilometers per hour, although the user doesn't need to use the highest speed in daily tasks.

Figure 4 Electric wheelchair used in this research

4 Advantages and design of the gadget

Users who are not able to use conventional wheelchair controls are divided into several groups. Such as the elderly or patients with mobility impairments or people who have lost contact with the brain and organs in an accident or they may not be able to carry out their daily activities, such as eating or using a wheelchair, People with disabilities have the heavy costs of hiring a nurse. But using these control systems will cost users very little.
The minimum movement required to use this control interface is to turn your head and show a happy feeling with a smile. The advantage of this control system is that it includes a wider range of users. Figure (5) shows the various parts of this wearable control interface, including the Raspberry Pi board and the camera, and the camera stand and acceleration sensor.

5 Algorithm steps

After turning on the device, the system first sends the initial value to the engines by default to stop. This is for the safety of the wheelchair user. This is because there may be noise in the system when the device is turned on, and this incorrect command may cause an accident.
In the next step, according to the diagram in Figure (6), the algorithm simultaneously starts receiving face information as well as the angle of the user's head.
In this step, the algorithm uses face analysis to first recognize the face and then identify smile; At this point, a conditional statement is executed to reduce the error: If the smile is not detected or if it is more or less than a threshold value, the movement should not be approved, so for safety reasons, a wheelchair stop order should be given; If a smile is detected, the wheelchair starts moving in a straight line. Wheelchair speed is kept to a minimum for added safety and to reduce user stress. In the head angle analysis section, the head angle is detected by an acceleration sensor and then the wheelchair moves around. If the algorithm detects the angle of the head in the right direction, the wheelchair will be in the right direction but if the orientation of the head is in the unacceptable range for five seconds for the safety of the user, the wheelchair is stopped.

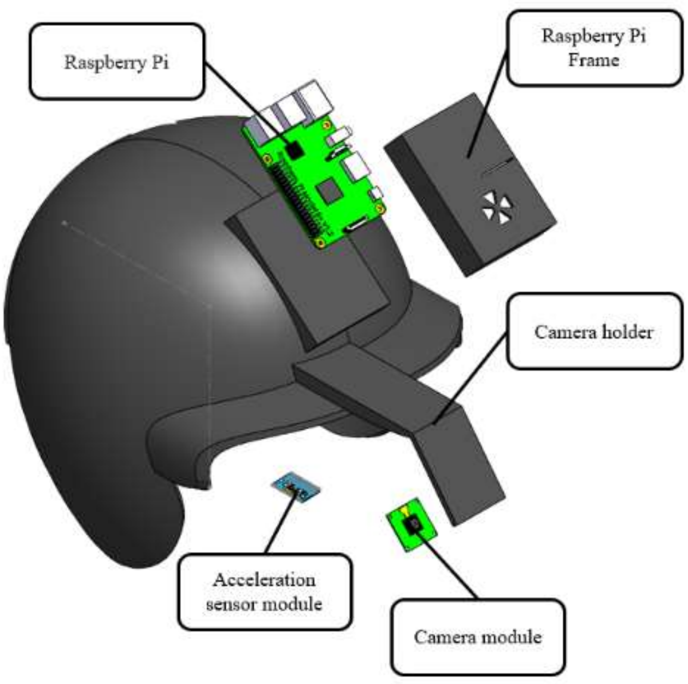


Figure 5 Explosive view of wearable motion control interface gadget

6 Image processing unit

To capture the image, the camera is connected directly to the Raspberry Pi CSI slot port. The camera is moved to the front of the control interface with a long cable connection so that the face can be photographed at the right angle.

Images are taken at high quality and detect smile. It should be noted that the facial expressions are constantly changing, which is why Python script processes images live. The OpenCV library is used to recognize faces and smiles [40]. After recognizing the face, a smile is detected, so the algorithm looks for the user's smile on the user's face. Smile is a gesture on your face when you are happy, amused in which the corners of your mouth turn upwards.

The algorithm can detect smiling faces and normal faces. As soon as the algorithm detects a smile, it estimates the threshold value of the corners of mouth. If the algorithm detects the lip threshold value more or less, no command will be sent to the wheelchair to start moving, as shown in Figure (7-A). If the smile algorithm confirms, the wheelchair starts to work and, as shown in Figure (7-B), a blue rectangle is drawn around the identified smile. Therefore, when the forward motion is sent from the wearable interface to the wheelchair, as shown in Figure (8), the wheelchair controller will apply the same voltage to both motors and the wheelchair will move in a straight line. The proposed algorithm uses the smile mode because the human

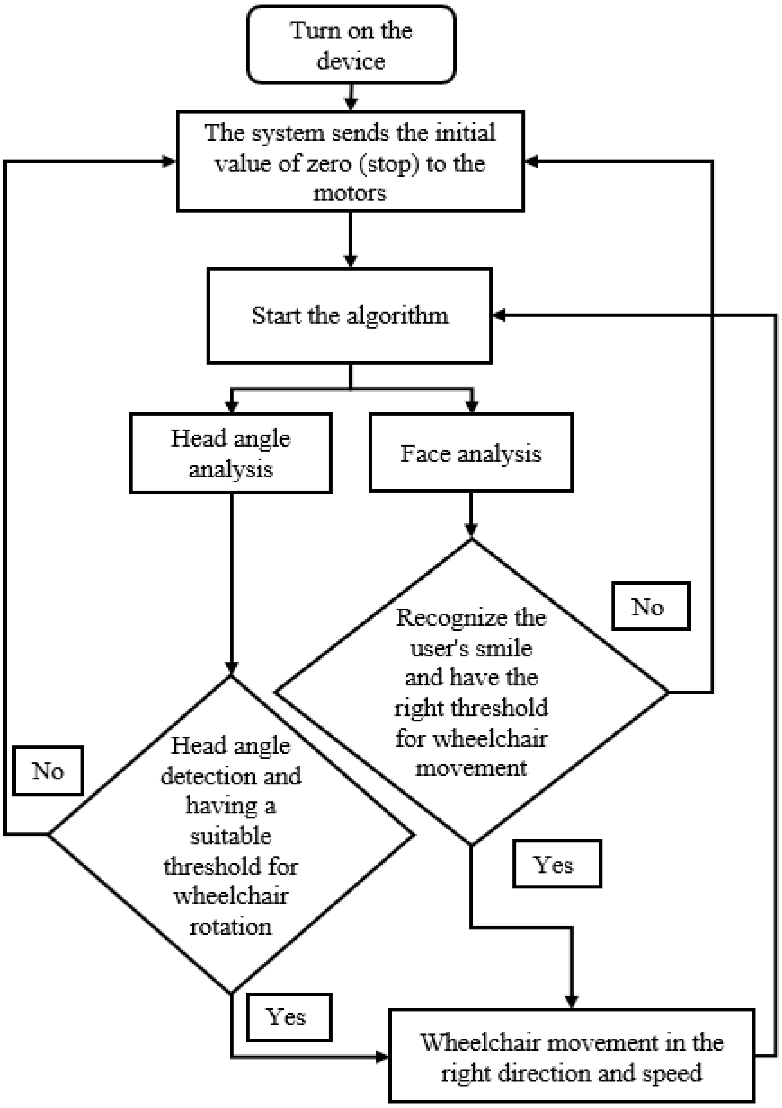


Figure 6 Flowchart of the designed algorithm

brain does not understand the difference between an artificial smile and a real smile, and on the other hand, smiling can affect people's feelings.

The algorithm considers images as a series of signals. The image is used to extract the signals and face recognition is performed by the Viola-Jones algorithm to detect facial features, [40]. These features are extracted with a set of filters, which are applied to the image one after the other to distinguish the face through its features. The rectangular function is used to draw delimiter boxes around the face. As shown in Figure (9), the desired files have been added with the “xml” extension.

To set up the algorithm, as shown in Figure (10), work begins with building an object in Video Capture and adding the OpenCV library. The vc object accepts only zero or one arguments. Zero for internal webcam and one for the case where an external webcam is used. Since the detection function works for a single image, a loop must now be created to do so in a set of images. Therefore, a While loop is used which is broken using the Break function.

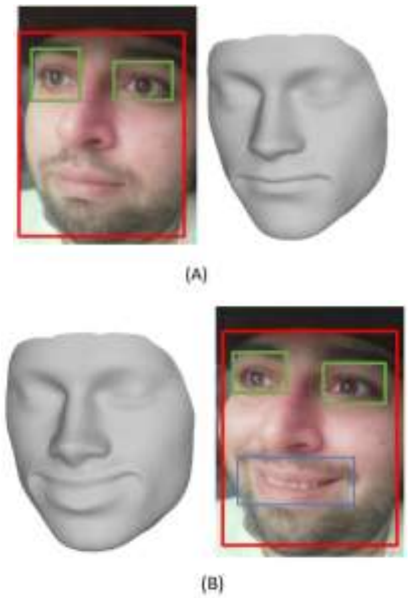


Figure 7 (A) The amount of smile less or more than the threshold, (B) The appropriate amount of smile threshold

Figure 8 Wheelchair movement forward under the influence of a smile

```
facePath = "face.xml"
smilePath = "smile.xml"
eyePath= "eye.xml"
faceCascade = cv2.CascadeClassifier(facePath)
smileCascade = cv2.CascadeClassifier(smilePath)
eyeCascade = cv2.CascadeClassifier(eyePath)
```

Figure 9 Facial feature extraction commands in the OpenCV smile detection algorithm

```
import cv2
    ⋮
cap = cv2.VideoCapture(0)

  while True:
  ⋮
        ret, frame = cap.read() # Capture frame-by-frame
        img = frame
        gray = cv2.cvtColor(frame,cv2.COLOR_BGR2GRAY)
  ⋮
        eyes = eyeCascade.detectMultiScale
  ⋮
        faces = faceCascade.detectMultiScale
  ⋮
        cv2.imshow('smile Detector', frame)
        c = cv2.waitKey(7) % 0xff == ord("s"):

            break
```

Figure 10 Parts of the code for face analysis

7 Acceleration sensor unit

While the imaging unit is working, acceleration sensor unit begins to detect the angle of the head. The sensor is hidden under the gadget interface. We connect it to the GPIO pins of the Raspberry Pi board by connecting the I²C with a specified address. The sensor detects the orientation of the head. In Figure (11) the Euler angles of the wheelchair are positioned to move in accordance with the orientation of the wheelchair. Angles can be classified into three categories: angle around the X-axis, angle around the Y-axis, and angle around the Z-axis.
The algorithm starts by collecting raw data from the sensor and measures the orientation of the user's head only on the X-axis, means no angle (Yaw and Pitch) is used so that users can freely turn their head. The algorithm examines the user angle data around the Roll axis or X in terms of the value of the threshold value, as shown in Figure (12). Depending on the threshold value, the head angle is used in positions (right, stop, left) to control the direction of the wheelchair. To change direction to the right, the speed of rotation right motor have to less than the value of the left motor according to Figure (13-A) and to change direction to the left, the speed of rotation of the motor of the left have to less than the value of the right motor,

Figure 11 Axes for Euler angles definition for EWC

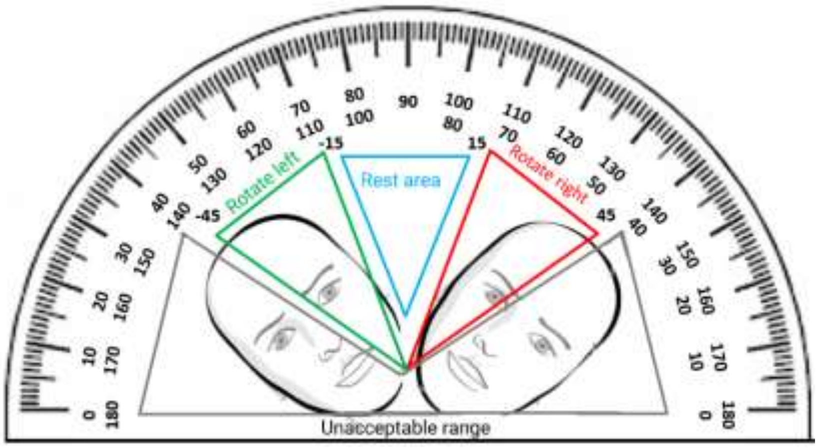


Figure 12 Motion threshold values in the acceleration sensor section around the Roll axis

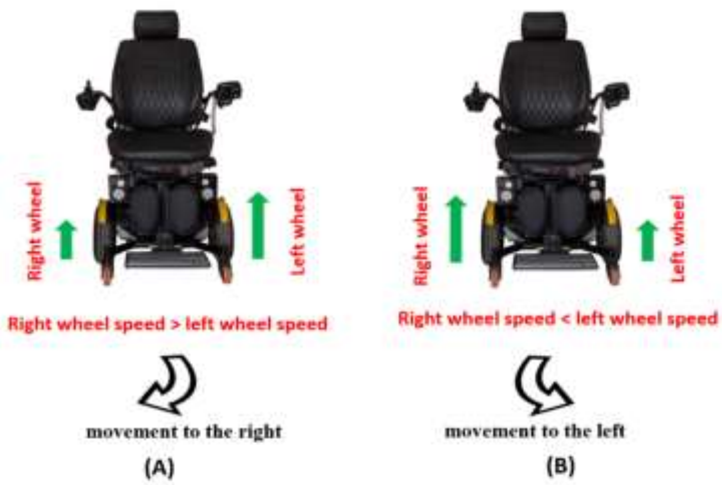


Figure 13 (A) Wheelchair movement to the right under the influence of acceleration sensor, (B) Wheelchair movement to the left under the influence of acceleration sensor

```
import smbus              #import SMBus module of I2C
from time import sleep           #import sleep
    ⋮
#some MPU6050 Registers and their Address
PWR_MGMT_1    = 0x6B
SMPLRT_DIV    = 0x19
CONFIG        = 0x1A
GYRO_CONFIG   = 0x1B
INT_ENABLE    = 0x38
ACCEL_XOUT_H  = 0x3B
ACCEL_YOUT_H  = 0x3D
ACCEL_ZOUT_H  = 0x3F
GYRO_XOUT_H   = 0x43
GYRO_YOUT_H   = 0x45
GYRO_ZOUT_H   = 0x47
    ⋮
def MPU_Init():
    ⋮
def read_raw_data(addr):
    ⋮
while True:
            #Read Gyroscope raw value
    acc_x = read_raw_data(ACCEL_XOUT_H)
    acc_y = read_raw_data(ACCEL_YOUT_H)
    gyro_z = read_raw_data(GYRO_ZOUT_H)

    if ( acc x > 6000 ) & ( acc y >100 ):# // left
   ⋮
    elif ( acc x < -6000 ) & ( acc y  > 100 ) :#// right
   ⋮
    else:
```

Figure 14 The code related to acceleration sensor unit

```
pyhton ==================================== gadget.py ====================================
x= 0.13436424411240122  y= 0.8357651039198697     z= 0.02544586099346 08
x= 0.8474337369372327   y= 0.43276706790505337    z= 0.5414124727934966
x= 0.763774618976614    y= 0.762280082457942      z= 0.9391491627785106
x= 0.2550690257394217   y= 0.002106053351110 6927 z= 0.38120423768821243
x= 0.49543508709194095  y= 0.4453871940548014     z= 0.21659939713061338
x= 0.4494910647887381   y= 0.7215400323407826     z= 0.4221165755827173
x= 0.651592972722763    y= 0.22876222127045265    z= 0.029040787574867943
x= 0.7887233511355132   y= 0.9452706955539223     z= 0.22169166627303505
x= 0.0938595867742349   y= 0.9014274576114836     z= 0.43788759365057206
x= 0.02834747652200631  y= 0.030589983033553536   z= 0.49581224138185065
```

Figure 15 Acceleration sensor unit output section

according to Figure (13-B). After verifying the data, the wheelchair is positioned in the desired direction. If the algorithm does not detect the appropriate data to move, a delay is issued during the execution of the command. To drive the MPU6050, the point is that this sensor data just a series of digital numbers and not the angular velocity and acceleration expected by the user. For this reason, a series of mathematical calculations must be performed on them to obtain the final data. To run this part of the algorithm, at first the desired modules are added to the program, then the *smbus* module that is imported. This module is used to communicate with the I²C protocol. Then the time module enters the program. This module causes a small-time delay between consecutive readings of the data, which will be an important factor in increasing the mobility of the wheelchair. According to Figure (14), variables with different names are defined, each of which has a hexadecimal value. These hexadecimal values are actually the addresses of the registers associated with the sensor. After the initial definitions, a function is defined that performs the initial configuration of the MPU module. Raw data is then called from the registers using the “*read_raw_Data*” function. Then its output is stored in variables. Finally, the data is displayed in the output, and the sleep command intentionally pauses between two consecutive readings for 1 second. This amount of time delay can be adjusted according to the conditions and needs of each user and so-called personalization. The output of the controller from this section is shown in Figure (15).

8 Discussion

Independent mobility is what engineers are devoted to studying. Gadget controller wheelchair a promising solution for those people with physical challenges. The most significant advantage of gadget is that the paralyzed patient can control the wheelchair directly from the physical movement and act like a joystick. The approach user to give enough freedom to execute these commands for example, go to the kitchen, bed room, etc.

The designed and developed controller hybrid prototype for wheelchair with image processing and head movement with the gadget interfacing was accomplished in this study, the movement of wheelchair was tested. The results showed that the gadget command when user smiles, wheelchair moves forward. In this hybrid method, the gadget does not respond to the wheelchair when the head is bend forward or backward. If the patient suffers a stroke, his head may tilt forward which will result in the wheelchair keeping to move forward, and causes an accident for this reason, we use image processing to move forward.

Movement of the wheelchair totally depends on the angle of the user's head. The wheelchair moved right when the user tilted his head right, moved left when the user tilted his head left. The readings of the sensor used to detect the head movements are converted to digital data and entered the microcontroller which translates this data in order to control the motors of the wheelchair.

9 Results

The results show that wheelchair users can drive successfully even in the most difficult conditions using combined data control. In order to evaluate the performance of the proposed gadget, several experiments have been performed, in each experiment we gave them some tips in order to use this wheelchair. The amount of user control on the wheelchair and the instructions performed by user at the end of each test are studied. In all the tests performed, the gadget was on the user's head and the camera took pictures of user’s face. The sensor installed below it is also used to collect the angle of the head. The mini-computer mounted on the wearable interface analyzes all the collected signals and then sends the motion data wirelessly to the wheelchair controller via the Bluetooth module.

The commands sent by the user are divided into four control commands (right, stop, move, left). In all the experiments performed, a small number of error commands were identified. If the user gets used to the so-called control interface by using it many times, the data success rate send from the gadget has reached 100%.

Moving forward and stop when moving forward should achieve a high percentage of safety. According to Figure (16), the forward movement command, which is performed by showing a happy expression on the face, is 100% safe for the wheelchair to stop and move. It was important to develop an algorithm that did not inadvertently send any forward motion instructions to the wheelchair while driving. This successful operation is due to the time delay mentioned in the description of the image processing code. On the other hand, since starting to move at a high speed makes effective wheelchair control difficult and stressful for the user, so the wheelchair speed is kept low at the beginning of the movement.

The success rate for stopping has 99%. To control the wheelchair rotation, the data of the acceleration sensor unit, which measures the angles of the X-axis or Roll, have been used. Because the wheelchair rotates at low speeds during its rotation (in situ), it is less likely to be seriously damaged than moving forward. Most those rates near to 100%. It has a 98% performance for moving the wheelchair to its right and left. To move in a circular or oblique direction, it is necessary both in terms of speed and direction, which in the tests doing on this part, the interface achieved a good performance of 99%.

In this hybrid gadget, the interface does not respond to the wheelchair when the head is bent forward or backward. If the patient has a stroke, head user bend then the wheelchair to move, after that an accident may happen, which is why image processing is used to move forward.

10 Conclusion

In this paper, an electric wheelchair motion control gadget is presented using a combination of data input for users of mobility disabilities. In this system, two categories of image processing data and acceleration sensor are used to generate and adjust control commands. The proposed system has been successfully tested and based on the success rate of the tests performed; this system can be considered a suitable alternative to controls. The body of the designed gadget can be made with a 3D printer, so it can be customized for any user and tailored to the dimensions and sizes of the user's head.

Finally, the main purpose of this interface is the possibility of independent movement control of electric wheelchair-like devices for people with mobility disabilities, the aging and people of disabilities in performing daily tasks. From a functional point of view, the experiments show that the head angle controller and the image processor react to the stop in the shortest time, which indicates that it has a high level of safety.

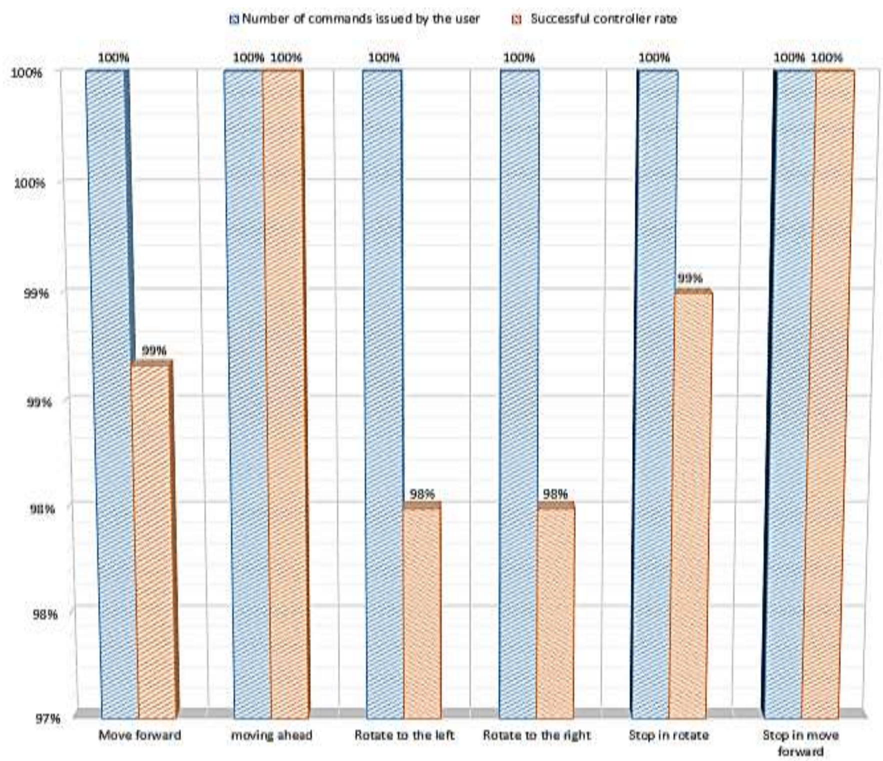


Figure 16 Results of error percentage of executed commands by direction

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