Smart Wheelchair with SMS Alert and Safety Features

Pratiksha Karn
Department of Computer and Electronics , Communication & Information
Kathford International college of engineering and Management,Tribhuwan University
Balkumari, Lalitpur
karnprtksh11@gmail.com

Nisha Somai
Department of Computer and Electronics , Communication & Information
Kathford International college of engineering and Management,Tribhuwan University
Balkumari, Lalitpur
asinmagar16@gmail.com

Ashish Kumar Das
Department of Computer and Electronics , Communication & Information
Kathford International college of engineering and Management,Tribhuwan University
Balkumari, Lalitpur
dasashishkr2017@gmail.com

Bikash Mallik
Department of Computer and Electronics , Communication & Information
Kathford International college of engineering and Management,Tribhuwan University
Balkumari, Lalitpur
bikashmallik49@gmail.com

Dipesh Silwal
Department of Computer and Electronics , Communication & Information
Kathford International college of engineering and Management,Tribhuwan University
Balkumari, Lalitpur
dipeshsilwal21@gmail.com

***Abstract*— Smart Wheelchair with SMS Alert and Safety Features is an electronic wheelchair, which has been designed to provide mobile independence with security to the differently abled people who suffer from various difficulties on movement in daily life even on using a manual wheelchair. To update it from manual to smart, RC remote has been used so that the wheelchair user can move on any direction just moving the stick of RC remote with one hand, reducing the need of manual force for moving the wheels. To control the system, ATmega328p microcontroller has been used with the added security features. The buzzer directly helps the user to be able to learn about any problem with the surrounding and provide instant aids. Similarly, accelerometer and ultrasonic sensors have been used for making the system safe and trustworthy. GSM module has been used to alert caretaker/family of wheelchair user. The system was well designed with SMS alert and safety features under low-cost.**

KEYWORDS: ***Smart, Differently Abled, Wheelchair, Mobile Independence, Accelerometer***

I. INTRODUCTION

Every human has right to independent movement. It is a simple statement, but has a great impact on the confidence and self-esteem of a differently abled person. Manual wheelchairs though provide independence in some cases of disability, not all the disabled are able to have movement manually driving the wheels. Thus, there is a strong requirement of electric wheelchairs. Smart Wheelchair with SMS Alert and Safety Features is an electronic wheelchair. The wheelchair consists of motors attached to wheels that can be controlled by a RC Remote thus providing automated movement without manual force. Once the system is switched on, a patient just needs to use his/her hands to move wherever they want. The wheelchair has some safety features such as obstacle detection by which a user gains the sense of self mobility with security. Similarly, the message alert feature helps a patient to alert his/her family.

To ensure the independence in mobility of locomotive disabled, this project is applicable. It reduces the effort for manual pushing of wheels as well as provides safety. It is seen effective for day-to-day movement of the disabled. This makes it more effective than the using of manual wheelchairs. For a developing nation like Nepal where more than 36 % of disabled have lost their mobility, this system is very essential [1]. To provide the disabled a sense of independence and movement as well as to ensure their safety by helping them alert their families when in need, this system is very much suitable.

II. LITERATURE REVIEW

Smart Wheelchair with SMS Alert and Safety Features is an electric wheelchair. The wheelchair consists of motors attached to wheelchair that can be controlled by a RC Remote thus providing movement without manual force. It reduces the effort for manual pushing of wheels as well as provides safety. The wheelchair has some safety features by which a user gains the sense of self mobility with security. To provide the disabled a sense of independence and movement as well as to ensure their safety by helping them alert their families when in need, this system is very much suitable.

The first electric wheelchair was the Klein Drive Chair which was invented by Canadian inventor George Klein and his team in 1953. His team developed a unique package of technologies while working for the National Research Council of Canada that are still current features of electric wheelchairs today. The electric wheelchair was propelled by batteries, which allowed automatic movements that were controlled by the user. [3]

At present day, there are number of small as well as large scale commercial enterprises working on smart wheelchairs, most of all in the developed nations. China Synergy Group is a Chinese professional manufacturing company in Shanghai which has developed smart electric wheelchairs. Another producing giant of wheelchairs is Ottobuck which produces customized wheelchairs for suiting the disability [4].

One of the greatest scientists in the world, Stephen Hawking has used a special designed wheelchair with voice systems. Professor Hawking controlled all the functions of his Windows tablet PC using just a single switch. Hawking's PC used a special interface called EZ Keys, which scanned across each letter of the on-screen keyboard, one at a time. When Hawking moved his cheek, a sensor detects the movement and the computer halts the scanner and picked that letter. All these devices were attached to his wheelchair [5]. Similarly, Navchair designed by Levine was developed for people who suffered from different sort of impairments such as bad vision. Its shared control decisions such as obstacle avoidance, safe approach to objects and maintenance of a given path with the user [6]. There are very few commercialized wheelchairs with the smart technology available. One reason is because the robustness and safety of the technology is not 100% guaranteed yet in many researches. Using high-tech smart wheel chairs depends on the severity of the disability, the individual's overall morale and attitude towards his or her condition and the most important is the price of the technology [7]. According to a paper published on the topic "Advances in smart wheelchair technology", a considerable amount of work has been done in the field of smart wheelchairs but small amount of attention has been given to user centric wheelchair design. Thus, the direction should aim at building user centered smart wheelchair considering several disabilities without negotiating user comfort [8].

In the context of Nepal, it has been found through several researches that there are no any commercial electric wheelchair manufacturers till present. In 2002, an electric wheelchair was imported by SOS Children Village, Jorpati for a patient of cerebral palsy. According to the patient, it was comfortable to use in terms of back movement. The director of SOS children village, Mr. Rabin Nepali confirms that despite the comfort of the wheelchair, the battery lasted for a limited period of time. Similarly, the cost was very high [9].

The team of Infinity Lab successfully tested an electronic wheelchair from Shantinagar in Baneshwor to Patan Dhoka powered by a rechargeable battery. This wheelchair was the first of its kind that has been designed and produced using mostly locally available materials called the 'Leopard', the wheelchair allows its users to travel at a top speed of 10 kilometers per hour and can cover up to 25 kilometers, after being fully charged for three hours [10]. The feasibility of wheelchairs imported from abroad is very less. They are not made considering the physical infrastructures of Nepal, especially the rough roads. The foreign designs are failure in Nepal's roads [11].

While the needs of many individuals with disabilities can be satisfied with power wheelchairs, some members of the disabled community find it difficult or impossible to operate a standard power wheelchair. To accommodate this population, several researchers have used technologies originally developed for mobile robots to create "smart wheelchairs" that reduce the physical, perceptual, and cognitive skills necessary to operate a power wheelchair [12]. A Smart Wheelchair Component System (SWCS) is the wheelchair with minimal modification of variety of commercial power wheelchairs.

Scottish designer Phoenix Instinct has developed a lightweight wheelchair with a movable axle position that automatically adjusts the chair's centre of gravity to stop overbalancing. The Phoenix i wheelchair uses smart technology to improve its basic functionality. Made of lightweight carbon-fibre, the wheelchair's wheels are mounted on an adjustable axle that can move forward or backwards depending on the user's position [13].

To ensure the independency in mobility and security of the disabled, smart wheelchair would be a key solution. The system uses ATmega328p microcontroller. In this project, we are adding alarm, message alert as well as obstacle detection features which will provide safety to the disabled people. Similarly, the person accessing the system will be able to control and move anywhere without any human help with ease and security.

III. METHODOLOGY

A. Block diagram of movement of the System

The system consists of 4 DC motor, RC remote transmitter and receiver, ESC and battery. The movement of all the four motors is controlled by the movement of RC remote. The motors are connected with ESC and LiPo battery provides the required power. When remote which acts as transmitter sends signals on receiving input from wheelchair user,

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receiver receives signal and directs ESC to enable motor. ESC controls the s motor movement or speed by activating the appropriate MOSFETs to create the rotating magnetic field so that the motor rotates. The higher the frequency or the quicker the ESC goes through the 6 intervals, the higher the speed of the motor will be. In this way the components in upper section work.

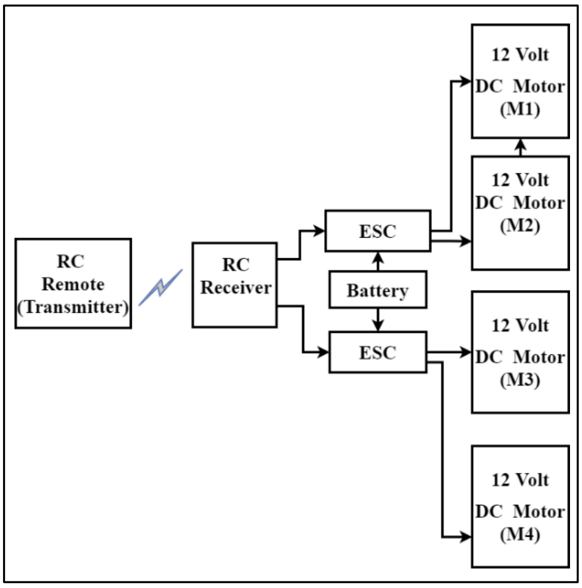


Fig. 1. Block Diagram of movement of the System

B. Block diagram of SMS alert and safety features

The system consists of Atmega328p microcontroller as the main controlling device. Similarly, two ultrasonic sensors are present on the front and back of the wheelchair and accelerometer is present on the middle for detecting change in orientation. For the SMS alert feature, GPS/GSM SIM 808 module is used. Ultrasonic sensors measure the distance to or the presence of a target object by sending a sound pulse, above the range of any obstacle, toward the target and then measuring the time it takes the sound echo to return. Thus, buzzer beeps on receiving a high from the microcontroller. Accelerometer gives value of three axis X, Y and Z from which we calculate the change in normal orientation of wheelchair.

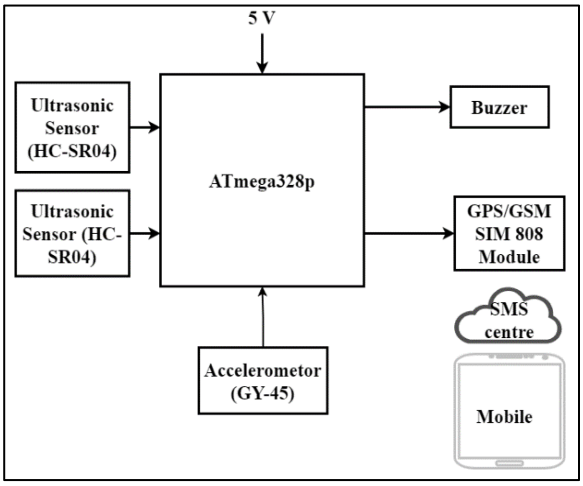


Fig. 2. Block diagram of SMS alert & safety features

C. Software Requirements

Our system uses Arduino IDE. It is an official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can easily understand. Similarly, Proteus has been used for simulation of the system.
It has been used to test the system virtually before its real implementation.

D. Flowchart for the movement of the System

When the system is initialized, RC remote is checked for the direction. If the RC remote handle is moved to left, the right motor is enabled and left motor is disabled. If the RC remote handle is moved to right, the left motor is enabled and right motor is disabled. If the RC remote handle is moved forward, then both motors are enabled. For backward movement, both motors are enabled. The proposed system goes on moving and keeps on checking RC remote handle for the change in the direction of movement.

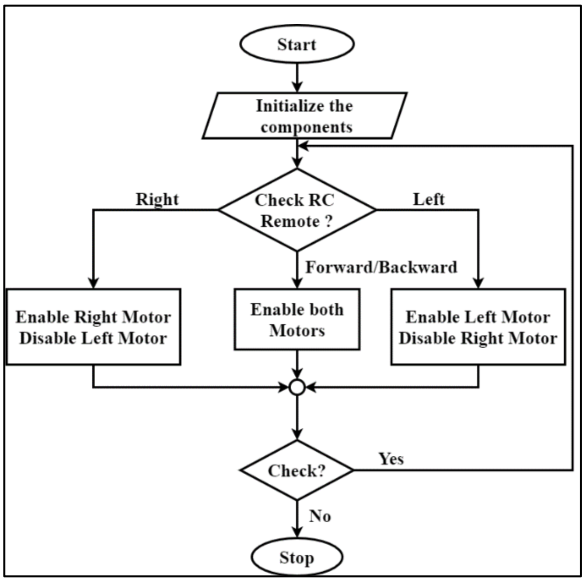


Fig. 3. Flowchart of movement of the System

E. Flowchart for SMS Alert and Safety Feature of the System

When the system is initialized, the microcontroller keeps checking whether the detected value of accelerometer and ultrasonic sensor are in the predefined range or not. If the values are not in the range, first of all the value of accelerometer sensor is checked. If the values are not in the range, the buzzer beeps. It represents that there is change in orientation of wheelchair. Hence, SMS is sent through GSM/GPS. If the values of accelerometer are in the range, value of both ultrasonic sensors are checked. If any of one sensors value is less than the threshold, the buzzer is beeps. Thus, the wheelchair user is alerted to take suitable action. If no input is applied, the microcontroller keeps checking till the system is on.

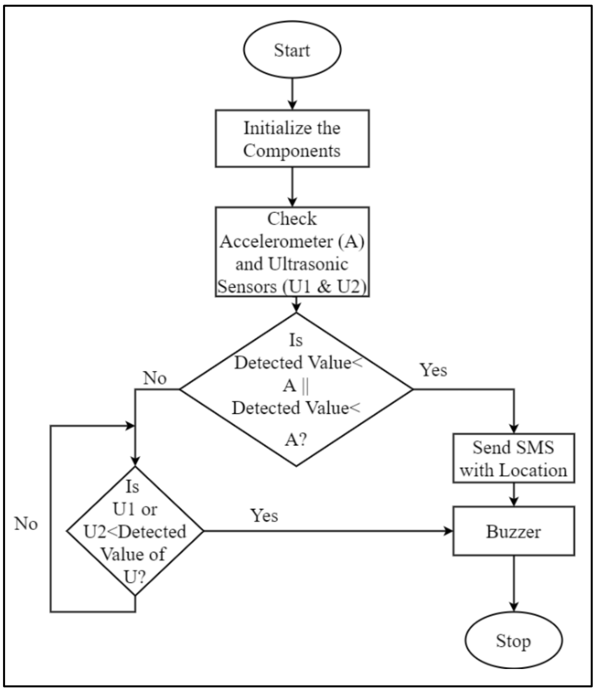


Fig. 4. Block diagram of SMS Alert & Safety Features

IV. Results And Discussion

A. Implementation of The System

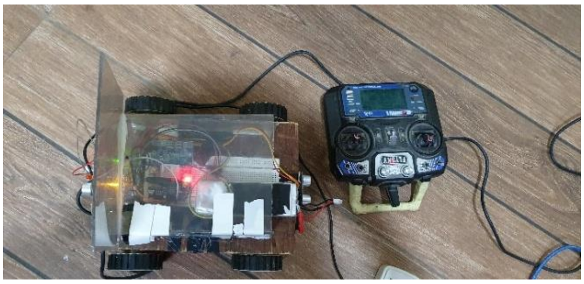


Fig. 5. Complete view of control system

The smart wheelchair is an implementation of a RC remote controlled robot. The two Ultrasonic Sensors i.e. US1 and US2 are used for the obstacle detection. Therefore, when US1 detects a value below threshold, the buzzer beeps and alerts the wheelchair user that he should stop the wheelchair from moving forward. Similarly, when US2 detects a value below threshold, the buzzer beeps and alerts the wheelchair user that he should stop the wheelchair from moving backward. Similarly, when GY-45 detects a value not in threshold range, the buzzer beeps thereby alerting the people nearby that the wheelchair has incurred some abnormal position, which may cause serious harm to user.

The response of smart wheelchair in different cases:

TABLE I. OPERATION OF THE SYSTEM

RC Remote	DC Motors		Wheelchair Direction
	M1 & M3	***M2 & M4***	
Back	Anticlockwise	Anticlockwise	Backward
Front	Clockwise	Clockwise	Forward
Right	Clockwise	Turn	Right
Left	Anticlockwise	Turn	Left

B. GPS/GSM SIM 808 module based SMS Alert

TABLE II. SMS ALERT OF THE SYSTEM

Case	RC Remote Signal	Sensors Indication	Wheelchair Response
Abnormal Orientation	Neutral	GY-45 not in threshold range	SIM 808 module send alert SMS

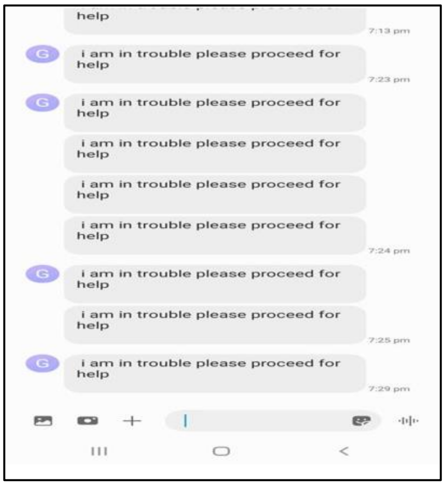
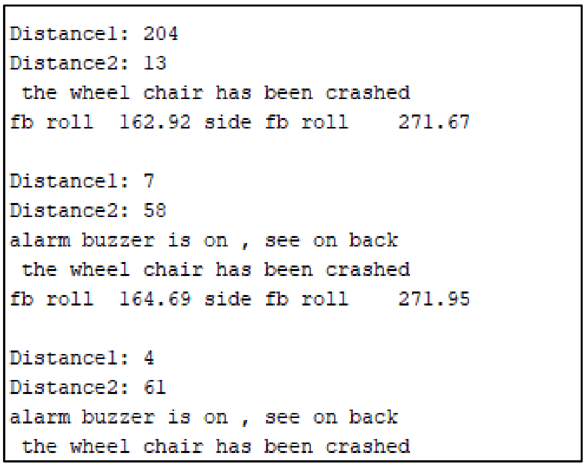


Fig. 6. SMS Alert via SIM 808 Module



```
Distance1: 204
Distance2: 13
 the wheel chair has been crashed
fb roll  162.92 side fb roll    271.67

Distance1: 7
Distance2: 58
alarm buzzer is on , see on back
 the wheel chair has been crashed
fb roll  164.69 side fb roll    271.95

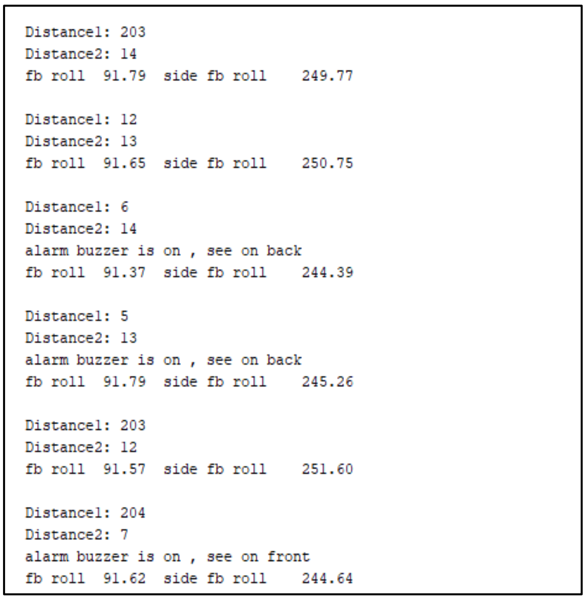
Distance1: 4
Distance2: 61
alarm buzzer is on , see on back
 the wheel chair has been crashed
```

Fig.7. Output of crash detection on serial monitor

C. Obstacle Detection of Smart Wheelchair

TABLE III. OBSTACLE DETECTION OF THE SYSTEM

Case	RC Remote Signal	Sensors Indication	Wheelchair Response
Obstacle in front of chair	Speed signal above neutral (forward movement	Ultrasonic sensor 1 value less than threshold distance	Buzzer beeps to alert user to avoid forward movement
Obstacle in back of chair	Speed signal below neutral (backward movement	Ultrasonic sensor 2 value less than threshold distance	Buzzer beeps to alert user to avoid backward movement



```
Distance1: 203
Distance2: 14
fb roll  91.79  side fb roll    249.77

Distance1: 12
Distance2: 13
fb roll  91.65  side fb roll    250.75

Distance1: 6
Distance2: 14
alarm buzzer is on , see on back
fb roll  91.37  side fb roll    244.39

Distance1: 5
Distance2: 13
alarm buzzer is on , see on back
fb roll  91.79  side fb roll    245.26

Distance1: 203
Distance2: 12
fb roll  91.57  side fb roll    251.60

Distance1: 204
Distance2: 7
alarm buzzer is on , see on front
fb roll  91.62  side fb roll    244.64
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Fig. 8. Output of obstacle detection on serial monitor

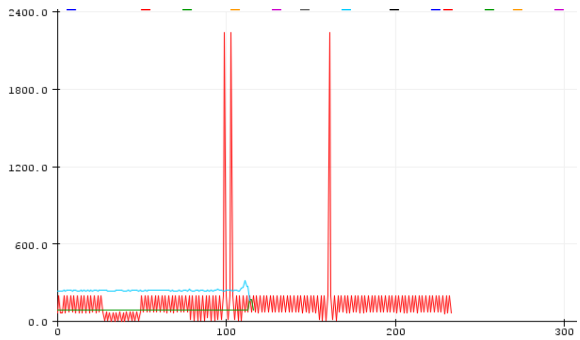

Fig. 9. Plot of obstacle on front and back on serial plotter

D. Implementation of Control System

The designed control system can be implemented into a real wheelchair as follows:

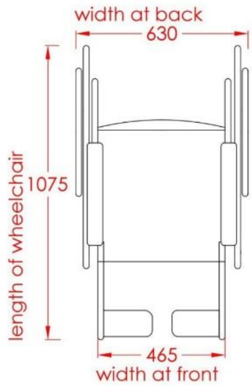

Fig. 10. Top view of wheelchair
[Available:www.firstinarchitecture.co.uk]

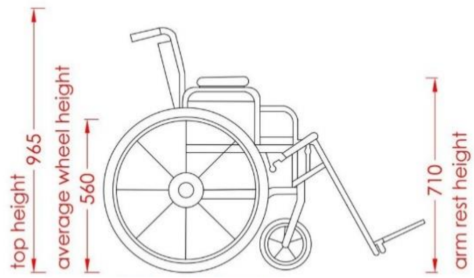

Fig. 11. Side view of wheelchair
[Available:www.firstinarchitecture.co.uk]

The motors will be connected to wheels of the wheelchair on both sides. Similarly, on the top right, joystick will be placed at a comfortable position for user to handle. Accelerometer will be placed at the center of the sitting considering the center of gravity. The GSM/GPS module will be placed on the lower section of sitting and the microcontroller will be placed in suitable position. Atmega328p will be replaced by Raspberry-Pi for better performance. Buzzer will be placed considering the comfortable and sound audibility of the beep. In this way, our control system can be implemented into real wheelchair.

E. Discussion

During the research of a smart wheelchair for real time, different methodologies were studied and best feasible method was chosen. In the course of our research, we found that the advance systems used raspberry pi as the microcontroller for better speed and faster processing. We used ATmega328p as microcontroller as our main goal was to achieve the functionality rather than speed being a key factor. Our system consists of SMS alert which is beneficial for the safety of wheelchair user and describes problem in wheelchair orientation. We used wireless communication for the alerting to the caretaker/family of the user. Overall, our research suggests a low-cost control system design which can give independent movement to a wheelchair user.

F. Result Analysis

Based on our research, analysis and the result we got during implementation of the project, overall we achieved a significant level of accuracy. Compared to Leopard, the first smart wheelchair in Nepal, our system can provide more efficiency at a low cost.
The accuracy obtained for ultrasonic sensor is presented below:

TABLE IV. ACCURACY OF ULTRASONIC SENSOR

Front ultrasonic sensor(cm)	**Back ultrasonic sensor(cm)**	**Accuracy range > (cm)**	**Result**
25	20	10	No obstacle
20	15	10	No obstacle
6	14	10	Obstacle in front
5	18	10	Obstacle in front
50	2	10	Obstacle in back
50	5	10	Obstacle in back

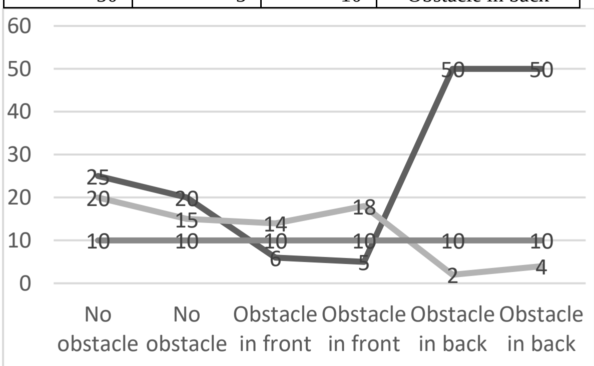

Fig. 12. Performance of Ultrasonic Sensor

Front Back Roll	**Side Roll**	**Front Back Roll (min)**	**Front Back Roll (max)**	**Side Roll (min)**	**Side Roll (max)**	**Result**
90	241.67	75	105	220	280	Normal
91.79	249	75	105	220	280	Normal
85	240	75	105	220	280	Normal
162	260	75	105	220	280	crashed front back
90	300	75	105	220	280	Crashed by side

TABLE V. ACCURACY OF ACCELEROMETER SENSOR

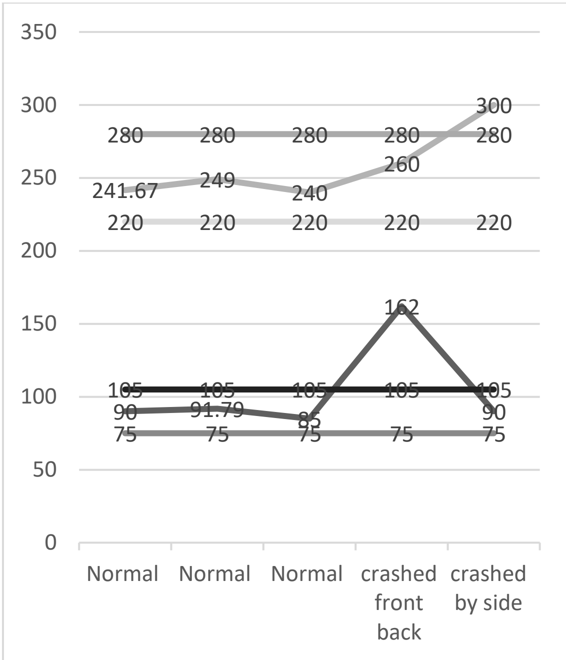

Fig. 13. Performance of Accelerometer Sensor

Motor speed range calculation

The normal speed of the system should be 8 cm/sec but the weighted wheel chair has some more power requirement. There is some loss of power while moving with load. For unloaded condition the vehicle top speed is 8.51 cm/sec, which can be considered good for normal home uses.

V. CONCLUSION

Smart Wheelchair with SMS alert and safety features was successfully tested. Also, the specific objective to design and develop a system that helps people with locomotive disability to have independent movement was fulfilled. The designed wheelchair provides SMS alert on emergency situations. Thus, the low-cost microcontroller and advances in wireless communication inspired us to design and develop the low-cost system. By using this prototype containing microcontroller (ATmega328p), GSM/GPS module (SIM 808) and other components, smart wheelchair can be successfully built to offer independence in movement and security to locomotive disabled.

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