



Smart Wheelchair-An Effective Transport for Handicapped and Aged Citizens

R. Venkatesan^{1,*}, Gokul Santhosh Y.², Sathya Preiya V.², V. D. Ashok Kumar³

¹Karunya Institute of Technology and Sciences, Coimbatore, 641114, India

²Panimalar Engineering College, Anna University, Chennai, 600123, India

³St.Peter's University, Chennai,600054, India

Emails: rlvenkei_2000@karunya.edu; gokulsanthosh@gmail.com; sathyapreiya@yahoo.com; akumar2879@gmail.com

Abstract

A wheelchair is a chair fitted with wheels. A survey says that around 132 million people use wheelchair around the world. But majority of them are dependent on others for their movements, especially people with some disorders. This dependent nature had hindered them from succeeding. To overcome this problem, they can use smart wheelchair, which is auto movable based on head tilt movements. It collects information from the patient through in built sensors and enhances the seating position. It is also designed with obstacle and fall detection system which reduces the chance of collision during their journey. This makes a physically challenged or dependent person as physically independent person. This wheelchair can also be used by aged people who lack motor skills. In this paper, we can review the art of smart wheelchair and the features of it.

keywords: Head tilt movements; In built sensors; Obstacle and fall detection system

1 Introduction

The chief motive of any individual is to live independent and privileged in the society. Yet, a handful amount of people in our society can't live independent since they get affected with severe diseases like paralysis, quadriplegia etc., and lose their motor abilities. A census says that around 10%-20% of the handicapped people in the world require wheelchair for their movement. To meet the needs of these 10%-20% of the population, there are tireless work undertaken by several medical and research organizations. Manual wheelchairs are the wheelchairs that are used currently to support the disabled people in their movement. But the disadvantage is that it can't be used by people who are affected with some severe diseases like tetraplegia etc., as these patients require some additional support for their movement. The non-availability of this additional assistance had always obstructed them from pursuing various activities and succeeding in life.

To overcome these shortcomings, we had proposed a smart wheelchair. This wheelchair could help all the patients who lack motor abilities regardless of what kind of diseases

Doi : <https://doi.org/10.54216/JCHCI.040201>

Received: March 19, 2022 Accepted: June 19, 2022

they are affected with. This paper describes about a smart wheelchair which is driven based on the head movements of the user. In this wheelchair, we add on a few hardware and software components to the standard manually driven wheelchair to make it self-driven. The main motive behind this wheelchair is to make the handicapped people live independent, to succeed in their life and also to motivate them to be an asset to the nation in various sectors. This system has a lot of significance as it enhances the living standard of a group of people by making them self-dependent. This paper comprises of four sections – 2. Related works, 3. Proposed system, 4. Conclusion. Section 2 describes about the views and ideas of various researches regarding smart wheelchair. Section 3 proposes the design of smart wheelchair system and the precautionary measures that it provides the user. Section 4 talks about the advantages and disadvantages of the smart wheelchair.

2 Related Works

Mohd. Razali Md Tomari and et.al [1] proposes a semi-independent manipulate wheelchair system with a numerous input interface to resource the mobility of people with excessive motor impairment. In this wheelchair, the user is accountable for heading the wheelchair into his/her desired directions while the computer will take over the duties for navigating and keeping off the feasible threat. In such a setup, the user can sense secure while steering the wheelchair. Narender Kumar and Vidhi [2] describes about the working of a wheelchair based on accelerometer. In this wheelchair the AI technology is employed for its functioning. It also includes two circuits namely transmitter and receiver circuit. The transmitter circuit is made up of three axis accelerometer and the receiver circuit is made up of a small wheelchair with RF. It is driven based on the head gesture of the user that is detected by the accelerometer.

Amiekl Hartman and Vidya K. Nandikolla [3] demonstrate the layout and overall performance of the interface among sensory comments and the computer-controlled system in smart wheelchair. Here, a user interface is developed in such a manner that it runs on a single client computer terminal in the network. Its cluster format is designed in order that three computers are deputed for perception and one computer for cognition. Jesse Leamen and et.al [4] had put forward a smart wheelchair system with a multimode interface and sensors that are ascendable on almost any PW. It consists of a HD camera and 3D scanner to accumulate scientific quantity observations. It also has LEDs that elucidate the darkness from the lane ahead. All the above features are achieved without expanding the PWs footprint or height which makes this wheelchair stand apart from the rest.

Siti Nur Suhaila Mirin and et.al [5] narrates about the development of a wheelchair system centered on the voice and touch of the user through an embedded system. An android application is developed and installed on the android smartphone. The commands stated by the user are executed by an Arduino Uno. It also comprises of MD30C and HCO5 Bluetooth module system. This wheelchair has an edge over other wheelchairs as it saves time and energy of the user. Akira Murai and et.al [6] develops a new functional voice activated wheelchair. It ensures the safety of the user since it consists of a collision avoidance system which avoids the obstacle by using the information detected by the sensor. It possesses three autonomous movements: stop, avoidance and declaration. Popescu Marius and Naaji Antoanela [7] present a faraway administered system installed at the seats that are utilized by the individuals with locomotor disabilities. This system that is used to guide or circulate a wheelchair on the ground incorporates numerous practical blocks that are sublime as structure, yet interdependent. The motion area is monitored with the aid of a camcorder integrated to the microcontroller.

Bader Dakhilallah Samran Alrashdi and et.al [8] utters about how to layout an electrically energized wheelchair with state-of-the-art technology to control the movements without straining its user. It is manufactured with two dc motors, each of 24V, 250 watts, an electrically chargeable battery, and two driving wheels coupled to the motor shaft through a 28:1 gear system and two stabilizing freewheels. Its hardware is manufactured with the help of an implanted system based on Arduino Uno hinged on microcontroller, user interface module. Here, a conventional joystick and popular smartphone are employed for the navigation of the wheelchair. Amit Ranjan Trivedi and et.al [9] sketches a smart wheelchair using hardware and open-source software which are economical. Here, the keyboard, webcam and a microphone are used as the three interfaces to control the wheelchair. The head movements of the user are detected by the webcam. The wheelchair could also be controlled by the user's voice with the help of the microphone attached to the wheelchair. The user can operate this wheelchair in three modes: manual, automatic and tele-operation modes. The keyboard is used to operate the wheelchair through tele operation methods. Hence this wheelchair could be used by people of all ages and all disabilities. Kazi Ehsanul Karim [10] designs an automated wheelchair for the physically disabled people of both developed and developing countries. It also regulates the seat of the wheelchair vertically in line with their needs. Here, A microcontroller based embedded system is designed to manipulate the wheelchair movement comfortably without any difficulty in conjunction with the vertical movements of the seat. The feasibility of this layout is also demonstrated through simulation works.

Aktar and et.al [11] confers the design of a wheelchair which is directed by the voice of the user. The voice of the user is controlled by the voice recognition system. The wheelchair has a GPS which sends the location of the chair to the mobile applications through Firebase. Since the wheelchair relates HMI with the detection of obstacles and the navigation systems, it is considered to be a hybrid system. Kathirvelan and et.al [12] develops a wheelchair that is controlled through LabVIEW-TM and FPGA which has been blended with ultrasonic sensors for obstacle detection. The role of LabVIEW-TM is to process the voice commands and the FPGA is responsible for controlling and monitoring system modules. The hallmark of this wheelchair is its low cost.

3 Proposed System

This system has an accelerometer which detects the head motion. The signal which is generated by accelerometer, are converted into digital signals through MCP3008. Subsequently raspberry pi interprets these signals and allows the wheelchair to move as shown fig 1.

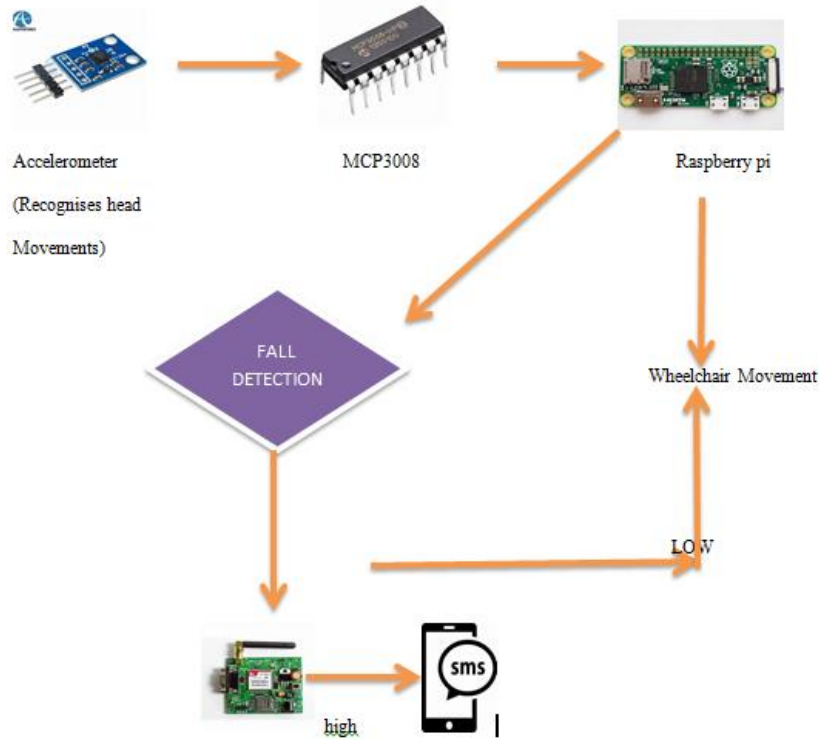


Figure 1: Architecture of proposed system

3.1 Fall Detection System

From the fig 2.,The inclination angle at which the patient could travel safely is at 20 degree. It is a system present in the wheelchair to ensure the safety of the user. There are sensors present on the seat of the wheelchair, which detects the fall percentage and also stores the information (i.e. reason why the user is using the wheelchair) about the user. If the fall percentage is low, it immediately changes the seating posture of the user based on the information stored. If the fall percentage is high, it sends a signal to GSM via USB to TTL to send a sms to the relatives and friends of the user.

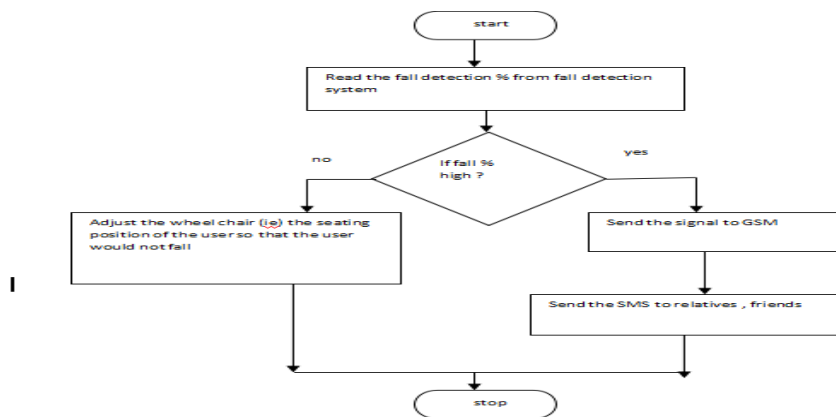


Figure 2: Flowchart for fall detection system

3.2 Obstacle Detection System

If it doesn't detect any obstacle, it allows the movement of the wheelchair. If it detects any small obstacle such as speed breakers, it sends information to the raspberry pi to slow down the wheelchair or rather if it detects obstacles like small stones; it gives information to the raspberry pi to divert the direction of the wheelchair as shown in fig

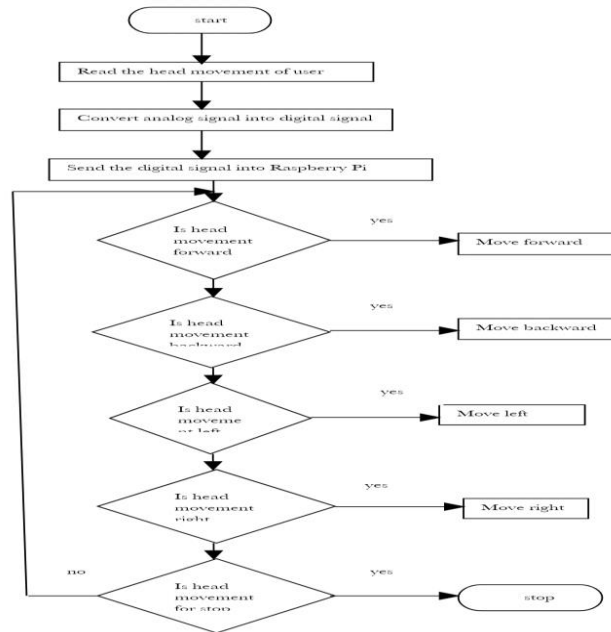


Figure 3: Flowchart for wheelchair processing

Working principle of wheel chair also clearly explained in the algorithm 2 given below.

ALGORITHM 1: WORKING PRINCIPLE OF WHEEL CHAIR
 INPUT: Head movements of the user
 OUTPUT: Analog signals
BEGIN
 Read the input head movements of the user
 Convert the analog signals into digital signals
 While(Head movements==forward):
 Wheelchair moves forward
 Do{ {Head movements==backward}:
 Wheelchair moves backward
 {Head movements==left}:
 Wheelchair moves left
 {Head movements==right}:
 Wheelchair moves right
 }
 Stop the wheelchair
END

If it detects some large obstacles such as walls, it stops the wheelchair and sends the signal to the GSM which sends an alert SMS about the location of the wheelchair to the relatives and friends of the user. As shown in the fig.4 and 5.

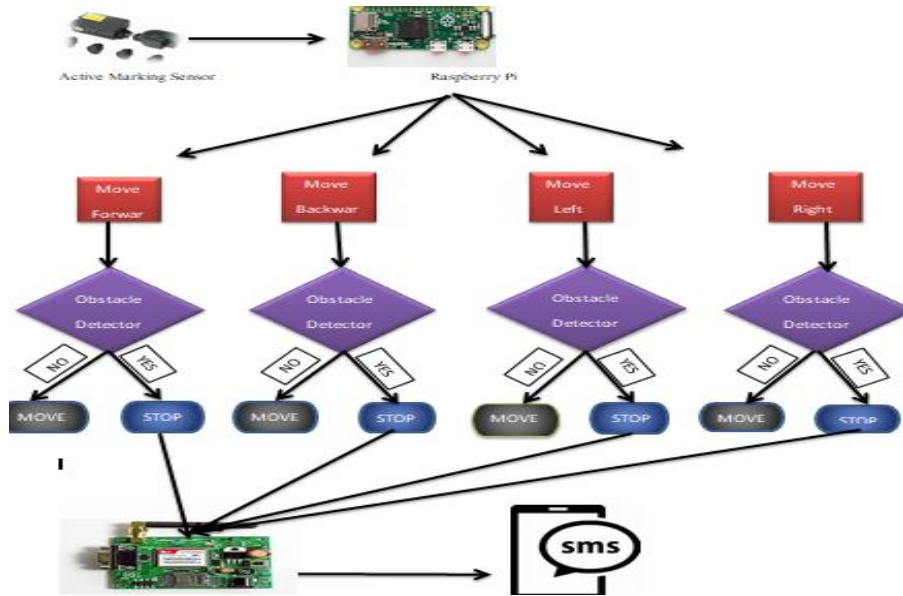


Figure4: Overall Architecture of Obstacle Detection

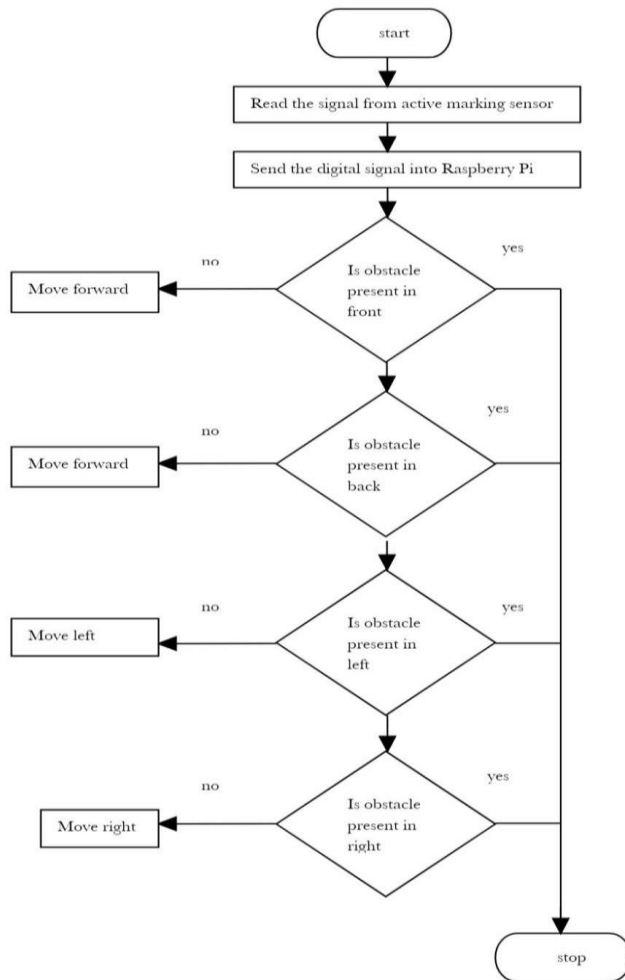


Figure 5: Flowchart for obstacle detection system

The working principle of obstacle detection is clearly explained in the algorithm 2 given below

ALGORITHM 2: WORKING PRINCIPLE OF OBSTACLE DETECTON SYSTEM

INPUT: Signals from active marking sensor

BEGIN

Read the signals detected by the active marking sensor

Send these signals to Raspberry Pi

Extract

If(signals|=obstacle):

Move Forward

Elif(signals|=obstacle):

Move backward

Elif(signals|=obstacle):

Move left

Elif(signals|=obstacle):

Move right

Else(signals=obstacle):

Stop

END

The above system is classified into various modules:

- Software used
- Accelerometer
- MCP3008
- Raspberry pi
- DC Motors and Batteries
- GSM
- Active marking sensor and USB to TTL

3.3 Software Used:

- Python software
- Putty application

We use python software since raspberry pi is used in the circuit of the wheelchair.

Python is selected as the main language for the functioning of raspberry pi because of the power, versatility and the practicality of the language. Hence python comes preinstalled in the raspberry pi; so that the designer or manufacturer of the wheelchair will be ready to start from the get go.

```

wheelchairFinal.py
import RPi.GPIO as GPIO
import time
import serial
import sysdev
import sys

pin = "101027118"
msg = "Obstacle Found"

GPIO.setmode(GPIO.BOARD) # for GPIO.setmode(GPIO.BCM)
# GPIO.setmode(GPIO.BCM)
GPIO_TRIGGER = 12
GPIO_ECHO = 11

# MCP3008 initialization and accelerometer control (ADXL345)
MCP = MCP3008(i2c=bus1)
MCP.open(I2C)
MCP.max_speed_hz=5000
MCP._i2c

# set up GPIO pins for (obstacle) sensor
GPIO.setup(GPIO_TRIGGER, GPIO.OUT)
GPIO.setup(GPIO_ECHO, GPIO.IN)

```

Figure 6: Example of python program used in smart wheelchair

From fig 6., In order to have a wireless connectivity we use putty application. Putty is an unfastened and open- supply terminal emulator, serial console and community record switch applications. It helps numerous community together with SCP, SSH, Telnet, login and uncooked socket connection.

3.4 Accelerometer:

It is a tool that measures proper acceleration. Here, it is used to detect head motions in all the directions (i. e) front, back, and left, right. It has three axes: X, Y and Z axis

X axis – Front and back movements.

Y axis - Front left and front right movement.

Z axis - Back left and back right movements.

It detects the tilt of the head in any axis and generates the analog signal.

3.5 MCP3008:

It is an eight channel ten bit ADC IC, so it can compute eight unique analog voltages. It acts as an ADC (Analog to Digital converter) to process accelerometer signals (i. e) converts analog signal received from accelerometer to digital signals. These digital signals are sent to the raspberry pi.

3.6 Raspberry Pi:

It is a low cost open hardware software computer. It acts as the heart of this entire wheelchair. It allows computing and human machine interaction. It runs python programs on Linux where it can be associated with primary board. It has its own operation system. The Raspberry pi detects these digital signals from MCP3008 and allows the movement of the wheelchair.

3.7 Dc Motors and Batteries:

A dc motor is a rotatory motor that convert direct current electric energy into mechanical energy. Here we use two dc motors and the drive to these motors are through L293D, which is a dual H- bridge motor driver integrated circuit. It permits the dc motor to drive on any direction. This IC is structured with 16 pins which are used to direct a set of two dc motors simultaneously in any direction. The two dc motors are responsible for hastening the wheelchair. The wheels of the wheelchair are commanded by stepper motor. Two Exide power safe plus batteries of 12V with 26AH are used to control the dc motors. IT-PB11K of 11000mAH power bank is used to operate the raspberry pi. The average speed of the wheelchair is close to 3.0-3.2 kmph as shown in below fig 7.

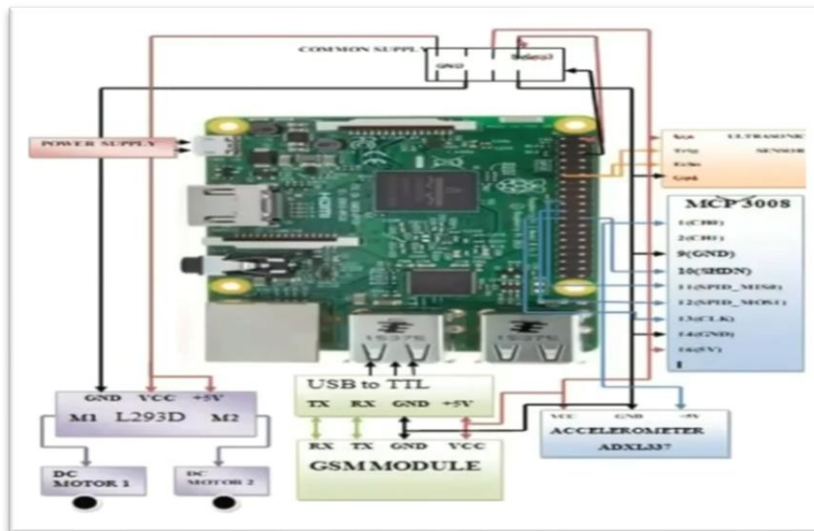


Figure 7: Wheelchair Circuit Design

3.8 GSM:

Global System for Mobile Communications (GSM) is a standard developed to outline the protocols for second generation (2G) exploited by virtual gadgets. It gets the information from the fall detection and obstacle detection systems and sends alert message to the relatives and parents of the user through USB to TTL.

3.9 Active Marking Sensor And Usb To Ttl:

This sensor is present at the bottom of the wheelchair, which detects both small obstacles such as speed breakers and large obstacles such as some walls and vehicles. It ensures the safety of the user. USB to TTL is a USB serial port converter made up of two ends: USB connector and four wires made to attach to terminal posts. The unit is powered from the USB port and requires no external power. It acts as an interface between raspberry pi and GSM. The gear ratio of the manual wheelchair and a smart wheelchair is in the ratio of 1:5

4 Conclusion

As we all know the wheelchairs that are currently used are manually driven which has created an over dependence of the user on others. To overcome this problem we had proposed a system named smart wheelchair which is self-driven centered on the head movements of the user. This wheelchair could be used by senior citizens as well as patients of all ages affected with paralysis, amputees etc. It increases the employment of the handicapped people by making them self-dependent and also affords self-confidence to the disabled citizens. Any technology has its own advantages and disadvantages in such regards the smart wheelchair has its own disadvantages. These wheelchairs are cost prohibitive as they can't be bought by people who are economically backward and they can't be transported easily because they are larger in size. These wheelchairs also need a regular maintenance which is an arduous task. Despite all these disadvantages,

there could be a huge demand for this wheelchair in near future. This wheelchair can be made more effective by making it cost efficient by adding solar charged battery rather than using electrically charged batteries and an intelligent tongue and voice controller can also be added to the wheelchair.

References

- 1) Mohd Razali Md Tomari, Yoshinori Kobayashi, Yoshinori Kuno, "Development of smart wheelchair system for a User with Severe Motor Impairment" International Symposium on Robotica and Intelligent Sensors 2012(IRIS 201 Control)
- 2) Narender Kumar, Vidhi, "Two Dimension Head Movements Based Smart Wheelchair Using Accelerometer: Head Motion can Control Wheelchair" International Journal of Scientific Research and Research, Volume 2 Issue 7, pp: 9-11, July 2014.
- 3) Amiekl Hartman and Vidya K. Nandikolla, "Human-Machine Interface for a Smart Wheelchair" Hindawi Journal of Robotics Volume 2019. (<https://doi.org/10.1155/2019/4837058>)
- 4) Jesse Leamen, Hung M. La and Luan Nguyen, "Development of Smart Wheelchair for People with Disabilities" 2016 IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems (MFI 2016) Kongresshaus Baden-Baden, Germany
- 5) Siti Nur Suhaila Mirin, Khalil Azha Mohd Anuar, Chai Pui Yook, "Smart wheelchair using android smartphone for physically disabled people" International Journal of Engineering and Technology, vol.7, no. 2 , pp: 453-457, 2018.
- 6) Akira Murai, Masaharu Mizuguchi, Takeshi Saitoh, Tomoyuki Osaki and Ryoosuke Konishi, "Elevator Available Voice Activated Wheelchair" 18th IEEE International Symposium on Robot and Human Interactive Communication Toyama, Japan, 2009. (DOI: 10.1109/ROMAN.2009.5326329) .
- 7) Popescu M., Naaji A. (2020) Intelligent Image Analysis System for Position Control of People with Locomotor Disabilities. In: Hemanth D. (eds) Human Behaviour Analysis Using Intelligent Systems. Learning and Analytics in Intelligent Systems, vol 6. Springer, Cham. https://doi.org/10.1007/978-3-030-35139-7_5
- 8) Bader Dakhilallah Samran Alrashdi, K. Prahlad Rao and Naif D. Alotaibi, "Smart Navigation and Control System for Electric Wheelchair" American Journal of Engineering Research (AJER) , Volume- 8, Issue- 8, pp-90-94, 2019.
- 9) Amit Ranjan Trivedi, Abhash Kumar Singh, Sundara Tejaswi Digumarti, Deepak Fulwani, Swagat Kumar, "Design and Implementation of a Smart Wheelchair" Proceedings of Conference on Advances in Robotics, Pages 1–6, 2013. (<https://doi.org/10.1145/2506095.2506140>)
- 10) Kazi Ehsanul Karim, Hasnayan Ahmed, Helal-An-Nahiyan Nahiyen, "Design and Simulation of an Automated Wheelchair with Vertically Adjustable Seat" 3rd International Conference on Mechanical Industrial and Energy Engineering (ICMIEE) , volume 3, DOI: 10.13140/RG.2.1.2258.2882

- 11) Aktar N, Jaharr L, Lala B, “Voice Recognition based Intelligent Wheelchair and GPS Tracking System “ In Proceedings of the 2nd International Conference on Electrical, Computer and Communication Engineering (ECCE 2019) Cox’ s Bazar, Bangladesh, 7-9 February 2019; pp.7-9.
- 12) Kathirvelan J, Anilkumar R, Alex Z, Fazul A,” Development of low cost automatic wheelchair controlled by oral commands using standalone controlling system” In Proceedings of the 2012 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC 2012), Coimbatore, India 18-20 December 2012; pp.1-4
- 13) V.D.Ambeth Kumar et.al. , “A Survey on Face Recognition in Video Surveillance,” Lecturer Notes on Computational and Mechanism, Vol. 30, pp: 699-708, 2019
- 14) V.D.Ambeth Kumar, , “Precautionary measures for accidents due to mobile phone using IOT”, Clinical eHealth, Volume 1, Issue 1, March 2018, Pages 30-35.
- 15) K. Nanagasabapathy; G. Harish; O. I. Allen Sebastian; N. Sowrabh Chandra; V. D. Ambeth Kumar,” Validation system using smartphone luminescence”, IEEE International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICT), Pages: 235 – 239, 2017. DOI: 10.1109/ICICT1.2017.8342566
- 16) V. D. Ambeth Kumaret.al , “ Cloud enabled media streaming using Amazon Web Services”, IEEE International Conference on Smart Technologies and Management for Computing, Communication, Controls, Energy and Materials, Pages: 195 – 198, 2-4 Aug. 2017, India (DOI: 10.1109/icstm.2017.8089150)
- 17) B. Aravindh; V.D.Ambeth Kumar; G. Harish; V. Siddarth, “ A novel graphical authentication system for secure banking systems”, IEEE (ICSTM), Pages: 177 – 183, 2-4 Aug. 2017, DOI: 10.1109/ICSTM.2017.8089147
- 18) V.D.Ambeth Kumar et.al., “An Efficient Security System for Data base Management from Illegal Access, IEEE International Conference on Wireless Communications, Signal Processing and Networking, 2016. DOI: 10.1109/WISPNET.2016.7566252
- 19) R. Subha Shini et.al., “ Recurrent Neural Network based Text Summarization Techniques by Word Sequence Generation”,IEEE International Conference on Inventive Computation Technologies (ICICT), 2021, DOI: 10.1109/ICICT50816.2021.9358764.