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COST EFFECTIVE SMART WHEELCHAIR USING SOLAR PANEL

[1]Sk Israfil, [2]Ahmad Shabir Seddiqi, [3]Arghya Ghosh, [4]Sourabh kumar, [5]Ahmad Seyar Sediqi
[1,2,3,4,5] B.tech, Lovely Professional University, Punjab, India

Abstract:

Now a days, physically disabled persons don't have much access to daily life activities as they face so many difficulties. They have difficulty in accessing manual wheelchair. There is also electric wheelchair with joystick which is costly and has less features. So, we have developed a cost-effective smart wheelchair which has more features and it will be beneficial in many aspects to the disabled persons. The main feature of this wheelchair is that it will be controlled using hand gesture for the movement of the wheelchair. The battery which is used in this wheelchair will be charged using solar panel when possible, and it can be charged using AC supply also. There is obstacle detection system using ultrasonic sensor which will help the person from colliding with any obstacle in case of wrong direction he or she is approaching. There are some SMD LED lights attached to the wheelchair which can be turned on if the surrounding has not enough light. If the disabled person is in any emergency situation or in any difficulty, he can send alarm to the caretaker or nearer person or relatives so that the person can be attended as soon as possible.

For gesture controlling, accelerometer is attached with hand and analog signal is produced by the movement of hand in x and y axis direction. The range of this analogue signal is then converted into angle range by mapping, and the Arduino converts it to a digital signal. Now Arduino compares the signal with pre-installed data with codes and values in terms of axis rotation and if the data matches, the Arduino then gives command to the relays to drive the wheelchair in various directions. This wheelchair will be giving the person much more comfort in day to day life and also it will reduce the cost, so it will be much more accessible to almost each category of people.

Key words: smart wheelchair, hand gesture, solar panel, DC motors, accelerometer

Introduction:

According to the 2011 Indian census, over 20.7 million individuals are disabled in any form. Among the disabled persons, around 20% people are suffering from movement disability. They always require the use of a wheelchair, stretcher, or caregivers. Normal or manual wheelchair or stretcher can't give them a comfortable feeling which they need strongly. There are electrical wheelchairs in market. But in rural areas and to lower class people, accessing costly electrical wheelchair is just a dream. So, cost effective smart wheelchair will be very much beneficial to them. Over the time, people have seen many changes to the use and features of wheelchair for differently abled persons who face difficulty in moving their legs or paralyzed to some other parts of their body.

In earlier days of wheelchair, there was manual wheelchair which needed a caretaker to move the wheelchair by pushing it from the back. If the caretaker is not available at any moment, the user could move the wheelchair by rolling the wheels using his own hand if possible. Then wheelchair with gear controlled by chain came to use. The shaft of the gear was rotated using another shaft by hand just like a bicycle. Later, some more evolving technology has been introduced to the physically disabled people. But there are always some drawbacks to the existing wheelchair models. But the proposed wheelchair model is very useful for the incapable persons in terms of suitability and affordability. This research paper aims to develop the manual wheelchair into a developed and well designed smart wheelchair which detects hand movement and produces analog signal. Then the signal is converted into digital form and after compiling some steps, it drives the motor accordingly. And also, the proposed wheelchair model is using renewable energy in the form of solar energy which is very eco-friendly. The main components in this wheelchair are ADXL335 accelerometer, Arduino UNO, L293D motor driver, DC motors, battery, solar panel, buzzer, ultrasonic sensor etc. Using this wheelchair, the disabled person doesn't need anyone's assistance to move from one place to another. This makes the person self-reliant. By reviewing all kinds of aspects, the development of solar powered wheelchair along with hand gesture-controlled movement is a great effort to the society. Another challenge that is taken is to make this wheelchair cost-effective because our motive is that it should be well affordable to all kinds of people. Solar energy is endless and renewable, so charging cost of the battery is reduced. Also, we have designed it in such a way that it has lesser components with increased facility. The maintenance and controlling of the wheelchair is very much user friendly and easily accessible.

Need of the project:

In this project, the main objective is to develop a wheelchair which is controlled by the movement of hand of the disabled persons in certain direction. According to a 2011 WHO report, around 15% of the world's population, or 1 billion people, are disabled in some way. Among them 2-4% people have serious difficulty. So, they need help from either caretakers or technology. And all the time it is very difficult for a disabled person to rely on caretaker or helper. That's why they need some sort of technology which would give them much comfort and makes them self reliant. Controlling wheelchair by hand gesture can give them the opportunity to be independent of others. We have planned to add some more features like object detection, alarm system which would give the person much more safety than the normal wheelchairs. For the paralyzed persons and the persons who have difficulty in speaking, this wheelchair will be boon for them. This project also reduces the daily cost because it will be charging using solar panel, so electricity bill will be reduced. Also total cost to make the wheelchair is much lower, so it can be affordable to many people. This wheelchair will be beneficial to the persons:

- Who are paralyzed on the body parts which are related to movement
- Who creeps while moving
- Who have joint or muscle problems
- Who need someone's assistance to move
- Who have stiffness or looseness in body joints
- Who have deformity in the body
- Who have broken legs permanently or temporarily

Literature review:

In earlier years, there were normal wheelchairs which needed caretaker to move and control that wheelchair. It only had the potential to manually move the wheelchair. If there was no caretaker, then user could move the wheels using his/her own hands. But for the people with multiple disability who cannot give much pressure on hand, it is not suitable option for them. Nevertheless, this kind of wheelchair is used in this era also because many people cannot afford smart or electric wheelchair. Continuous research is carried on and many researches already have been made regarding wheelchair development, some of them are mentioned below:

T. Saharia, J. Bauri and C. Bhagabati have conducted research on an electric wheelchair that is navigated using a joystick. Arduino receives information about the joystick's movement and responds accordingly. However, not all physically challenged people can operate their wheelchair with the help of a joystick. The persons who have difficulty in moving the right hand where the joystick is connected, they cannot use it. Also, this wheelchair is costly, so everyone cannot afford it.

Ayush pandey et al from St Aloysius Institute of Technology proposed a voice controlled wheelchair by the project name "Smart Electronic Wheelchair". In this type of wheelchair, user uses voice command like go, front, back, left, right and the module detects the sound and works accordingly. But this is not much efficient because it cannot recognise voice every time properly, and it does not work in noisy environment.

Devaraj A/L Kaliannan et al from Politeknik Malaysia proposed some advanced approach of voice modulation in the paper titled "Smart Wheelchair". They added controlling wheelchair using mobile Bluetooth connection as well as voice modulation. This technique also has similar kind of drawback like less efficiency in noisy environment.

In a research of "Smart Wheel Chair" by Sabin Adhikari et. al., they have proposed an idea of wheelchair based on hand gesture as well as voice-controlled navigation, and also it includes obstacle detection system. But this system is wireless in one part, so it may not work properly as there may be some interference and there may not be proper communication between receiver and transmitter and also speech synthesizer does not work properly in noisy environment.

Femy John et al in "Gesture Controlled Wheelchair" published in Journals of Embedded Systems and Processing also prescribed similar types of approach to make smart wheelchair.

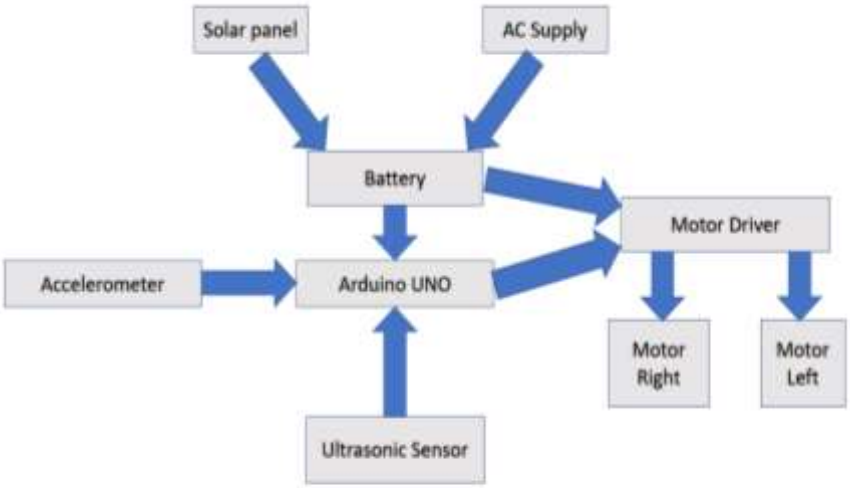
Another proposed idea is to use tongue gestures to operate the wheelchair. This tongue gesture controlled wheelchair was proposed by Xueliang Huo, Jia Wang, and Maysam Ghovanloo. In this type of wheelchair, magnetic sensors such as ferromagnetic material is used for detecting tongue motion. The person will need to pierce his or her tongue to attach the sensor. Also, at the time of MRI or any such type of tests, the material should be removed. This is huge discomfort for the disabled person.

Another new technology Brain Computer Interface (BCI) has been applied to the wheelchair by Nikhil Shinde and Kiran George. This design uses mental concentration and eye blink of the disabled person using BCI headset and other electronic components. But the drawback is that the brain impulse and signals differ from person to person and it needs to be calibrated for different users.

By reviewing some more articles along with these, we have come to a conclusion to make more reliable, cheaper and faster response wheelchair. We have added some more features in a single wheelchair which will help the user to have more comfort than the other wheelchairs.

Methodology:

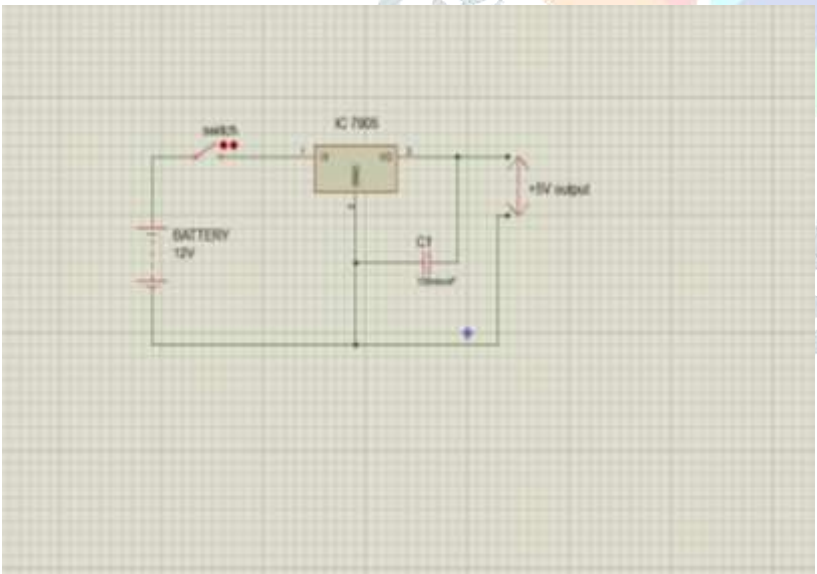
Firstly, a block diagram of central components is shown below to understand the design properly.



Block diagram of Smart Wheelchair main design

At first, a 12V battery is taken, and it needs to convert this 12V into 5V because this 5V is required for the Vcc pins of the Arduino, and other ICs and components. So, an IC7805 is taken to convert that 12V into 5V. The IC7805's first and second pins which are input and ground respectively are linked to the battery's positive and negative terminals. An SPST switch is used to power on and off the circuit before attaching the positive terminal of the battery with IC7805. A 12 volt 26 Ah battery has been chosen as the power source. Between the IC7805's output and ground, a 100 microFarad capacitor is placed.

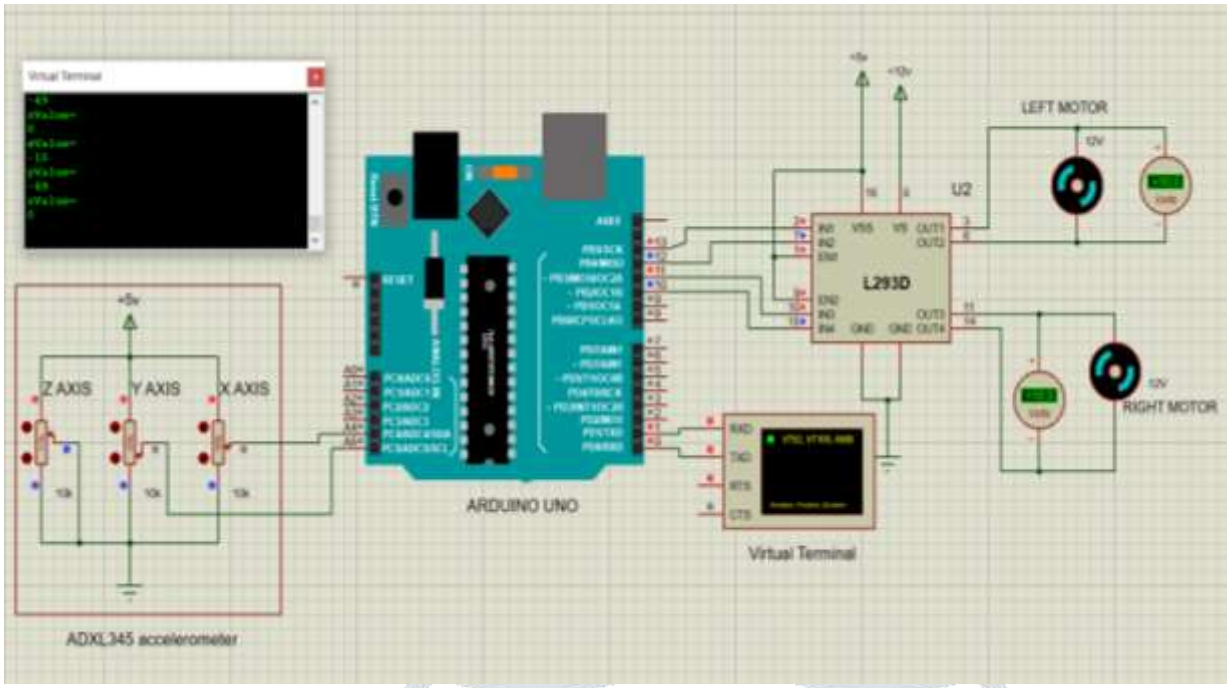
The battery is charged using solar panel mounted over the wheelchair as well as using the AC supply. Both the options for charging is provided because every time it is not possible that there is sunlight and user can charge it. The solar panel has a capacity of 40 watts and in powered by 12 volts. A single MPPT charge controller is attached to control and monitor the solar charging device. MPPT controller has been chosen over PWM controller because its efficiency is about 95% but PWM controller has efficiency of 75%.



pic: 12V battery and voltage regulator connection

Voltage and ground are appropriately connected for Arduino connection. Then the reset pin of the Arduino is connected with the output of the 7805 IC with a 10K ohm resistor in between them. Output of IC7805 is connected with Vcc of ADXL335 accelerometer and Vcc and enable pins of the L293D motor driver IC. The grounds of accelerometer and motor driver IC are also connected to the battery's ground terminal. The accelerometer's SDA and SCL pins which works as x and y axis, are connected to the Arduino's A4 and A5 pins, respectively. These SDA and SCL pins serve as the accelerometer's X and Y axis navigation outputs. Since there is nothing to do with z axis rotation in this project, the accelerometer's SDO pin is connected to ground. Also, 5V output from 7805 is connected with the SDA and SCL of the ADXL335 with 10K ohm resistors connected in between them.

Here in the simulation part, the ADXL335 accelerometer is designed using three potentiometers which acts as X axis, Y axis and Z axis respectively. The first potentiometer is connected with the SDA pin of Arduino which works as x axis navigation. The y axis navigation is controlled by the second potentiometer, which is coupled to the Arduino's SCL pin. The third potentiometer is connected the ground because we don't need z axis navigation to control the wheelchair.

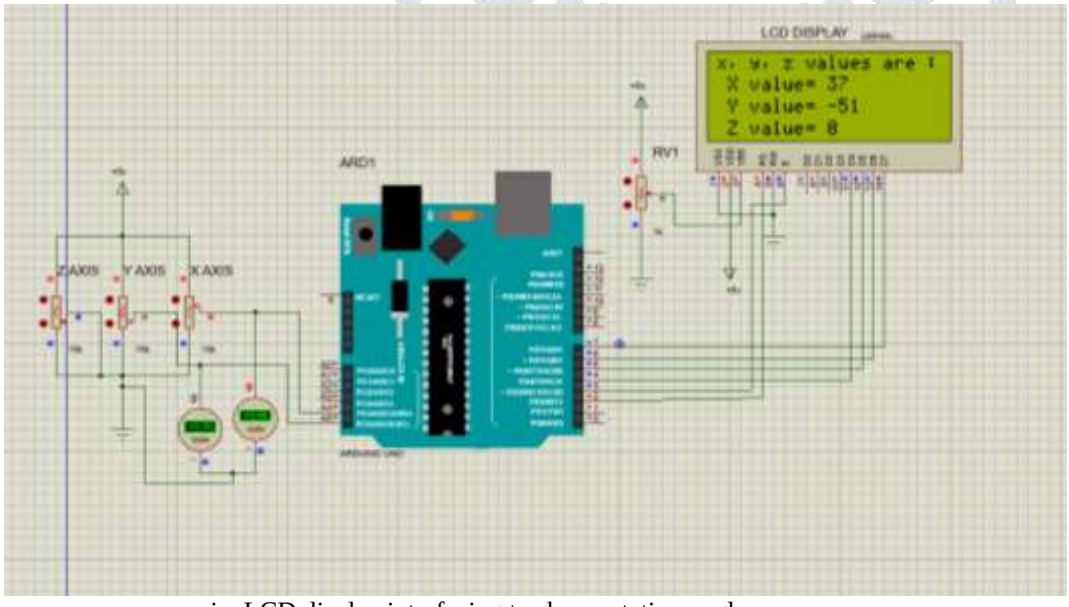


pic: hand gesture controlling unit main diagram

The Arduino's digital pins 13, 12, 11 and 10 are connected to the L293D motor driver's input 1, input 2, input 3 and input 4 respectively. The left DC motor is connected between output 1 and 2 of the motor driver and the right DC motor is connected between output 3 and 4 of the L293D IC.

When hand moves in any x or y direction, the accelerometer senses the movement and sends the signal to the Arduino UNO through the SDA and SCL pins. Then the analog signal is converted to degree angle inside the Arduino and the data is compared with the preinstalled data which is uploaded into the Arduino with the angles and other values in the coding. If the data is matched with the preloaded values, then it gives command to the motor driver IC and the wheels move accordingly.

Algorithm: the algorithm of moving the wheelchair using hand gesture is designed in a simple way which is easy to understand by all types of users. The direction and position of hand gesture determines the wheelchair's mobility in certain direction. The position of the hand is detected by the accelerometer ADXL335 which is attached to the hand using a gloves and it detects the position as analog signal which ranges between 0 to 1023. After detecting the analog signal, it is sent to the Arduino UNO and it converts the analog signal range to degree value ranges from -90 to +90. It's also possible to map it as a PWM signal with a 0 to 255 range. By ranging it in degree, it is easier to calculate and detect the angle rotation by which the motor starts to run in a certain direction. One LCD display is also connected to the Arduino in which the x and y axis rotation values from accelerometer is shown. It will be easier for the user to check the angles by which the wheelchair runs in certain direction.



pic: LCD display interfacing to show rotation angle

When the user tilts his or her hand in forward direction more than 25 degree, then both the motors connected to the wheels moves clockwise, which results in forward direction. When the user tilts hand in backward direction more than 25 degree, both the motors run anticlockwise resulting backward movement of the wheelchair. When the user tilts hand in right direction more than 30, then right motor stops and left motor runs clockwise which results in right movement of the wheelchair. When the user tilts his or her hand more than 30 degree to the left, the left side motor stops and the right side motor rotates clockwise causing the wheelchair to turn left side. If hand is placed in normal position or tilted a little bit which is not in the range of movement angles,

then both the motors subsequently stop rotating, and the wheelchair comes to a halt. This allows a user to relax his or her hand in little bit tilted position which does not run the wheelchair. One virtual terminal is linked to the Arduino's RX and TX pins in this simulation, allowing us to examine the x and y axis rotation values in degrees.

Important specifications:

Components	**Specifications**
Battery	12V, 26Ah
Solar panel	12V, 40 watt polycrystalline
Motor	12V, 60 RPM DC geared motor (BLDC)

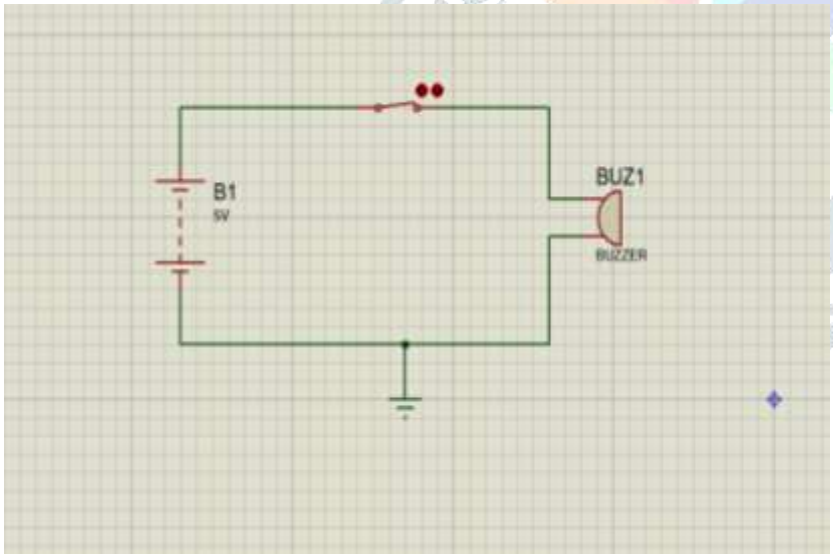
The minimum and maximum angle rotation of the accelerometer by which the wheelchair moves to the certain directions are shown below:

Direction	**Angle range**
Forward	y < -25
Backward	y > +25
Left	x > 30
Right	x <- 30

Table: reference angle of x and y axis direction for different movements

Alarm system and lighting system:

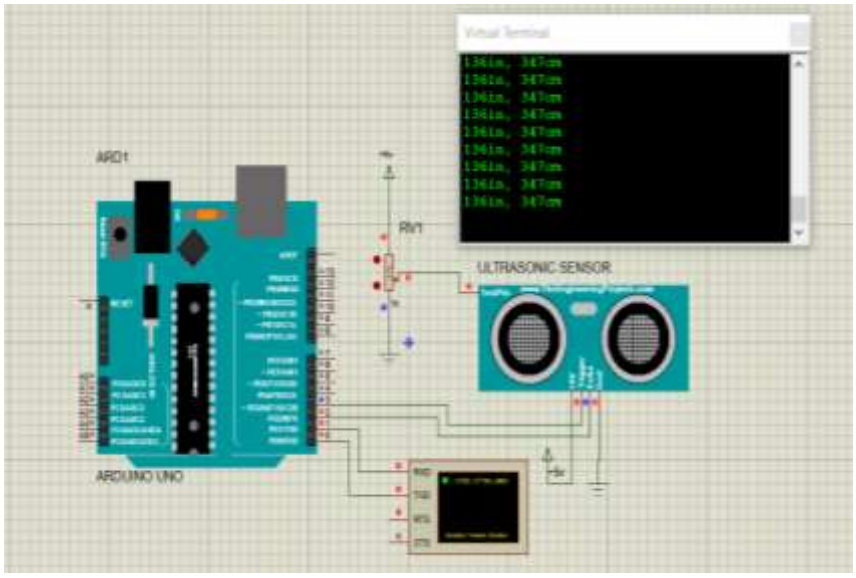
For the alarm system, a buzzer is used which is typically seen in alarm devices, timers etc. Buzzer is a very small and efficient component to use in this wheelchair as an emergency device. It takes very less space and works on lower voltage of 5-6 Volts. The connection of this buzzer is simple. It takes the voltage of 5V from the output of the IC 7805 and connects it to ground. One switch is connected in series so that the alarm can be enabled by the user when he or she needs someone's help. If the user of the wheelchair is in any serious situation or needs attention of the caretaker or relatives, then he or she can activate the buzzer using switch and it will produce sound. The caregiver can attend to the individual as soon as possible. The simple buzzer circuit diagram is displayed below:



pic: emergency alarm circuit

Ultrasonic sensor HC-SR04 is used for object detection system. It has 2 cm to 400 cm measurement function and its accuracy is about 3 mm. The distance is calculated as the formula is:

Distance= {high level time * speed of sound(340m/s)} / 2, where the high level time is the total time taken by IO trigger high pulse from transmission to reception. This IC works on 5V DC supply. It has trigger pulse input and echo pulse output from which the pulse signal is transmitted and is received respectively. It takes 15mA of current and its working frequency is 40Hz.



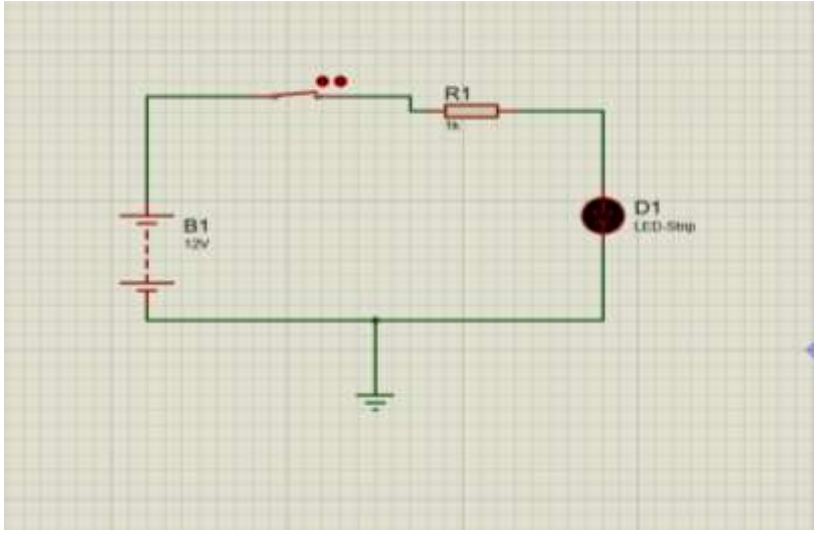
pic: HC-SR04 interfacing

To start the ranging, one 10 µs pulse to the trigger input and the
n the SR04 will automatically send total 8 ultrasound of frequency 40 kHz. If any object comes in between the range of the sensor, it will receive the pulse through echo and the distance is calculated using the above mentioned formula.

In case the user of the wheelchair is in any darker place or electricity is not there at night, he/she can switch on the LED lights connected to the wheelchair using a manual switch connected near the hand rest. A 1 meter long SMD (Surface Mounted Device) LED strip in the front and side part of the wheelchair is connected. SMD LED have much more lumen per watt value and it is cheaper and easy to install in almost everywhere. This will allow enough light to illuminate the surrounding in darker areas.

pic: Bright SMD LED

The SMD LED strip which is used here has 60 LEDs per meter length and it operates on 12V DC power supply which will be taken from the 12V battery. It needs 1 meter length of the LED strip which is attached along the peripheral of the wheelchair in lower side of it. For one meter length of this LED strip, it consumes 14.4W and takes 2A current. Its power consumption is lesser than other LEDs and lifespan is about 50000 hours which is much more. The circuit is shown below:



pic: SMD LED connection

Price estimation:

in modern world of technology, there are continuous research going on for smart wheelchair on its cost, special features and other comforts. But commercially, its cost is much higher. Also, in the online search engines, there are mostly manual wheelchair or the wheelchair controlled using joystick which is electrical wheelchair. The estimated total cost of hardware components to build the wheelchair is below Rs 18000 (INR). The following is a cost estimate for our suggested wheelchair system:

Components	Cost (in INR)
Battery	2500
Solar panel	2000
DC motor	4000
Wheelchair configuration	6000
Accelerometer	140
L293D IC	30
Arduino UNO	750
IC 7805	10
LCD Display	500
SMD LED strip	100
Buzzer	40
Wire	200
Other costs	1000
Total	17270

table: cost estimation of different components

Future scope:

This wheelchair has been made using hand gesture with some other features added to it. But there is always a scope of improvement to the already improved idea or technology. As world of technology is reviewing everything and there is continuous research going on, there is much more thing to be improved further and much more features can be added to the smart wheelchair. Joystick controlling and brain information controlling can be added to it, so that there will be much more option for a disabled person to choose among them whichever controlling unit is suitable at any point of time. There can be many sensors and devices attached to that the wheelchair is controlled remotely, but it will eventually increase the cost. Accurate frequency and accurate receiver and transmitter can reduce the external interference when it is designed wirelessly. The accelerometer which we have used here is connected with a hand gloves, but it can also be attached to the head of the person. The direction and control of the wheelchair will be determined by the person's head movement in this case. Various emergency features like GPS location tracking system and GSM system can be added to the wheelchair which will improve the emergency feature of the wheelchair. For fully paralyzed persons, there can have much more security and improved features like remote controlling.

Conclusion:

we have proposed this smart wheelchair based on hand gesture and solar powered charging to help disabled people having a comfortable feeling to use this wheelchair. They should not regard their handicap as a curse to them. Also, one of the main objectives of this project is to make it cost effective so that it can be accessible to almost all kind of people. Keeping in mind all the aspects, we have finally designed this smart wheelchair with simplified algorithms. This will allow people to handle this wheelchair very easily. The maintenance will be also easy to understand. Different components has been tested throughout the project work and the best suitable components have been taken to use. These experiments and hard works have given us a lot of experience and extra knowledge which will be very effective towards the future.

Reference:

[1]"Joystick Controlled Wheelchair" published on International Research Journal of Engineering and Technology, 2017 by T. Saharia et al

[2]"Smart Wheelchair" by Sabin Adhikari et al from Kathmandu Engineering College

[3]"A Study on Low Cost Solar Powered Wheel Chair for Disabled People of Bangladesh" by Syed Nazmus Sakib et al, 2015

[4]https://innovate.mygov.in/wp-content/uploads/2018/08/mygov1534052685344389.pdf

[5]http://repository.psa.edu.my/bitstream/123456789/3190/1/WHEELCHAIR.pdf

[6]"Wireless control of powered wheelchairs with tongue motion using tongue drive assistive technology" published in 30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (2008)

[7]"Brain-controlled driving aid for electric wheelchairs" by Nikhil Shinde and Kiran George, published on 13th International Conference on Wearable and Implantable Body Sensor Networks (BSN), San Francisco, 2016

[8]"Smart Wheel chair" by Sarmad Hameed et al from Shaheed Zulfiqar Ali Bhutto Institute of Science and Technology, Pakistan, published on Annals of Robotics and Automation, 2021

[9]"Solar Based Smart Wheelchair with Stretcher Mechanism" by Mayur Waghea et al published on International Conference on Communication and Information Processing, 2020

[10]"A Study on Smart Wheelchair System" by Mohammed Hayyan Alsibai and Sulastri Abdul Manap which was published on International Journal of Engineering Technology and sciences, 2015

[11]"Head Gesture Controlled Wheelchair for Quadriplegic Patients" by Jigmee Wangchuk Machangpaa , Tejbanta Singh Chingtham, which was published on International Conference on Computational Intelligence and Data Science (ICCIDS) 2018