And Beyond

Abstract

Tetraplegia is a paralysis that causes a total or partial loss of the motor and sensory of the four limbs and torso. This disease decreases the quality of life of the patient and increase his dependence on other people in basic human activities like eating, bathing, and transferring. The selected problem in is this project is the dependence of the patient on other people during transferring. Prior solutions for this problem included electrical wheelchairs with a control unit on one of the sides of the chair. The disadvantages of this solution are that it is relatively expensive, it isn't available locally, and it can't be controlled by patients who had their injuries between the C1 and the C4 levels of the spinal cord due to their inability to move their fingers or hands. The proposed solution for this problem is a system that can be controlled by patients of injuries in the levels between C2 and C8, can be applied to traditional wheelchairs and has a relatively cheap cost.

Introduction

Tetraplegia, also called quadriplegia, is an illness caused by the injury of the spinal cord above the thoracic vertebra and within the cervical sections C1 and C8. This causes the patient to be unable to sense or move some or all of his four limbs and torso. The level of severance depends on the injured part of the spinal cord and the severity of that injury. As the level of severity of the illness increase the dependence of the patient on other people increases till it reaches total dependence for patients with injuries in the C1 level as they can't move or feel any part of their bodies except their eyes. The level of dependence is shown in table 1. The patients are required to have physiotherapy times per week on average 3 and require weekly checks on their health. This may require them to be transferred to and from hospital often. Due to their dependence on other people during transferring to and from the hospital, the process of treatment becomes more strenuous, thus decreasing the quality of the patient's life. While pursuing a solution for this problem, some prior solutions were studied. These prior solutions are electrical wheelchairs available in the markets. The disadvantages of these chairs are that they are relatively expensive and unavailable locally. They also require hand and finger movements to control them, which some tetraplegia patients lack.

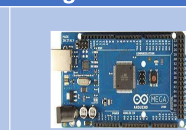
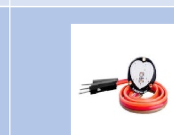
Domain	C1-C4	C5	C6	C7-C8
Pattern of upper extremity weakness	Total paralysis of extremities	Absent elbow extension and pronation, all wrist and hand movements	Absent wrist flexion, elbow extension, and hand movement	Limited grasp release and hand dexterity due to intrinsic muscle weakness
Respiratory	Ventilator dependent (some C3, many C4 may be able to be weaned off ventilator)	Low endurance and vital capacity; may require assistance to clear secretions	Low endurance and vital capacity; may require assistance to clear secretions	Low endurance and vital capacity; may require assistance to clear secretions
Bowel management	Total assist	Total assist	Some to total assist	Some to total assist
Bladder management	Total assist	Total assist	Some to total assist with equipment; may be independent with leg bag emptying	Independent to some assist
Bed mobility	Total assist	Some assist	Some assist	Independent to some assist
Bed and wheelchair transfers	Total assist	Total assist	Level transfer: some assist to independent Uneven transfer: some to total assist	Level transfer: independent Uneven transfer: independent to some assist
Pressure relief/ positioning	Total assist; may be independent with equipment	Independent with equipment	Independent with equipment or adapted techniques	Independent
Wheelchair propulsion	Manual: total assist Power: independent with equipment	Power: independent Manual: independent to some assist indoors on non-carpet surface; some to total assist outdoors	Power: independent with standard arm drive on all surfaces Manual: independent indoors; some assist outdoors	Manual: independent on all indoor surfaces and level outdoor terrain; may need some assist or power for uneven terrain or long distances
Eating	Total assist	Total assist for setup, then independent eating with equipment	Independent with or without equipment, except total assist for cutting	Independent
Dressing	Total assist	Some assist for upper extremities; total assist for lower extremities	Independent upper extremities; some to total assist for lower extremities	Independent upper extremities; independent to some assist for lower extremities
Homemaking	Total assist	Total assist	Some assist with light meal preparation; total assist for other homemaking	Independent for light meal preparation and homemaking; some assist with heavy household tasks

Table 1 shows the dependence of patients with different injuries

The requirements of our solution were determined as based of the disadvantages of these prior solutions. The main requirements are the ability of most tetraplegia patients to control the system, the availability of the system, and the relatively cheap cost of the system. A solution was determined and a system that was able to meet those requirements was produced. The materials that this system was made from are discussed in the following section.

Materials and Method

Materials:

Type	Description	Image	Cost
Arduino Mega	An electronic board with a chip that can receive, process, and send data		260
DC motor and L298N driver	A 24 volt electrical motor and a driver to configure it		200
Driver A4988	A chip that is able to regualte the signals between the arduino board and the stepper motor		55
Batteries	3.7 volt rechargeable lithium batteries		30
Pulse sensor	A sensor that measure the hearbeat rate		110
Touch sensor	A sensor that can sense touches		30
IR kit	A kit that includes an infrared reciver an infrared emmiter		35
LCD screen	A screen that can show values		30
Smoke sensor	A sensor that senses smoke		65

Methods:

The following circuit were made using the Arduino mega board and connecting wires and the materials shown above, a code that will be explained in the analysis section was written to receive information from some of these parts and send command to other parts:

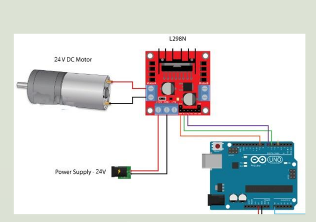


Figure 1 the DC motor

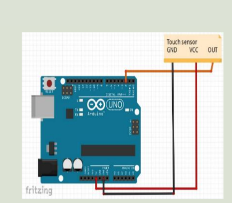


Figure 2 touch sensor

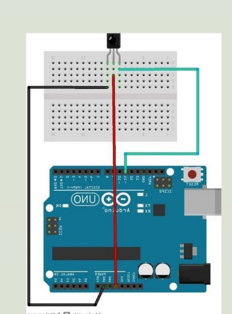


Figure 3 Infrared remote

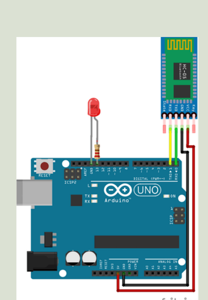


Figure 4 Bluetooth Module

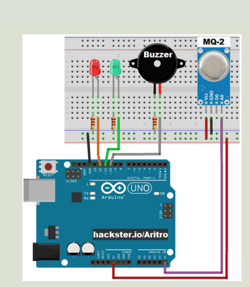


Figure 10 Smoke sensor

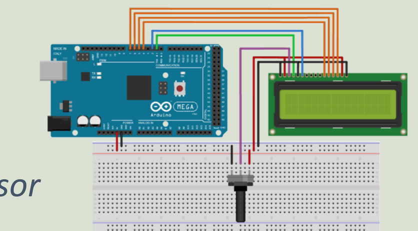


Figure 6 LCD screen

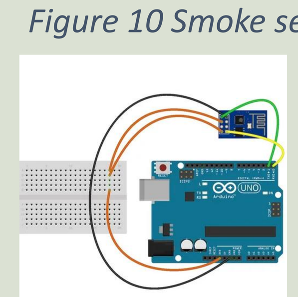


Figure 5 Wi-Fi Module

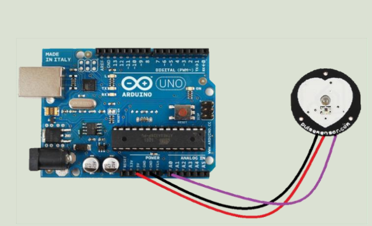


Figure 7 Heart beat sensor

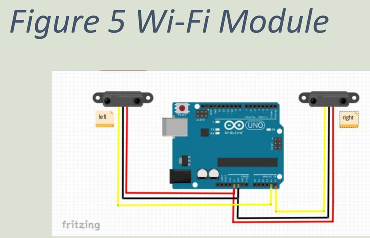


Figure 9 Line follower

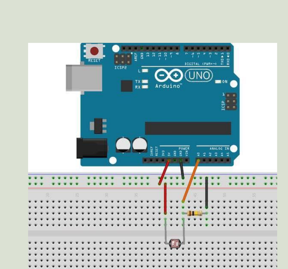


Figure 8 Light dependent resistor sensor

Analysis

Our project achieved its three main requirements, but it couldn't have done that without being built on a scientific base. The first requirement was the availability of the system and its materials. This was achieved by making the solution into a small system that can be applied to most traditional wheelchairs by just modifying the front wheels and connecting them to the system. This was further achieved by making the system from common electronical materials.

The second requirement was that tetraplegia patients with different types of injuries could control the system. The system achieved this requirement by having multiple control systems for different injuries. The first control system is the tongue motion control system. This system consists of a stick that extends from the wheelchair to the patients' lips. At the end of the stick there are four touch sensors at each direction from the lips of the patient. when the patient touch one of the sensors with his tongue the sensors send an electrical signal to the Arduino main system which in turn moves the motors in the specified direction. This system can be used by tetraplegia patients with injuries in the C2 levels to C5 levels as most of them can't move their fingers but can move their tongues.

Another method that be used by patients with injuries in lower levels is the remote control. When a button on the remote is pressed it send infrared rays. These rays are received by the receiver led connected to the Arduino system which then powers the motors according to the received signal.

An automated system is also added to the main system, for usage by patients with injurie at the C1 level. This allows the wheelchair to follow a black line on the ground. An infrared emitter under the wheelchair sends an infrared ray to the ground. As the rays hit the ground, they a reflected with different wavelengths according to the color of the surface that they hit. The rays reflect onto an infrared receiver led that transfer the signal to the Arduino system which in turn determines where is the black line powers the motor in its direction.

The system can also be connected with a companion app using the Bluetooth module or the Wi-Fi module. When connecting with either the module connected to the Arduino system works as an access point for either Bluetooth or Wi-Fi. the system can be controlled remotely from any android phone using the companion. The app works by connecting to these Bluetooth or Wi-Fi access points, then sending commands to the Arduino system. When any of the four directional buttons is pressed on the app, it sends a command to the system to move in that direction. The voice option in the companion app works by using Google's voice to text extension into converting the voice command into text command which are send using either Bluetooth or Wi-Fi to the system.

The system also monitors the safety of the patient, as it contains three main sensors that monitors the health of the patient. The first one is the heartbeat sensor that monitor the heartbeat rate of the patient. this sensor works by emitting light through the skin of the patient and measuring the reflected light by a LED light receiver. The amount of reflected light will vary according to the number of pulses under the skin. The heartbeat rate is measured in beats per minute (BPM) and is displayed on the LCD screen and the companion app. If the heartbeat rate falls below a certain threshold, the buzzer will make an alarm. The second sensor is a system made from a light dependent resistor. This is a variable resistance that changes its resistance according to the amount of light that fall upon it.

Analysis

If the amount of light in the room decreases the resistance in the light dependent resistor decreases, thus enabling the dark mode. When the dark mode is turned on, the LEDs in the different parts of the system are turned on to allow the patient to see. The third sensor is the smoke sensor which checks for fires. This sensor works by sending a light wave into a reflecting chamber. If smoke enters the device light is refracted thus the angle of light is changed triggering the alarm in the buzzer.

The mechanism of the motion of the system is as follows when the system receives a command to move forward or backward it powers both of the motors in the same direction either forward or backward. If it gets a command to move to the right or to the left it powers the two motors in different directions if it wants to move to the right it powers the left motor forward and the right one backward and vice versa. The system uses three rechargeable lithium batteries of 3.7 volts each to supply energy for all of its components.

All these different methods of controlling the system proves that it has achieved the second requirement. The third requirement was that it should be relatively cheaper than commercial wheelchairs. Although material's costs aren't constant and it can't be calculated efficiently, it can be clearly seen that our solution's cost added to the cost of a traditional wheelchair is at most equal to an electric wheelchair's price if not less than it. Thus, it can be inferred that the system has achieved the third requirements as it used common and cheap materials.

Conclusion

As mentioned earlier, the project aims mainly to solve the problem of depending of the patients of Paralysis of the four limbs on the people during the transportation , after analyzing the results and testing the prototype according to the design requirement, it achieved the design requirement, which are the low cost of the project, the availability of the materials and to make more people can auto move without help . The prototype had achieved high rate in the efficiency cost ratio as the prototype's materials are available and low in cost. So, it was concluded that the prototype is tremendously striking as they were an auspicious indicator of the project successfulness.

Recommendation

Technology of artificial intelligence:

It's recommended to use to technologies of artificial intelligence and image processing to make a self-driving wheelchair that can interpret images from the real world and decide its direction upon doing that.

Contacts

Tarek Mohamed Ghonemy Kassab: - +201008352462

Citation

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